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Exploring the Footprint of Data on Our Planet and Beyond

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NOTES ON AN ARCHAEO

NOTES ON AN ARCHAEOLOGY OF DESIGN DATA LITERACY

Georg Vrachliotis

'In recent years, "data" has become one of the most important aspects of architectural design. With the advent of new technologies, architects are now able to collect and analyse data about everything from building materials to weather patterns. This data can be used to create more efficient and sustainable buildings. In some cases, data can even be used to create entire new neighbourhoods or cityscapes.' The sentences sound like a quote, one that could have come from an interview about the history of digital culture or the interconnections between architecture and technology. But as authentic as this statement sounds, it was never said. Anyone who thinks they hear the voice of an architect, computer scientist or historian is mistaken. Strictly speaking, the words do not come from a human being, but from the language software Generative Pre-Trained Transformer, GPT-3 for short. The program is the third generation of artificial intelligence, considered one of the most impressive products our digital culture has produced to date. On a timeline of disruptive technologies, it currently occupies the most current position. GPT-3 is a text generator that can write poems and dramas, provide answers to complex questions on topics such as love or trust, discuss the weather or international climate policy with us—and that has also written the short statement on the subject of 'data and architectural design' mentioned above. The *New York Times* calls the program 'amazing, spooky, humbling and more than a little terrifying'.[1]

Design is more than just generating texts and images using intelligent machines, as is made possible, for example, by the increasingly powerful text-to-image software, such as DALL-E and Midjourney.[2] But such examples make it clear where the journey could also go for architecture and urban design. While physical models are still regarded as an essential medium of knowledge production, there has been an ever-widening spectrum of machine learning models for discussion for some time. A glimpse at the architecture history of digital culture makes us realize that data technologies are far too social to be understood only technically, just as societies are far too driven by data technologies to be understood only socially.[3]

The architecture history of design data literacy is a long search to find a proper culture form for the structural form of the computer. It is fundamentally about how we, as humans, want to behave towards operational technologies, and how to interact and learn with tools and machines to design buildings, explore cities and think about societies. In the twentieth century, we were primarily concerned with learning about machines; instead, we are now concerned with how to teach machines to design. This paradigm shift is accompanied by recalibrating the fundamental cultural technique of learning and interacting with tools to produce new imaginaries about the living environment and, thus, of the architect's role as a creative communicator and explainer linking design, data and society. This change also brings new cultural, ethical, and political questions about how to rethink authorship, creativity, diversity or the digital gab in societies from a data perspective. The debate about biased training data, for example, has repeatedly shown in recent years that the humanistic ideal of learning has become a complex discourse about the power of technical intelligence on an industrial scale.[4]

The sphere of the digital has emancipated itself from being a pure history of tools machines and interfaces to a planetary narration of information networks, feedback, digital ecosystems and data economies based on machine intelligence. It is as if we need to read Marshall McLuhan's *The Invisible Environments*, published in 1967, in the opposite direction to understand that it is now the algorithmic environments that learn something about us.

As we move into the world of integral, computerized knowledge, mere classification becomes secondary and inadequate to the speeds with which data can now be processed. As data can be processed very rapidly we move literally into the world of pattern recognition, out of the world of mere data classification. One way of putting this is to say that our children today live in a world in which the environment itself is a teaching machine made of electric information.[5]

McLuhan suggests that digital media have the power to challenge and recalibrate existing social and cultural structures in societies. Or, as architecture historian Antoine Picon put it, our world today is 'an heiress of the universe opened up by cybernetics and electronic art in the 1950s and 1960s'. 'But who would have thought,' Picon continues, 'that digital life would get under our skin to this degree?'[6] It doesn't take long to realize that this is a rhetorical question that is completely in step with our times. The radical nature of the question is already evident in the fact that even the idea of digitization creeping 'under our skin' is no longer a metaphor. For some time now, we have been experiencing new cultural forms of a recoding, transcoding and converting of spaces, objects, forms, surfaces, materials and the human body. We have, according to the argument behind the following reflections, become actors in a data-based world of operationality that will lead to new cultural, aesthetic, social and political design paradigms within the natural and built environment. So what does it mean to design for a data-driven society that is seeking a balance between an ecological sense of resources and artificial intelligence?

