Which Structure

Luigi Cocchiarella

Introduction

Research and applications of graphic representation largely concern the 'design' of form. Form is, in fact, the powerful reference, the attractor toward which the processes of knowledge acquisition and design generation tend to converge. Research and applications on the structure instead, which nevertheless supports the form, is sometimes less evident, either because it is somehow taken for granted and considered less relevant than the corresponding formal outcomes, or because it remains hidden behind a certain intellectual secrecy, not always naïve. The topic of codes, methods, and tools adopted in the work on the structure, therefore offers an interesting frame for further explorations.
But which structure?

The term has a very general meaning, however, with specific reference to architecture, it can be considered in relation to the spatial dimension, and therefore to Geometry as a control structure of that dimension through Representation. In turn, architectural space is a particular subset of the abstract space, both in dimensional and substantial terms. The first limitation is banal, given that, although the William Morris's definition has invested the entire Earth's crust with potential architectural connotations, it is still a limited field compared to the theoretical extension of pure geometric space. The second one requires some further reflection, since architectural space, although endowed with geometric characteristics, is not a purely metric

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editorial director's responsibility.

space, but it is qualified by the human presence. It is rather an existential space, as Christian Norberg-Schulz has well clarified [Norberg-Schulz 1996]. And yet, despite these limitations, the field of investigation remains broad. Renato De Fusco, among others, offers a convincing example of this in his delightful book *Architecturminimum* [De Fusco 2010]. In the chapter on "*spazialismo*," he compares Bruno Zevi's position, according to which anything lacking physically usable internal space should be excluded from the field of architecture, with the less radical and more inclusive opinion of August Schmarsow, who, based on also considering intellectual and spiritual values, admits that even inaccessible constructions can legitimately be considered architecture. The example of the Greek temple is quite convincing in this regard [De Fusco 2010, pp. 46-51]. Accepting this axiom, greatly broadens the spectrum of the configurations of interest for geometric research in architecture and, as we will see, it is somehow in line with the findings of artificial intelligence on this subject. Moreover, Erwin Panofsky, in his epochal essay *Perspective as 'Symbolic Form'*, had already theorized the spatial unity between architecture and sculptural masses, also highlighting the decisive role that this concept would have played in the development of perspective in painting [Panofsky 1997]. And by extension, we could add, in the development of the projective forms of representation, intended as privileged devices for the graphic control of the geometric structures, the validity of which is increasingly confirmed, and not only in architecture, in the era of digital visualization and simulation.

A latent presence

The inextricable connection between form and structure is immediately evident, even from the earliest experiments with perspective, primarily showing in the sinopia as the latent essential support structuring the pictorial composition (fig. 1). Piero Della Francesca himself, one of the most sensitive initiators, recommended first defining the perspective skeleton, that is the configuration pattern, which would then be coated with the pigment to express the final visible form. This approach has survived the analog era and been revived in the digital world, where the wireframe or mesh modeling of the geometric structure offer the basis for rendering the apparent material qualities.

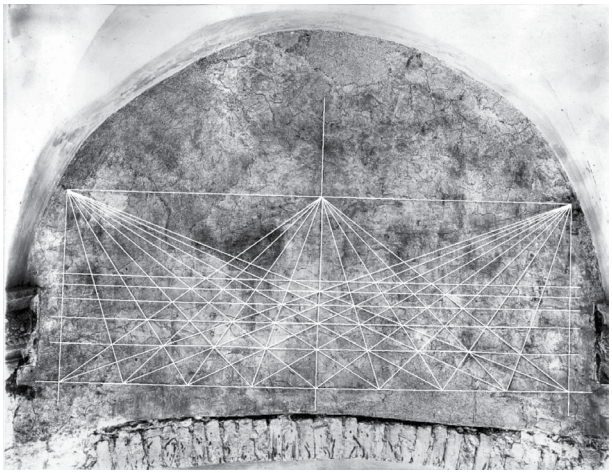

Fig. 1. Paolo Uccello, sinopia of the Nativity of Jesus (1446). Source: <https://catalogo.beniculturali.it/detail/HistoricOrArtisticProperty/0900285185> (accessed 5 December 2025). (Graphic elaboration by the author).

