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Digitally Intelligent Architecture Has Little to Do with Computers (and Even Less with Their Intelligence)

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Myths—classical myths—are a complicated matter. As the great classicist Paul Veyne famously asked long ago, did the Greeks themselves really believe in their myths? [1] Would Euclid, or Aristotle, for example—from what we know of them, not the kind of guys likely to abet improbable flights of fancy—really have believed that Athena leaped from Zeus's head, fully grown and armed, when Zeus complained of a headache after swallowing his pregnant mistress Metis whole, and someone cleaved Zeus's head with an axe to relieve him of his pain? There are many theories, of course, trying to account for the enduring power of classical myths over time—but postmodern myths, unlike Roland Barthes's modernist ones, no longer need any hermeneutic subtleties: as any dictionary will tell, today's myths are just fake news, often involving a supernatural protagonist, used as ploys to justify something otherwise inexplicable, or unpalatable. [2] Alongside real, classical myths inherited from the Vitruvian tradition, today's architectural history and theory offer plenty of examples of such opportunistic storytelling. The one I shall discuss here has the additional advantage of being apparently self-evident—a truism, almost: computer-aided design depends on computers. Who would deny that? Computer-driven architecture is what happens when architecture meets one of these mythical, almost magical protagonists: after all, not long ago computers were still called, in most languages, "electronic brains," and to this day some see them as endowed with supernatural (or "singular") powers. [3]

Yet the first encounters between designers and electronic computers in the years of postwar reconstruction were frustrating, and unfruitful. A low-added-value professional service dealing with complex problems and data-heavy images and drawings, architecture did not directly partake in the first age of electronic computing, if not as a ricochet: designers were, like everyone else at the time, inspired and excited by the development of

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1 Paul Veyne, *Les Grecs ont-ils cru à leur mythes? Essai sur l'imagination constituante* (Paris: Seuil, 1983).

2 Roland Barthes, *Mythologies* (Paris: Seuil, 1957).

3 As a reviewer pertinently noted, by debunking this myth in this article I shall more or less inadvertently construe another one—that of a crucial "digital turn" in architecture that would have occurred in the early 1990s, brought about by the conflation of Deleuzian and deconstructivist theories in architecture, affordable computation, and the rise of spline-modeling software. But I have a vested interest in that historiographical construction: I first suggested it in 2004, when, together with its guest editor, Greg Lynn, I republished the seminal *Architectural Design* issue on "Folding in Architecture" (March/April 1993), with new prefaces by Lynn and me; this republication was celebrated by a memorable conference in Vienna in the spring of 2005 ("Twelve Years of Folding—Deleuze and the IT Revolution in Architecture," Vienna, MAK—Museum für Angewandte Kunst, and the Kiesler Foundation, May 20–21, 2005). I have reiterated the notion of a crucial watershed in digital design theory around 1993 in all my subsequent publications and in my teaching; the same historiographical timeline has been adopted by other historians and critics (see in particular the series of events and publications organized by the CCA in Montréal under the title *Archeology of the Digital*), and it is now often taken for granted. Therefore, I may be forgiven for being more partial to this myth than to others I did not personally nurture; and I would suggest that myths we like, or myths that serve us well, may be seen as simple instruments or devices we sometimes use to compress a variety of diverse and often unrelated events into simplified, streamlined, and memorable narrations—which is, after all, a form of inductive generalization inherent in all cognitive processes. In that, as already noted by Walter Benjamin in *Der Erzähler* (1936), storytelling, historiography, classical myths, and Christian parables all serve similar purposes: by picking a few accidental events out of many unrelated ones, and putting them in some rational sequence, they make order out of chaos, and they present a causal interpretation of the unintelligible in a user-friendly format, which can be easily conveyed and remembered—together with the more or less esoteric meanings that each story may conceal.