Operational Thinking

Since the mid-twentieth century, architects debated whether machines would cause severe damage to the supposedly humanistic core of design.[7] Almost unnoticed, a second intellectual battleground of entirely different dimensions developed on the peripheries of this debate, which was burgeoning, especially in the 1970s, almost ten years before the World Conference on Computers and Education in Lausanne would talk about 'computer literacy' for the first time.[8] Instead of *computer-aided design*, it was about *computer-aided instructions*, so not about the digitization of design but of learning. But this should not obscure how closely the one was coupled to the other—and still is today. What connects the datafication of design and learning is the technologization of intellectual work itself. The automation wave of the 1970s was, therefore, nothing less than a large-scale attempt to externalize and operationalize tacit knowledge and make it accessible and valuable for the societies. Digitization has not only brought about new tools, but a fundamental change in 'intellectual work' is up for debate in the future, changing design and learning. With a view to the history of digitization, two different but essentially related forms of knowledge production are thus at issue: processes of learning are, to a certain extent, also processes of designing and vice versa, whether drawing machines or learning automatons. It was about the technologization of thinking itself.

The roots of the so-called educational technology are crucial for repositioning design in the age of data. They go back to the field of 'human engineering', an interdisciplinary branch of research established at the time of the Second World War. Its goal was to optimize the interaction between humans and machines. The knowledge gained in the context of the US military was transferred to various areas: this included not only Buckminster Fuller's Dymaxion Houses[9] and Konrad Wachsmann's US Aircraft Hangar,[10] but also the automation of learning itself. Learning automata were an attempt to integrate the school as a social institution into the system competition of the Cold War, which meant not only system building and comprehensive schools, but also learning automata and cybernetic pedagogy. The catalyst for this development was the 'Sputnik shock', which grew from the awareness that the Soviet Union had gained a technological lead over the capitalist West with its successful launch of an earth-orbiting satellite in 1957.[11] The reaction of the American government was not long in coming: in 1958, only one year later, President Dwight D. Eisenhower established not only the defence institution DARPA and the space agency NASA, but also the National Defense Education Act, which entailed a large-scale reform of the American school curriculum and led to the upgrading of the technical intelligence in the country. The focus was on greater individualization of instruction and developing new kinds of interdisciplinary knowledge production. This included so-called creativity research[12] and brainstorming as well as the development of special thinktanks and 'auto-instructional programmes'. The individualization of learning led to the founding of Educational Technology, or 'edtech' for short, a new branch of research in the education industry, based in particular on the behaviourist theories of the influential psychologist and behavioural scientist B.F. Skinner.[13] Edtech promised efficiency in every respect, knowledge production and ideological protection from communist ideas. In fact, the 1960s were the golden age of the so-called teaching machines. The star of this movement was called PLATO—short for Programmed Logic for Automated Teaching Operations—and was probably the most influential teaching machine system of the post-war period. Assembled by engineers, educationalists, mathematicians and psychologists at the University of Illinois from parts of an old radar set, the new machine required the decomposition of all content into so-called 'teaching quanta' according to behaviourist theories. Content and topics were no longer to be thought out of complex contexts but sequentially and additively, as if on an assembly line. If you like, the automation of teaching went hand in hand with the automation of learning. The goal was to build a smooth control loop of learning consisting of theory, hardware, software, information and user. The focus was on creating devices that could be operated with simple buttons. In the operation of the early teaching machines, the hand was regarded as the central tool of sensory perception and haptic feedback. It is probably hardly known that Norbert Wiener, for example, also developed a special device for the deaf in 1948, one year after the publication of his epoch-making book on cybernetics. This device translated spoken language into vibration patterns that the deaf could feel with the help of tiny sensors on their fingertips and thus understand. Wiener did not develop this so-called correlator any further, but the project illustrates that the development of the early teaching machines was predominantly a question of hardware and the design of haptic human-machine communication, and that physical space played hardly any role in this. This changed with the beginning of new network technologies. Instead of just individual places, it was now about global systems, networked thinking and communication environments. Architects rediscovered the physical space, not to design it, but to overcome it.

