The Dodecahedron and the Basket of Fruit
Architecture in the Age of Artificial Intelligence

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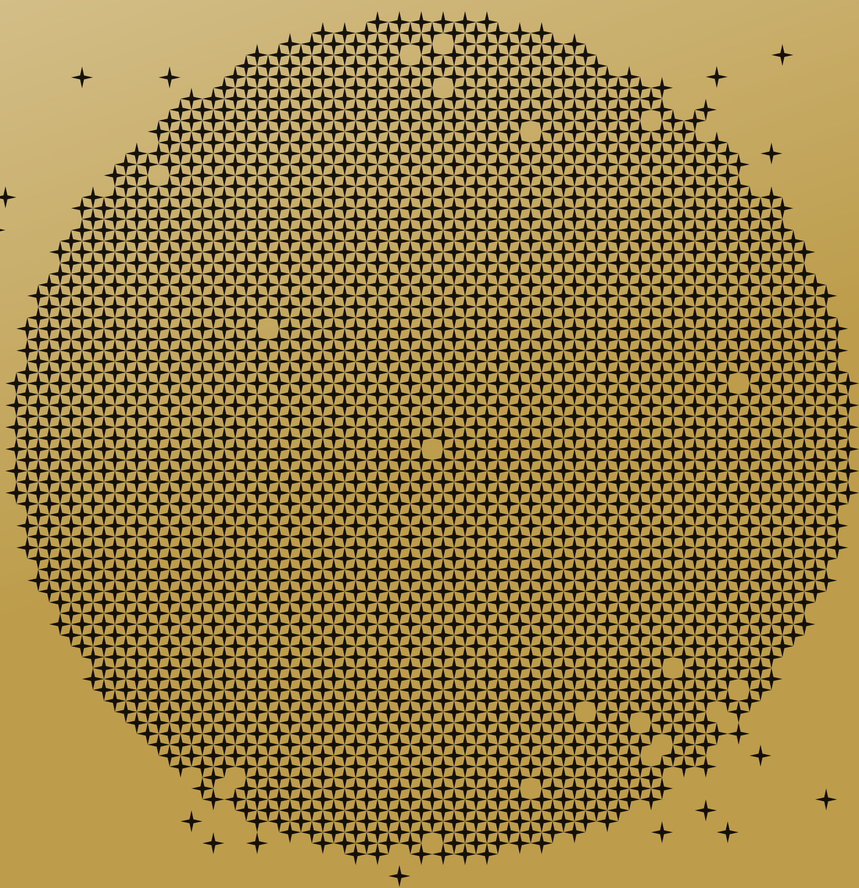

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THE DODECAHEDRON AND THE BASKET OF FRUIT

ARCHITECTURE IN THE AGE OF ARTIFICIAL INTELLIGENCE

Stefano Corbo

ABSTRACT

Starting from the late 1980s, the advent of digital design—the possibility to ideate, develop, and generate projects via computers—has progressively pushed the disciplinary discourse to rethink architecture's role in society, as well as its formal manifestations. The contemporary evolution of digital architecture has taken different directions, which are sometimes contradictory and ambiguous in their intents. This paper especially focuses attention on one of those directions—the opportunities that artificial intelligence can offer in the future production and communication of architecture. Recent episodes are analysed and contextualised within the historical antinomy between two diverging worldviews that, since the fifteenth century until the end of the twentieth century, have informed the architectural discourse. These worldviews can be exemplified in the dichotomy between the dodecahedron and the basket of fruit.

#artificial intelligence, #digital culture, #architecture, #form, #process

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When analysing the general relationship between ideation and production in his recent *Beyond Digital*, Mario Carpo (2023, 3) identifies three fundamental eras that have chronologically characterised human history: "the age of hand-making, which was the universal human condition before the invention of machines; the age of mechanical machine making, when hand tools became actual machines; and at the end, the age of digital making, when machines became electronic and started to function with a new technical logic, different from and in many ways opposite to the analogue logic of yesterday's mechanical or electromechanical machines." According to Carpo, such a differentiation in the way of making implied three different technologies: that of the artisan, the factory, and computation.