The concept of structure has become more precise over time, especially in the field of linguistics, where, starting in the first decade of the Twentieth century, it began to identify a field of study known as *Structuralism*. Renato De Fusco, again, noted that the basic notions of "organization" and "abstraction" come into play in this field [De Fusco 2010, pp. 66-70]. In the last two decades of the Twentieth century, this theory also received experimental confirmation on the cognitive level. Thanks to research conducted in those years at the Massachusetts Institute of Technology by the scholars Susan Carey and Nancy Soya on the language of children under three years of age, it emerged that infant lexical and syntactic learning revealed the existence of recurring mental structures, which, beyond the specific language spoken, would lead to at least a partial reconsideration of the principle of linguistic arbitrariness advocated by Willard Van Orman Quine. It is curious to note that this significant contribution to the development of a new theory of mind based on the recognition of cognitive structures, occurred precisely at the same time as a certain weariness of the structuralist movement in architecture, now on the way out due to its abstract determinism [Cocchiarella 2012, pp. 103-117]. On the other hand, in the wake of Albert Einstein's thought, the awareness that the entire physical world is characterized by structure persisted. And soon, the World Wide Web would in addition demonstrate the potential of information structures. In a certain sense, the Twentieth century trajectory and the subsequent developments of the Neo-structuralism at the dawn of the new millennium showed a substantial structural coherence between the levels of thought, reality, and representations, which Karl Popper identified as the three fundamental worlds, of which the world of representations, to which Drawing most closely belongs, constitutes the connecting link –in his words, a properly said third world. A revolutionary explanation compared to the dominant Platonic dualism in vogue in the Western world, apart from the warning implicit in the Myth of the Cave.
With reference to architecture, the concept of structure, in the synthetic terms used by Renato De Fusco, takes us beyond the visible. In this sense, it would therefore identify the configurative organization that defines the essence of a given space or category of spaces.

Biographic warning

The author of this essay, was educated in the second half of the 1980s, a period in which the structuralist approach had been fully embraced in some Italian university Schools. An undisputed pioneer, Anna Sgrosso, professor of Drawing and Surveying, and of Fundamentals of Descriptive Geometry at the University of Naples Federico II, was among the first teacher experimenting with analogue graphic interpretations aimed at highlighting, through appropriate 'transparency' effects, the geometric structure of the architectural spaces, which became evident once the masonry masses were visually lightened in the representation [Sgrosso 1984]. Despite the considerable aesthetic appeal of the resulting unusual images, made even clearer and more compelling by the use of translucent colored adhesive filters applied onto acetate bases to highlight the essential generating surfaces, the cognitive contribution of this approach, which allowed architectural spaces to be displayed and interpreted simultaneously from 'the outside' and 'the inside' thanks to carefully studied graphic and chromatic transparencies, left an indelible legacy in the 'students-architects' (as she used) of those years. Even more importantly, these applications directly revealed the interplay between the mentioned abstraction and organization levels, that we considered to be the foundation of the very concept of structure. By making evident the action of (abstract) geometric structures in the configuration of the (specific) physical spaces represented, the perception of a gap between theory and practice, a barrier usually difficult to overcome in teaching, naturally faded as well. This vision, shared at an interdisciplinary level, led to the establishment of a University Department that promoted it in its very name: the Dipartimento di Configurazione e Attuazione dell'Architettura. The theme of configuration was thus taken up in the design disciplines in a pre-figurative and, more generally, in a meta-design perspective, and assumed as one of the relevant foundations of the design process (fig. 2).

Substantial continuity

These experiments were also in line with the forms of digital representation, particularly vector-based, emerging with the widespread use of personal computers, and