new tools for electronic computation that, back then, were entirely out of their reach, and would have been of no use to them if they could have afforded to pay for them—which they could not. Some techno-friendly vaticinations and sci-fi visions of the age of cybernetics then took on a life of their own, and spawned the so-called high-tech style of contemporary architecture, which continues to this day. But there was not much that designers could have done with computers in the 1960s and 1970s, due to the technical limits of early electronic computation; pictures in particular, when converted into numbers, become big files, requiring more memory and computing power than was then commercially available: indeed, anecdotal evidence suggests that mainframe computers in a handful of major architectural firms that could afford them at the end of the 1960s were bought for bookkeeping, not for design purposes. [4] Even the first releases of affordable CAD software meant for workstations and early personal computers in the 1980s failed to bring about any significant architectural upheaval. Digital change in architectural design came only in the early 1990s, due to a combination of techno-cultural, social, and theoretical factors, and largely due to ideas inherent to and inscribed in the long duration of the history of architectural theory.

The 1946 ENIAC, often seen as the first modern computer, had a weight of 27 tons and occupied a surface of 127 square meters in the building of the School of Electric Engineering of the University of Pennsylvania, where it was built during the last years of the Second World War, as a part of the war effort. It was meant to help with ballistic calculations; it did little more than additions, subtractions, multiplications, and divisions—but did them faster than any other machine. Computers got smaller and cheaper, but not necessarily more powerful, after the introduction of transistors in the course of the 1950s. Mainframe computers priced for middle-size companies and professional offices started to be available as of the late 1950s, but a mass-market breakthrough came only with the IBM System/360, launched with great fanfare on April 7, 1964. Its more advanced versions from the late 1960s had the equivalent of 1/250th of the random access memory we find in most cell phones today. Yet the very expression "computer-aided design," or CAD, had been around since at least 1959, when it was adopted by a new research program in the Department of Mechanical Engineering of the Massachusetts Institute of Technology (MIT), devoted to the development of numerically controlled milling machines. A PhD student in that program, Ivan Sutherland, wrote the first interactive software for CAD, called the Sketchpad, which used a light pen, or stylus, to draw and edit geometrical diagrams directly on a cathode-ray tube monitor (a TV screen).

4 In 1968 one the biggest architectural firms of the time, SOM, presented some programs for cost estimates and building area calculations as new and ground-breaking research carried out, apparently, on a machine they owned. See Daniel Cardoso Llach, *Builders of the Vision: Software and the Imagination of Design* (London: Routledge, 2015), 23–24. One noted exception was the global planning consultancy of Constantinos Doxiadis, who in 1964 established a computer center as an independent company to provide statistical analysis and other data processing to its own offices in Athens, Greece. See Alexandros-Andreas Kyrtsis, ed., *Constantinos A. Doxiadis: Texts, Design Drawings, Settlements* (Athens: Ikaros, 2006), 455; Mark Wigley, "Network Fever," *Grey Room* 4 (2001): 82–122, esp. 88, 98, 118.

Sutherland did not invent the light pen, which had been in use at MIT since the mid-1950s; the novelty of the Sketchpad was a program that allowed for the geometrical definition of scalable planar objects that could be cut, pasted, and resized. [5] When the program was shown in Cambridge, England, in 1963, it created an immediate sensation—but the demonstration only showed slides, or possibly some illustrations of the machine at work, because no computer in Cambridge would have been powerful enough to run Sutherland's software, and even the military-grade mainframe computers at MIT would have taken hours to recalculate and show each new diagram. [6] And regardless, the cybernetic excitement of the 1960s was not about what computers could actually do: it was about the expectation or the promise of what they would do—some day in the future. In 1970 Nicholas Negroponte, then twenty-seven years old, predicted that computers would soon become universal design assistants, enabling every end user, customer, or citizen to design almost everything all alone, without the need for any mediation or architectural expertise or advise to be provided by anyone else: the computer would replace the architect, and become the designer. [7] Even by today's standards, that would still be a tall order.