If we focus on the age of digital making—on the role played by computation in offering new formal and expressive opportunities—we might say that its impact on the architectural discourse can be better understood within the context of the tension between two worldviews that, since the fifteenth century until the end of the twentieth century, have informed the conceptualisation of architecture, its production, and its dissemination. These worldviews have not only shaped the architectural imagery, they have largely anticipated the questions and challenges that today, in radically different forms, computer-driven robotic design and artificial intelligence are posing to the architectural discipline. These two worldviews are exemplified in the dichotomy between the dodecahedron and the basket of fruit.

The first position is paradigmatically described by Jacopo de' Barbari's *Portrait of Luca Pacioli* (ca. 1500, fig. 1). Pacioli, a Franciscan friar and mathematician, was the author of the seminal book *Summa de arithmetica, geometria. Proportioni et proportionalita*, and collaborator of Leonardo da Vinci for around ten years. In this painting, he demonstrates a Euclidian theorem. On the table are Pacioli's privileged tools: a book, slates, chalk, compass, and a dodecahedron model. The presence of these geometrical instruments recalls his interest in proportions and the golden ratio but, above all, invites us to reflect on the role played by geometry in envisioning a new system of values, and reconsider the traditional relationship between man and God.

Pacioli's painting also indirectly illustrates a new socio-economic milieu which involves the role of the architect and their relevance;

FIGURE 1. *Jacopo de' Barbari's, Portrait of Luca Pacioli (ca. 1500). https://it.wikipedia.org/wiki/Ritratto_di_Luca_Pacioli#/media/File:Pacioli.jpg Copyright: Wikimedia Commons*

geometry becomes a self-reflective medium to investigate and communicate architecture as an abstract system of signs. In fact, a few years before Jacopo de' Barbari painted the portrait Leon Battista Alberti officially institutionalised the profession of the architect by proposing the systematic introduction of notational codes. In his treatise *De re aedificatoria* (1450), Alberti paved the way for a theory of architecture as an art of design—an authorial, allographic, notational art. His theory contributed to defining how architects would operate in the Western world for the following 500 years. For Alberti, any new building must be conceived and represented on paper before construction starts, through a series of scaled drawings—plans, elevations, and side views. Construction, consequently, follows the architect's indications without any changes. The building becomes the exact manifestation of the designer's drawings. By systematising the design process, Alberti operates an ideological distinction between ideation and construction. These are conceptually and practically separated: the architect is an intellectual who works on ideas; the act of building is on the contrary mechanical, manual, almost a servile process made by others.

Jumping to the twentieth century, we might say that the project of modernity developed an accentuated tendency towards reduction and abstraction, both in its avant-garde movements and in its most heroic architectural episodes, as dramatically expressed by Piet Mondrian's Neoplatonic compositions or by Mies van der Rohe's search for truth. Despite their obvious differences, in all these historic precedents geometry worked as an introspective and absolute tool, in the sense of a radical disconnection from any reference to external conditions. Geometry was a vehicle for a progressive process of dilution, where any initial design gesture was absorbed into a general logic, aimed to investigate reality, spirituality, or the universe until its physical disappearance.

Opposite of the dodecahedron position is Caravaggio's *Basket of Fruit* (*La canestra di frutta*, ca. 1600, fig. 2). The geometric construction of the painting is irregular, asymmetric, apparently arbitrary. Fruit is presented in a decaying condition, each element of the composition has its own independent shape and features: some leaves are dying, others are crumpled up, the apple is infested by worms. Caravaggio's painting is a metaphor of life and death, achieved through the exaggeration and deformation of natural elements according to a cultural perspective: that is, through the transformation of nature into a human-made process.

When it comes to architecture, one may refer to the famous legend of the birth of the Corinthian capital: Callimachus, in passing one day by the tomb of a young Corinthian girl, observed a basket placed on top of an acanthus plant, containing those items she had particular affection for when alive. Interested in its form, the sculptor translated that ensemble into an architectural element, associating it with a column according to arranged proportions.[1] This legendary anecdote served not only to corroborate the idea that arbitrary gestures can generate a form and then an architecture but, also, to demonstrate how, throughout the centuries, architects and artists have been struggling in defining a new dialogue between nature and culture, authenticity and artificiality, and purity and hybridisation.