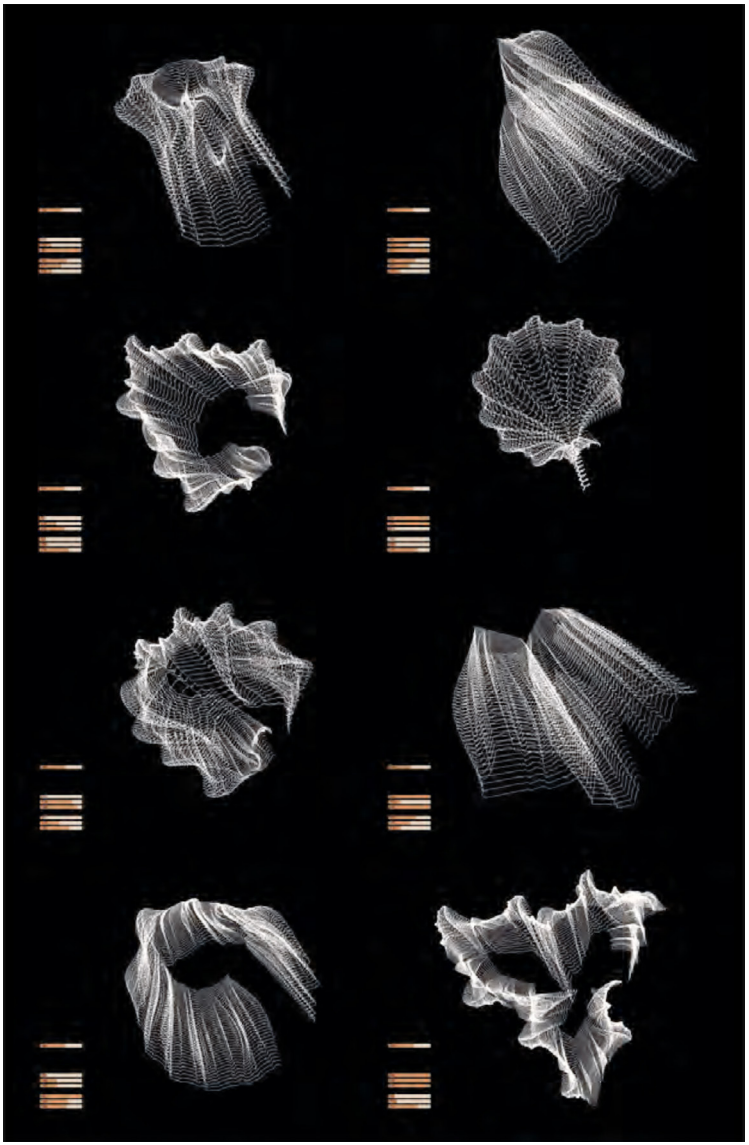

Fig. 2. Parametric variations based on the same geometric structure. Benjamin Dillenburger, Hua Hao (ETH). Source: Cornelie Leopold, Università Tecnica di Kaiserslautern (Eds.). (2013). A hermit's cabin: [Erasmus intensive programme, Kaiserslautern]. Kaiserslautern: Technische Universität, p. 31.

consequently of digital drawing and modeling software programs. The most obvious affinity concerned, again, the relationship between structure and form. The hidden lines of traditional drawing were now used to show hidden lines, surfaces, and volumes, as components of the geometric-structural skeleton, subsequently covered by the rendering patterns in the advanced stages of the three-dimensional modeling.
In essence, digital graphic representation further confirmed the validity of the concept of structure, both with reference to the form of architectural space and to the forms of its representation. Regarding the first point, so-called 3D modeling required the construction, in a software environment, of the entire architectural space –that is, of every angle or detail, and not just a few views, or projections, as it was used to do in the past. In this way, properly said 3D models were generated, which could subsequently be viewed as images from every possible viewing point: we had defined this new concept as model-image, completely opposed to the analog image-model, which consisted of a certain number of views from which the actual form of the space could be deduced, but only indirectly, by a mental reconstruction [Cocchiarella 2006, pp. 183-197]. This novel approach, until then only experimented in the construction of physical *maquettes*, required the preliminary construction of a schematic, that is abstract, geometric model of the space investigated, based on the consideration of its overall organization; in other words, it made it impossible to ignore the identification of its structure. Regarding the second aspect, the uniqueness of the model allowed for multiple simultaneous visualizations, each in its own graphic area or viewport, updating synchronously with all the other views with every change in shape or position made to the model. In other words, the editing of the model implied a coherent reorganization of the views. This demonstrates the structural value of the projective form as well, regardless of its declination according to the conical or cylindrical regimes. To generalize, the structure of space was revealed not only in the Euclidean and Projective fields, but also in their correspondence.
This brought with it a new expressive code, or rather, an expansion of the classical static semiological figures, such as plan, section, axonometric projection, and perspective, now transformed into temporary shots generated from a model that was also potentially in constant transformation, within a dynamic operational space that appeared now as a truly digital stage.