In the summer of 1968 in London, the now famous exhibition *Cybernetic Serendipity* celebrated the new age of electronic art; in the show, however, architecture was remarkable for its absence—and the few instances of computer-driven architecture that were shown were remarkably dull. The noted futurologist Gordon Pask participated with an interactive installation, *The Colloquy of Mobiles*—a game of reflecting mirrors. [8] Pask was the cybernetic consultant for Archigram's Instant City (1968) and the "cybernetic resident" in Cedric Price's Fun Palace (1963–1967); he contributed to the 8th *Archigram* magazine, and he went on to collaborate (alongside John and Julia Frazer) on Price's Generator Project (1976–1979). [9] No computer was used to make any of Archigram's, or Price's drawings—nor could have been, for the reasons just said; and no one can tell if any computer would have been needed to design and build any of those buildings—as none of them was buildable and none ever built. Why were these buildings meant to be "cybernetic," then, and in what did their "cybernetic" nature reside? To answer, we should first have a look at what *cybernetics* meant back then—as that is not what it means right now.

In the introduction to the first edition of his seminal book *Cybernetics; or, Control and Communication in the Animal and the Machine* (1948), Norbert Wiener recounts how the team of scientists gathered around him and the physiologist Arturo

5 Cardoso Llach, *Builders of the Vision* (see note 4), 49–72.

6 Oral communication from Philip Steadman (Centre for Land Use and Built Form Studies [LUBFS] at the School of Architecture of the University of Cambridge; cofounder, 1967). There are some slightly different anecdotal traditions on what Sutherland would have actually shown to his British colleagues in 1963.

7 Nicholas Negroponte, *The Architecture Machine: Toward a More Human Environment* (Cambridge, Mass.: MIT Press, 1970).

8 See Jasia Reichardt, ed., *Cybernetic Serendipity: The Computer and the Arts*, exh. cat. (London: Studio International, 1968). See at page 9 a digital scan of a photograph of Norbert Wiener, to the resolution of 100,000 b/w cells (known today as pixels; i.e., the scan would have had the size of 100 kilobytes). The caption describes the process and the technology used; the scan and print took sixteen hours of non-stop machine work.

9 See Usman Haque, "The Architectural Relevance of Gordon Pask," *Architectural Design* 77 (July/August 2007): 54–61; Molly Wright Steenson, *Architectural Intelligence: How Designers and Architects Created the Digital Landscape* (Cambridge, Mass.: MIT Press, 2017), 156–75. For the *Archigram* issue and Instant City, see http://archigram.westminster.ac.uk/project.php?revID=2720 and http://archigram.westminster.ac.uk/project.php?id=119 (accessed January 18, 2019).

Rosenblueth had invented the term *cybernetics* to designate a new discipline devoted to the holistic study of feedback in all processes of communication and control, whether machinic or biologic. The term they chose was derived from the ancient Greek *κῠβερνήτης* (*kubernḗtēs*, or steersman: hence the etymology of *governor* in English, or *gouverneur* in French, both in the navigational and in the political sense of the term), and it was meant to refer to the steering engines of a ship, seen as the earliest and best-developed forms of feedback-based servomechanisms (as well as, Wiener recounts, the starting point of his own studies on the subject, impelled by a war project on the self-correction of gun pointers aimed at airplanes with known or predictable trajectories). [10] In the same book Wiener emphasize the similarity between the binary operations of electronic computers and the reactivity of the living cells of the nervous systems, or neurons, which were already known to operate on an all-or-nothing, or binary, mode. This suggested a deeper correspondence between mathematical logic and neurophysiology, warranting the parallel study of computation in electronic machines and of "neuronal nets" in living beings. Wiener's team further grounded the theoretical basis of the new science of cybernetics in a vast program of vivisection of the muscles of decerebrated cats, carried out at the National Institute of Cardiology of Mexico City. [11] Wiener claims that his ideas on cybernetics and electronic computing were endorsed by, among others, John von Neumann at Princeton and by Alan Turing at Teddington, [12] but in the late 1950s and early 1960s the field of cybernetics was seen as primarily devoted to the study of analog, electromechanical, or organic feedback—so much so that when John McCarthy, Marvin Minsky, and others convened the now famous first seminar on artificial intelligence (AI) at Dartmouth College in 1956, they studiously avoided the term *cybernetics*—and indeed, it appears they chose to call their seminar "The Dartmouth Summer Research Project on Artificial Intelligence" specifically to avoid any association with Wiener's science and with Wiener himself, who was not invited. [13] When a few years later Minsky wrote a capital article often seen as the theoretical foundation of AI, he took care never to use the term *cybernetics*—except in a one-line footnote citing the title of Wiener's 1948 book. [14]