[1] *See Rafael Moneo (2005) on the notion of arbitrariness in architecture.*

FIGURE 2. *Caravaggio, Basket of Fruit (ca. 1600). https://nl.wikipedia.org/wiki/Bestand:Canestra_di_frutta_(Caravaggio).jpg Copyright: Wikimedia Commons*

In 1634, for example, Francesco Borromini accepted the commission to build a church and a monastery for the Spanish order of Trinitarians on the Quirinal Hill in Rome: *San Carlo alle Quattro Fontane*. Borromini's design efforts addressed the cloister first—an anticipation of his real intentions. Here the Italian architect operates a spatial turn through deformation: by pushing the corner columns towards the centre, he transformed a rectangular plan into an elongated octagon.

Different geometrical signs overlay: linear balustrade, flat surfaces, round columns, curved corners. Complexity is achieved through the exuberant exhibition of heterogeneous elements that generate an unstable and fragmented collision. Borromini's interest in manipulation, assemblage and heterogeneity can be associated with other contributions from different eras: Rococo architecture, Antoni Gaudí's personal obsessions, or Enric Miralles' petrified landscapes. What all of these different figures share is the same concern with geometry in the sense of its philological root: geometry as γεωμετρία; *geo-* "earth," *-metron* "measurement." For these architects, geometry becomes a medium to interact with physical and external agents to pursue an alliance between nature and architecture, design and topography, and city and landscape. Any geometrical operation—distortions, rotations, displacements—is exacerbated and celebrated as an exploration of the possibility of a natural history.

FIGURE 3. *AI-generated image, achieved by morphing all the projects mentioned in the paper.*
Copyright: Stefano Corbo (source: Midjourney)

The way architects have looked at geometry and, consequently, have approached the problem of form in architecture obviously changed with the introduction of the first computers and the proliferation of computer-driven design processes. The scope of such a technological shift has not only produced what historians and theoreticians called the digital turn but has also allowed us to reinterpret the simplified separation of the dodecahedron and the basket of fruit—to reformulate it under different premises.

While it was only in the 1980s that computers reached a wider public (the IBM PC, based on Microsoft's disk operating system (MS-DOS) was launched in 1981, Steve Job's first Macintosh in 1984, and the first AutoCAD software was released by Autodesk in December 1982), the initial attempts to introduce machines in architecture can be traced back to the 1960s, when designers and scientists worked together to envision future scenarios that could influence what we design, the process through which we design, the role of the architect in the process, and the degree of participation or engagement of the users in the same process. One specific example of these attempts is cybernetics.

As Georg Vrachliotis (2022, 38) has pointed out, "cybernetics transformed the notions of the machine as a physical, functional, concrete object into an operative conceptual model detached from specific functions: a symbolic behavioural machine." This transformation was carried out by different protagonists and in different forms: among them, a key role was played by Gordon Pask. In September 1969, the British magazine *Architectural Design* published an essay by Pask titled "The Architectural Relevance of Cybernetics," in which he tried to describe the possible impact of cybernetics on environmental design. Over the years, Pask's interests did not simply remain on paper, they were translated into various installations and spatial interventions.

In one direction, Pask was directly involved in projects such as *Musicolour* or *Colloquy of Mobiles*. *Musicolour* was an interactive device consisting of a microphone and a lighting system, which was associated to the microphone's circuits and projected coloured light determined by the sounds. Thanks to a learning algorithm, *Musicolour* was able to react to the users' behaviour and to change sound and colour effects accordingly. Ten years later, Pask transferred what he learnt with *Musicolour* to a different machine: *Colloquy of Mobiles. Colloquy of Mobiles* represented the evolution of the previous project, as it consisted of a series of devices integrated by small mirrors that could reflect and redirect the rays of light produced by those devices. The overall goal of this installation was to establish a more direct dialogue between users and the machine, by introducing a loop of communication in the perception of space.