From Places to Networks

McLuhan's vision about the disruptive potential of electronic media on education developed into an equivalent debate about space and new communication technologies. In the late 1960s several architects, including Toyo Ito, Buckminster Fuller, Yona Friedman and Constantin Doxiadis, began to interpret the building not as a single object, but as a global network of virtual nodes. Swiss architect Fritz Haller, for instance, had realized a series of innovative school and university buildings since the 1950s and was also known for his USM Haller building systems and the USM Haller furniture system.[14] For the competition for a new university campus for the École Polytechnique Fédérale de Lausanne (EPFL), he submitted a project that attempted to leap from an architectural building system to a technological communication system. According to Haller, a university is no longer an autonomous institution but a node in a worldwide knowledge network linked by telephone, television, data interconnection and high-speed trains. Added to this is the idea that universities are no longer limited to academic discourse but radiate into society as 'cultural centres'. This network thinking was the highlight of the project. Haller, who had visited the recently completed university buildings in West Germany for the competition, developed a speculative scheme of how the spaces of learning would develop in the future. According to Haller, the 'general transformation trend' of school models will develop in four stages: from the traditional hierarchizing model to an ever-flatter hierarchy. First, the head teachers will disappear and then the teachers; then classical frontal teaching will be replaced by dynamic forms of community and team teaching. In the fourth and final stage, the school is a network of interdisciplinary learning made up of nodes. Specific types of space are assigned to the different levels under the heading 'Building Structure'. The first three levels can be brought into line with examples of Haller's school buildings, such as the Höhere Technische Lehranstalt Brugg-Windisch (1961–1966). In the last level, he proposes an open-plan school as a system open on all sides, with separable rooms, depending on the visual, acoustic and climatic requirements of teaching. But by the end of the 1970s, the time for visionary school-building projects seemed to have finally run out. And so Haller's network university was not awarded a prize. The competition jury found the vision too radical and not sufficiently application-oriented. Haller expressed his disappointment to the Studiengruppe für Systemforschung (Study Group for Systems Research), co-founded by Horst Rittel, a mathematician and former teacher at Ulm School of Design: 'The experts called the work interesting, but too progressive—too inhuman—too un-architectural. Maybe later on, you can build something like that.'[15] Haller held on to the idea of expanding spaces of learning through communication technologies. In 1996, only a few years after the foundations of the modern World Wide Web were laid at the European Organisation for Nuclear Research (CERN), Haller was also sure: 'Schools will no longer be schools. They will be communication nodes of a global network of relationships and data, in which people of all levels of knowledge and rank will act within their possibilities and create new values.'[16]

What Haller describes here as a vision for education would later become the basis of a platform-based data economy. His idea of open networks and knowledge societies builds on concepts developed since the 1970s. In particular, Daniel Bell's *The Coming of Post-Industrial Society*,[17] published in 1974, laid the foundation for our current discussion on the spatial impact of platforms and logistics on the built environment.

From Instructions to Discovery

In 1970, the same year Haller submitted his entry for the EPFL competition, Marshall McLuhan published an essay titled 'Education in the Electronic Age', with which he arguably created one of the most influential blueprints for the digital culture of learning. The division into chairs, according to McLuhan, also belonged to the dissecting and specializing age of printing, a time still without feedback. McLuhan said that anyone could learn about anything on their own if they were given encouragement and tools. And this is precisely where the utopian potential of the early digital tool culture lies. So, it was educational issues that decided the future of computers and societies, from the earlier teaching machines to Fritz Haller's global university networks. McLuhan was convinced that you could transform learning if you transformed the spaces of learning. Modern communication technologies could even liberate societies from the rigid thought patterns of school institutions so that, in the end, they would practically no longer be needed. Technology's reform potential was no longer located in schools, but in the outside space, cities and the environment. It is no coincidence that McLuhan spoke of 'classrooms without walls', a wonderful metaphor that could also be used as a proxy for the countless experimental places of learning in the digital age.

The changes have gone on outside, not inside the school. The outside environment, perhaps for the first time in history, is, in terms of information, many times more heavily laden than the inside environment of the school. What is going on inside the school is puny and nourished compared to what goes on the moment the child steps outside ... What goes on inside the school is an interruption of education, of the education available in the current environment. In the electric age, people make their world in an entirely new way; the whole environment is created.[18]

McLuhan tried to overcome schools as institutional and built spaces, which may have been because he saw in the mass media, and especially in communication technologies, a new kind of global feedback infrastructure for unfolding independent and individual learning. Education in the electronic age was a matter of discovery and exploration.

From Miniaturization to Ecosystems

Haller's network architecture and McLuhan's vision of education must be seen in the context of another debate. In the 1960s, much revolved around digitizing basic cultural techniques, such as writing, arithmetic or reading, which meant reading, writing or calculating and drawing. Thin graphic lines flickered on architects' screens initially introduced by the military industry (ARPA), and the traditional coupling of drawing and seeing, as well as seeing, was scrutinized by a new kind of computational knowledge. The intuitive dialogue between the hand and the creative eye was thus severely disrupted. Drawing is linked to design and, accordingly, to thinking, and many architects feared the automation of one also meant the automation of the other. Machine intelligence, therefore, seemed to be about a double cultural devaluation: that of the architect as the sole decisionmaker and that of the design process as a creative genius technique. This was prompted by new digital infrastructures as well as machine storage, processing and communication.

The early computer avant-garde understood that you had to focus on people's behaviour and therefore also on their mental schematic. Influential figures such as Steven Coons laid the conceptual foundation for a machine world in which the mathematical control of abstract input and output variables rather than the mechanics of the physical object could be regarded as the characteristics of a machine. The boundaries between man and machine, nature and culture were to be overcome in order to arrive at a new kind of behaviourist machine thinking and finally at a superordinate method of algorithmic world analysis.