Once the correspondence between physical and digital space was established, geometric structures controllable via software soon transcended the Euclidean and Projective fields, extending into other geometric fields. Indeed, upon closer inspection, the programming language underlying visual processing itself, rested on a mathematical logical structure, which by its very nature was widely adaptable. Among the most interesting extensions is that concerning topological structures and their management through NURBS curves and surfaces [Ciammaichella 2002; Brevi 2004]. The most surprising aspect for those accustomed to traditional disciplinary divisions, was undoubtedly the near-total absence of discontinuity in the transition from the Euclidean, Projective, and Topological fields. This paved the way for an intense period of design experimentation based on morphing, thus further emphasizing the relationship between structure and form –that is, the relationship between organization, abstraction, and form– to recall the previously introduced notions. Architectural structuralism itself experienced a new era, leveraging new tools and procedures to capitalize on what had previously been experimented in the analogue way, and to propose new advances from a front soon identified as Neo-structuralist, as it was mentioned before (Fig. 3).

Visuality and beyond

Another interesting stylistic innovation concerned the possibility, translating the Cartesian approach into a digital subspecies, to easily and interactively connect numerical and graphic structures, thus drawing with numbers and generating numbers by drawing. As predicted by Michael Foucault and later noted by Régis Debray, digital technology was gradually shifting the level of processing to a visual level. New graphical interfaces allowed programming, within certain limits, by operating on highly intuitive graph structures rather than through traditional machine language codes. With regard to the theme of "revealed structure", this is perhaps the most innovative step, since through the introduction and rapid widespread diffusion of visual programming, the very structure of spatial thought was exposed, shedding light on the generative process underlying the spatial elaborations. We are thus at the stage of parametric modeling, an approach that, like theoretical abstraction, allows us to manipulate the