In a different direction, Pask collaborated with architects on other large-scale projects such as Fun Palace (1961), an unbuilt proposal derived by the partnership between the theatre producer Joan Littlewood and Cedric Price. Fun Palace was to be more than a building, it was to be an interactive dispositive—an ever-changing architecture that worked according to cycles of assembling and destruction. As a designer, Price believed that his task was to implement buildings' performance, their functioning, and their temporal-programmatic configuration. For this reason, during Fun Palace's design process, Price collaborated with Pask to investigate the forms in which social, biological, and mechanical systems self-organise, self-regulate, and evolve. Pask's contribution to the project consisted of instituting a Cybernetic Commission, whose main objective was to define new environments capable of adapting to the needs of the users and stimulating different modalities of participation within the building. To achieve these goals, the main preferences of users would have been recorded via electronic sensors, and an IBM 360-30 computer would have processed this data to extract general principles that could eventually lead to define criteria of spatial modification.

The Fun Palace program, rather than in its conventional correspondence to fixed architectural spaces, was therefore a set of algorithmic functions that were supposed to control events and processes. By doing so, the dream of a virtual architecture came true for the first time. The environment envisioned in the Fun Palace by Price (and Pask) was a world in flux, in which time and performance shaped an (open) notion of form. Such a notion implied the redefinition of traditional disciplinary categories. The interior-exterior dialectic was replaced by an undefined infrastructural framework that rejects any idea of formal tension among its constitutive elements. Interior and exterior merge into an atmospheric process of flows: within the building, different flows interact with each other and can produce infinite configurations.

What emerges from this specific project and from other similar contributions is the role played by the computers: the machine is a tool to deal not only with space, but mostly with the time of architecture, by looking at its materials as something with emerging, vibrant, and evolving properties. In other words, the idea of form generated by the machine reaches beyond the dichotomy between the dodecahedron and the basket of fruit to propose an idea of space shaped by communication and data.

A similar attempt to integrate machines and architecture is the work of Nicholas Negroponte and Yona Friedman. Negroponte founded the Architecture Machine Group at MIT in 1968: his ambitious goal was to develop machines that would not only make architects' work easier, but even replace them completely. Negroponte questioned the architect's traditional tools as well as their effectiveness in translating users' desires into actual space. The machine Negroponte had in mind would have ceased to be a passive device and would have been a generative interface, able to envision new futures. In 1970 Yona Friedman developed the design concept *Flatwriter: Choice by Computer*, which he originally conceived for an IBM pavilion at the Osaka World Expo. *Flatwriter* was a machine designed to involve future inhabitants in the planning of their own homes and help them automatically generate an apartment unit in just a few steps, by simplifying the design process and assimilating it to a scientific method. For Negroponte, "the architect was to be replaced by the universality of a learning machine, for Friedman by the participation of occupants. Friedman's idea of direct feedback from the user was covered by Negroponte's concept of the individual designer." (Vrachliotis 2022, 207) The ultimate goal for both Friedman and Negroponte was the elimination of the designer according to the slogan "architecture without architects" that gained attention in those years (Rudofsky 1964). With these doubts about the role of architecture in general and, more specifically, about the form/function formula typical of certain functionalist culture, Friedman and Negroponte proposed alternatives: Negroponte's was characterised by the assumption that architecture should be close to science, and Friedman's was permeated by user participation as a sociological and ethnographic dimension. However, despite their efforts neither position found widespread application in architectural design, nor systematically addressed the question of form generation in architecture.

The case machines informing computer-driven design processes is different. In 1963 a PhD student at MIT, Ivan Sutherland, presented Sketchpad, an interactive CAD software which used a light pen, or stylus, to draw geometrical lines directly on a CRT monitor. While the light pen had already been in use by radar operators since the 1950s, what made Sketchpad innovative was the program allowing it to define planar objects—to cut, past, and resize them. A pioneer of CAD and other similar software, Sutherland laid the foundation for a paradigm shift that drastically affected the way architecture is conceived and produced.

The progressive rise of a digital culture in architecture cannot be understood, therefore, without acknowledging the role of CAD in influencing the daily activities of practitioners all around the world. Thanks to digital and technological advancement, architects have been able to test new expressive possibilities as well as to experiment with new methodologies to pursue their design choices.

In this context, Frank O. Gehry represents an interesting case study: his use of geometry, in fact, has been for a long time ambiguous and ambivalent, especially after the immediate proliferation of CAD programs. As is well-known, Gehry's formal explorations begin with a handmade sculptural model. The use of specific software (CATIA, for example) helped him translate his visions into architectural drawings and to control the evolution of the entire design process. The initial separation between a first, individual moment of manual ideation, and its subsequent translation into complex computer-driven geometries, emerges somehow in most of Gehry's projects under the antinomy between classical and rational plans, and irregular, dynamic, and complex facades, whose realisation is only possible due to digital technologies—see, for example, his Peter B. Lewis Building in Cleveland (2002).