Many years later, for reasons never fully elucidated, the science-fiction writer William Gibson famously adopted the prefix *cyber-* to create the expression *cyberspace*, populaized by his best-selling novel *Neuromancer* (1984). Without any direct reference to Wiener's science, the term was soon generically and universally adopted in popular culture to evoke almost

10 Norbert Wiener, *Cybernetics; or, Control and Communication in the Animal and the Machine*, 2nd enlarged ed. (Cambridge, Mass.: MIT Press, 1961), 11. The introduction is dated "Mexico City, 1947."

11 Ibid., 14, 19.

12 Ibid., 15, 23.

13 At the time of this writing the best source of information on the Dartmouth workshop, seen by many as the act of foundation of AI as a discipline, is a remarkable *Wikipedia* entry, https://en.wikipedia.org/wiki/Dartmouth_workshop (accessed January 18, 2018). We must assume that in this instance, contrary to its terms of service, but faithful to its spirit, *Wikipedia* serves as an aggregator of oral traditions, mostly contributed by the protagonists of the story being told or by people that were close to them.

14 Marvin Minsky, "Steps toward Artificial Intelligence," *Proceedings of the IRE* 49, no. 1 (1961): 8–30.

anything related to electronics and computers—up to and including Gibson's own style of fiction, known to this day as cyberpunk; in the course of the 1990s the term was metonymically extended to everything occurring on the Internet, and *cyberspace* became a moniker for any technologically mediated alternative to physical space. Back in the 1960s, however, the first AI scientists saw Wiener's cybernetics as something quite separate from the mathematics of computation; even if the analogy between computers and neural networks was generally admitted, the cyberneticians' sometimes sulfuric interests in neurophysiology were often met with reservations by the engineers and mathematicians that constituted the core of the AI community. [15]

15 For an introduction to this discussion (but with the same disclaimer as in note 13), see Piero Scaruffi, *Intelligence Is Not Artificial* (self-published, 2018), 19–23.

In this context, Gordon Pask's credentials as a cybernetician should be seen as a sign of his lifelong interest in the interactions between humans and machines, machinic responsiveness and feedback, and of this "cybernetic" line of research we find abundant evidence in some architectural works Pask participated in or otherwise mentored and inspired. Price's visionary work, in particular, based as it was on modularity, assembly, and mechanical transportation, was pervaded from the start by ideas of automatic responsiveness embedded in buildings and building components, and this in turn invited the use of electronic computers to command and control the movements of various mechanical parts.

As Price did not leave blueprints for his most famous projects, we do not know precisely how computers would have managed to move and reposition the modular components that were plugged into the vast steel frame of his famous Fun Palace; Pask suggested in this instance to use a system of punched cards to memorize the best configurations and also to collect data on users' satisfaction. Price's Oxford Corner House project (1965–66) envisaged floors that moved up and down on demand, but the computer in the basement of that building (an IBM/360) was meant to feed educational and entertainment content to the various interactive terminals disseminated inside the building. Likewise, the Potteries Thinkbelt (1964–66) was a project of modular university buildings to be transported and delivered on rails, permanently reconfigurable on demand, but it is in Price's later Generator Project (1976–79) that we find a fully developed attempt at the cybernetic governance of an entire built environment (a theme park that should have been built in a plantation in the South of the U.S.). All the installations in the park would have resulted from the recombination of a set of 150 modular room-size cubes, to be permanently moved around by cranes based on users' feedback or automatic recalculations by a central computer. John and Julia Frazer made a model of the system with Plexiglas boxes, and wrote a program for a Commodore PC that would have managed the movement of the various parts of the model. [16] Price appears to have claimed that his Generator Project was the world's first intelligent building, but we know today of at least one very similar precedent—Negroponte's *SEEK* installation of 1970, where cubes were moved around in a box by a robotic arm driven by a computer that interpreted, somehow, the intentions of a population of big rats. [17] Similar modular boxes were also the basis of Negroponte's URBAN2 and URBAN5 interactive design systems, all illustrated in Negroponte's seminal *Architecture Machine* of 1970 (*sans* rats, which were added as the free-will ingredient—the human factor in the cybernetic machine, in a sense—only in the show at the Jewish Museum in Boston, titled *Life in a Computerized Environment*). [18]

16 Wright Steenson, *Architectural Intelligence* (see note 9), 127–75.

17 Ibid., 128, source not cited. Wright Steenson adds that the Generator Project "actually showed how artificial intelligence could work in an architectural setting."