Exemplary for such a behaviourist view was Augmenting Human Intellect, a human–machine theory developed by electrical engineer Douglas Engelbart. He believed computers could expand the cognitive abilities of humans, and designed a remarkable vision of the future for the architect. With the sentence 'Let us consider an augmented architect at work',[19] he began to describe the working process of a computer-aided architect. This 'augmented architect'[20] was to have a screen and a small keyboard at his workplace, which he could use to communicate with the machine. 'With a "pointer", he [the architect] indicates two points of interest, moves his left hand rapidly over the keyboard, and the distance and elevation between the points indicated appear on the right-hand third of the screen.'[21] It is possible to rotate a drawing constructed in this way. Using the keyboard, the architect can also enter metric data. After several steps, the first outlines of the building would emerge. At the same time, the mechanical architecture assistant calculated the possible effects of the designed building and tested them under different parameters. All the data produced in the course of such a working process—which, interestingly enough, Engelbart understood to mean not only 'the building design' but also 'its associated thought structure'—could ultimately be saved on a 'tape' and retrieved at any time.

With Marshall McLuhan, we could say that Engelbart understood computers as a creative prosthesis, that is, an extension by means of which the architect's cognitive and physical abilities can be extended and technically enhanced.

The term 'augmented architect' makes it clear that the architect should be woven into an information technology milieu and that the digital should be wrapped around him like a second skin. The architect's drawing table was transformed into a digital ecosystem of interfaces, tools and databases.

Towards Design in Open Data Societies

The image of the future is by no means just a question of data—although in many ways it is. Today, almost 50 years after McLuhans *invisible environments*, Bell's *post-industrial society* and the dazzling wave of cyberneticization of learning, and designing, modern forms of societies have emerged that could perhaps best be described as 'delivery societies' or 'cloud economies', linking people and buildings to platforms, interfaces, data centres and machine intelligence. Data is no longer just traded like an important raw material. It also forms the economic basis of perhaps the most powerful promise of a predictable future. French philosopher Cornelius Castoriadis claimed that 'no category apart from the *imaginary* allows us to reflect on the idea of society'.[22] This is an appealing and clever assertion, as it gets to the heart of something that seldom attracts much attention, that is that we are constantly searching for new models of community and living together. This is no longer about the conscious fusion of aesthetics and life, however, as was so vehemently demanded by the artistic avant-garde movements of the last century. Rather, it seems, a new kind of data-based reading of the entire environment is up for debate. Whether bodies, buildings, cities, landscapes, oceans or climate, we are at the beginning of a large-scale operationalization project in which, in terms of media technology, there is no longer an inside or an outside and whose goal is nothing less than a planetary rereading. In other words: the computerization of the world makes us realize what it means to be part of a globally operating industrial complex. This is especially true for architectural production. Materials, objects and capital circulate in an infrastructural matrix whose scale and impact we are only gradually beginning to understand. Thanks to more precise simulation models of material and substance cycles, we are increasingly able to document and research the consequences of an environment that has been completely transformed by humans. Digital mappings are now emerging that will lead to new insights and simultaneously question traditional supply and production systems. We are only beginning to grasp, for example, that the *way* buildings are manufactured and constructed around the world is a process that no longer takes place only on the Earth's surface, but also leaves traces deep inside it. Copper and lithium are mined and processed for the global construction industry. Even the ocean has changed from a once mythical place into a vast geopolitical infrastructure project, whose story can no longer be told without oil platforms, undersea cables, floating server farms and forensic oceanography.

How can construction, raw materials and digitization be brought together in the future? And what is actually the geological footprint of future data-based digital architectural production? These are tricky but nonetheless important questions that are not only about innovation, but also about responsibility, and in the coming decades they will certainly have a greater impact on construction than we may have expected. The twenty-first century will require us to design in an open-data-based and ecological way, which is nothing less than developing design data literacy for the age of machine intelligence. The question of what it means to design in such societies, or even how we can produce meaning at all from the vast amounts of environmental data, is the other side. In the future, we will not be able to avoid computer vision and machine learning, because human intuition will eventually reach its natural limits when faced with so much data. We are collecting more and more data about materials, the environment and the climate, but the faster this data is collected, the more likely we are to be confronted with the limitations of our own ability to make judgements. We will have to admit to ourselves that we will neither be able to evaluate nor judge the complex structure of open-data societies without automated analytical capabilities.

Instead of purely technical aspects, today's focus is increasingly on social, ecological and ethical aspects of platform technologies, such as the digital divide, privacy, ownership, accessibility, sustainability and public trust in clean and qualitative architectural datasets. These issues form perhaps one of the most significant architectural challenges in the coming decade, aiming to sovereignly position and critically examine the creative, social and political potential of operational design thinking in open data societies.

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