Whereas Gehry is considered among one of the first to use computer-driven processes in his projects, it is in the 1990s that a sort of new digital avant-garde took the scene: emblematic of this period was the Spring 1993 issue of *Architectural Design*, titled *Folding Architecture* and edited by the then twenty-nine-year-old Greg Lynn. Lynn was part of a wide group called Paperless Studio, created at the Graduate School of Architecture, Planning, and Preservation at Columbia University. Since then, a heterogeneous series of design proposals has emerged—different in scope, formal articulation, and materiality. Architecture began to look first at the world of biology, and later at geology, to borrow concepts and symbolic associations. The result of those extra-disciplinary or multi-disciplinary approaches was a constellation of phenomena such as datascapes, landform buildings, mega-forms, and vast interiors. All these different episodes expressed the multiple possibilities offered by digital technologies, which accomplished an increasing level of formal complexity and changed the role of geometry via specific spatial operations: folding, manipulating, moulding, perforating, etc. At the same time and by focusing on hyper-complex formalisations and audacious translations, the use of geometry was aimed to pursue a certain idea of innovation or creativeness, rather than to act as a critical medium to interrogate the relationship between space and society.[2]

Digital design has therefore been around for more than thirty years. Its evolution has recently developed across two different directions, which is still unclear what kind of repercussions they might produce in the territory of architecture: computer-driven robotic assembly and artificial intelligence. In reality, both robotic automation and artificial intelligence were already in the public domain in the late 1950s; however, they have only recently been consistently applied to architecture. Also, while in the past both robotic automation and artificial intelligence emerged out of the same preoccupations and ambitions, today they do not have much in common. In the specific case of artificial intelligence, there are many current attempts to look at machine learning as an instrument to optimise the performativity of architecture, to suggest design decisions, or to formalise architecture's appearance. Among these possible applications, one in particular, the so-called generative adversarial networks (GAN), is used as an image processing tool, and has retained the attention of computational designers. One of the main machine learning models developed for image

[2] *See the debate on critical and projective cultures outlined in Somol and Whiting (2002).*

synthesis—along with variational autoencoders (VAEs), flow models, diffusion models—GAN was first presented by Ian Goodfellow et al. (2014) in "Generative Adversarial Network." GAN works by recognising patterns: out of a conspicuous body of images, it utilises parameters such as visual similarity or resemblance to extrapolate common traits that can then drive the generation of new images.

Today the main players in text-to-image generative AI are Midjourney, Dall-E, and Stable Diffusion. All have partially employed GAN at the beginning before migrating towards other models. Nevertheless, what Midjourney and the other platforms can currently do is also symptomatic of the relevance of these technologies for contemporary architectural design as, to date, their impact is mainly limited to imaging or design process optimisation (fig. 3).

In this respect, the work of Matias del Campo and Sandra Manninger is an exception. Their office, SPAN, has collaborated with AI experts since the 1990s, and has variously employed GAN models to produce a wide range of experiments: datasets turned into 3D models or built projects like *Robot Garden* (2019–21), in which each step of the design process was fully informed by artificial intelligence. Overall, SPAN questions the possibility for AI to inform new design sensibilities, and investigate the creative potential of imitation intrinsic to AI.[4]

Whether artificial intelligence will get to influence design language and formal expression in a more incisive fashion is hard to tell. For now, what we can say is that the differentiation between the dodecahedron and the basket of fruit, which apparently evaporated throughout the centuries, has actually latently accompanied the evolution of architecture and its vocabularies: as a constant dichotomy between the smooth and the rough, the assemblage and the fusion, the collage and the morphing, or, in today's vernacular, between the pixel and the voxel. It is very likely that this differentiation will also inform the digital architecture of the future. The technological shift operated first by CAD and then by robotic automation and AI then is, by different means and under different premises, posing the same problem: the problem of what form does for architecture and what meaning it aims to convey.

[3] *For more information on SPAN, see https://span-arch.org/.*

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