18 Negroponte, *Architecture Machine* (see note 7), 104–5; Wright Steenson, *Architectural Intelligence* (see note 9), 185.

Fifty years later, it is easy to see a few reasons why the digital turn changed architecture in the 1990s, and cybernetics failed to do so in the 1960s. For a start, computers in the age of cybernetics were seen primarily as new technologies for information and communication, whereas designers as of the 1990s used them primarily as tools for design and fabrication. As a result, in the course of the 1990s computational tools successfully replaced traditional architectural notations (plans, elevations, and sections) with digital scripts. Such notational scripts are pure information, and they are eminently variable media: They are interactive, and they can be participatory, collaborative, crowdsourced, automated, self-optimized, even self-organizing. They can change and morph all the time because they are made of bits and bytes. Buildings are made of steel and reinforced concrete, and after they are built they cannot change that much. Good software is responsive and interactive, but even the smartest steel I-beam can provide only limited feedback. Software can be intelligent, to some extent, but the degree of self-determination expressed by even the most sophisticated of today's buildings remains confined to gadgetry or environmental controls (heating, ventilation, air conditioning). At the time of writing, self-driving cars seem promised a bright future, but research on self-building buildings is not yet booming. The cyberneticians of the 1960s wanted to make buildings as responsive and interactive as a web page is today. In this sense, their visions may indeed have prefigured some aspects of today's Internet, but they certainly did not prefigure any aspect of today's architecture. Price's and Pask's cybernetic approach to reconfigurable, stackable buildings pales in comparison with the computerized logistics still needed for handling even the dumbest shipping containers, but the one building their cybernetic visions did famously inspire, the Centre Pompidou in

Paris, does not have any conspicuously moving parts, other than one big escalator; and it was built in the early 1970s without any computer at all. [19]

While the Centre Pompidou was built, the cybernetic exuberance from which it derived was being quickly eroded by the energy crises and by the economic and political turmoil of the 1970s; by the end of the decade the techno-optimism of the 1960s had been entirely replaced by the technophobia of postmodernism, and in the course of the 1970s the terms *cybernetics* and *artificial intelligence* fell out of use. As of the early 1970s it became apparent that cybernetics and AI, in spite of the extraordinary expectations they had aroused, were not delivering any usable results; credits—particularly from the military—then dried up, and the most ambitious research projects were abandoned or retrenched. Computer scientists today disagree on the timeline and causes of "the winter of Artificial Intelligence" that set in around that time; however, while academic research on AI mostly went into hibernation, some smaller projects were opportunistically reoriented towards commercial electronics, with some unexpected results. [20]

The cyberneticians and AI scientists of the 1960s had been dreaming of a techno-driven future made of bigger and always more powerful central computers; the digital revolution of the 1980s and 1990s came instead from smaller and smaller machines that did very little—almost nothing—but put that very little amount of cheap computation at everyone's disposal, on everyone's desktop. That was the PC revolution, which started with the IBM PC in 1981. Steve Job's first Macintosh, in 1984, famously adopted a mandatory graphic user interface; but, unlike the MIT's light pen, which cost millions, the mouse (made by Logitech in Lausanne) cost a few dollars apiece. Autodesk and Adobe were both founded in 1982, so as of the early 1980s all the tools needed for computer-aided design were available and affordable, and indeed by the end of the 1980s many schools of architecture in Europe, the U.S., and Canada offered some basic training in computer-based drafting. Yet, once again, this failed to bring about any significant change in architectural design, in the architectural discipline, and in the design professions at large.

Many multistory parking lots today are designed and built using the most advanced building information modeling software that money can buy, and muster more computer power than Frank Gehry and Dassault Systèmes could dream of to design and build the Guggenheim Bilbao in the 1990s. Yet the building type of the multistory parking lot, particularly in the Americas, has not changed for many decades, and if the adoption of digital tools

19 Competition launched December 1969; results announced July 1971; construction started May 1972; building inaugurated January 31, 1977. Architects: Richard Rogers and Renzo Piano; engineering: Edmund Happold and Peter Rice at Ove Arup and Partners.

20 Wright Steenson, *Architectural Intelligence* (see note 9), 192–95; Scaruffi, *Intelligence* (see note 15), 62–75.

for design and fabrication may have made some parking lots cheaper or faster to build, that has not changed their architecture in the least. In purely architectural terms, the tools adopted to design and build most standard parking lots today are irrelevant—as all parking lots always look exactly the same anyways. On the contrary, to build a big metal fish floating over the beaches of Barcelona, as Gehry did for the Olympic Games of 1992, computer-aided design was a game changer—because using computers we can design and build a big fish, and without computers we cannot. That is one reason why big fish were seldom built before 1992. In that instance, famously, CAD software originally developed to solve aerodynamic problems in aircraft construction allowed Gehry to design and build complex streamlined lines (technically known as splines) that would have been too difficult to measure and draw by hand. [21]

It is not a coincidence that digitally intelligent design in the early 1990s was invented, encouraged, and promoted by designers that aimed at, and cherished, complexity: Bernard Tschumi, Peter Eisenman, Gehry, Coop Himmelb(l)au, Zaha Hadid. Their idea of complexity in design came from the architectural theory and ideas of deconstructivism. Architectural deconstructivists were evidently familiar with the work of Jacques Derrida, and when they read Gilles Deleuze's book on *The Fold: Leibniz and the Baroque* they found a long footnote by the young polymath, architect, and mathematician Bernard Cache, who explained that Deleuze's view of Leibniz's mathematics also served to explain how computer-aided design works: namely, by writing parametric notations of families of objects (or generic objects) that morph and change with every new set of parameters, just like the parametric notations of curves in differential calculus. This was, in a nutshell, the idea of digital mass-customization: one of the most revolutionary, disruptive ideas that designers ever came up with; an idea that has not only changed the history of global architecture—an idea that is now changing the world in which we live. The mass-production of variations at no extra cost, hence the technical logic of an industrial society without economies of scale—a flat-marginal-cost society—is so alien to our modern mentality that economists, politicians, and technologists, are still struggling to come to terms with it. [22]

Whether we like it or not, this idea was invented by a handful of avant-garde architects and designers, in some schools of architecture, one generation ago. It was not an idea designers imported into design discourse from elsewhere—as designers sometimes do: it was an idea that was born straight out of design theory. And this happened when some new design technologies, and some new design ideas, crossed paths and started to

21 See Mario Carpo, *The Second Digital Turn: Design beyond Intelligence* (Cambridge, Mass.: MIT Press, 2017), 55–65.

22 See Mario Carpo, *The Alphabet and the Algorithm* (Cambridge, MA: MIT Press, 2011), 81–106.

resonate in sync. Before these theoretical motivations emerged, in the 1990s, computers were of no use to architecture—and architects either did not use computers, or tried to put computers they did not have to tasks computers could not do, or used computers to do the same things they could have done without them. These considerations may be particularly timely today, as AI is emerging from the torpor of its long winter and going through an unexpected and spectacular comeback—in computation in general, as well as in computational design. But the revival of this vintage term, which harks back to the golden age of cybernetics, the space race, flared jeans, and Jefferson Airplane, may be misleading, as it belies the technical logic and the scientific nature of today's computational methods. [23] Nobody knows precisely what AI means today, nor why designers should care about it, but one thing for certain we can already learn from history: AI today does not mean what it meant in 1969, hence designers would be well advised not to repeat their early cybernetic blunders.

23 See Carpo, *The Second Digital Turn* (see note 21), 70–98.