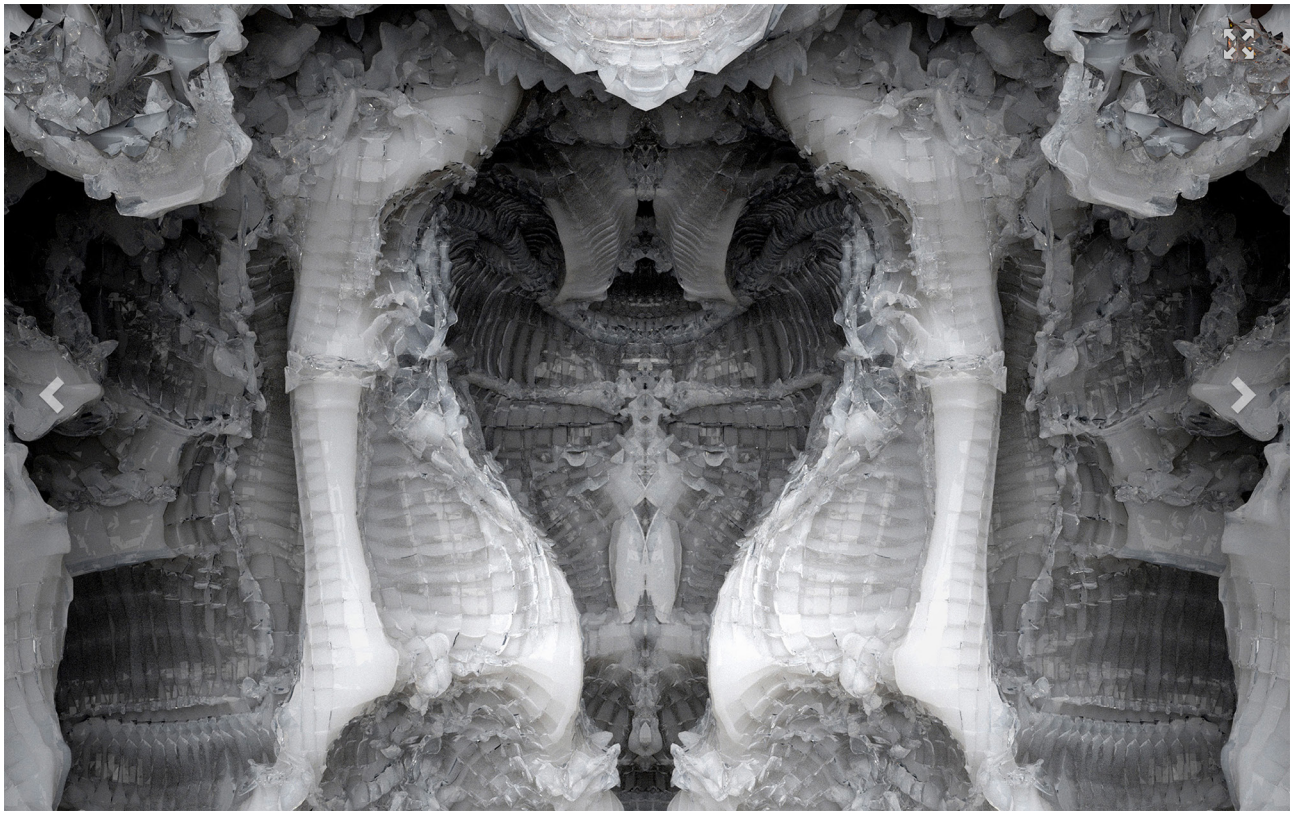

Fig. 3. Digital Grotesque I (2013). Michael Hansmeyer with Benjiamin Dillenburger. Source: <https://michael-hansmeyer.com/digital-grotesque-1> (accessed 5 December 2025).

genetic organization of the configurations and to generate virtually any formal outcome consistent with that structure –in short, to operate on the geometric-spatial genotypes underlying the multiplicity of the related formal phenotypes obtainable. This partnership helps shed new light on the foundational relationship between *logos* (let's say logical thinking and expression) and *graphè* (let's say visual thinking and expression) [Ugo 1984].
Thus far, these advances have focused on the control of the geometric properties of architectural space and the launch of new operating methods related to computational design. Further developments in parametric modeling have subsequently allowed for the addition of further, non-geometric attributes, to the configurations. Upon closer inspection, rendering itself marks a first step in this direction, albeit still on a purely visual level, surpassing the simplicity of the images offered by early CAD systems, starting with the monumental *Sketchpad* developed by Ivan Sutherland. The integration of additional informative parameters, both visual and non-visual, has gradually broadened the semantic consistency of the modeling processes, leading first to thinking of them in terms of digital objects and finally of digital clones. Of the three components of representation –Geometry, Graphics, and Information– the latter is also gradually absorbed into the body of the model and interacts with it, effectively becoming an active operator [Hemmerling, Cocchiarella 2018]. Indeed, the acronym BIM (Building Information Modeling) refers not so much to the process of constructing space as to the modeling of information. Yet geometric structure provides for the essential scaffolding, without which other information systems would remain in the status of mere lists of data. On the other hand, interaction with increasingly sophisticated types of information, tends to make the structure more 'sensitive' to the specific organizational and the constitutive characteristics of the final form. In this sense, at least at a theoretical level, each set of parameters, alone or in synergy with other sets of data, can have an impact on the structure, triggering mutations that to some extent may resemble the natural evolutionary mechanisms (fig. 4).

Novel postures

Let us return to the initial theme, in the sense that this semantic enrichment is consistent with a concept of structure that embraces the richness characterizing the existential space and the vital significance of its real configurations, together with its purely metric aspects. Managing this additional level of complexity is aided by the transition from modeling to simulation, which in the most sophisticated versions can even prefigure actual scenarios, where even the temporal parameter is incorporated into the foundational structure. The most suitable context for this type of representation is undoubtedly the gaming environment, which boasts over forty years of 'ludic' testing and now offers adequate 'serious' operational bases for complex architectural space simulations.
Technologies based on virtual reality offer new possibilities for its use, in more or less hybrid environments, redefining the gradient of the relationships between physical reality and the purely digital dimension. The human-keyboard-screen posture remarked by Alessandro Baricco in the essay *The Game* [Baricco 2018], which has dominated the digital age for decades, is here replaced by freer postures, tied to haptic devices. This is a sort of Copernican revolution in the digital universe, which is now no longer confined beyond the screen, but surrounds us with its cross-media structures, where the visual dimension integrates with other sensory perceptions. Here too, and even more so, we are dealing with a structured space, whose geometric articulation, though not directly perceptible, dynamically supports semantic components that transcend the pure metric organization.
Interaction with this new environment, partly physical and partly digital, for which the neologism 'phygital' has been coined, can be programmed in various ways, reaching very realistic levels of interaction with the support of artificial intelligence.
Even in the field of artificial intelligence, a revolutionary shift has occurred, specifically in the transition from the "intelligen system" to the "intelligent agent" [Cocchiarella 2025, pp. 44-51]. While the first type of artificial intelligence relied on information previously encoded by the operator and compliant with the current linguistic codes, the new devices tend to mimic human mental processes, autonomously and directly drawing input from real-world contexts through their own sensors, without any prior linguistic mediation. Technically, new generation machine learning processes interact with symbolic codes and sub-symbolic mechanisms, and the processing phases therefore proceed therefore proceeds both parametrically and non-parametrically, learning from the context and reacting to it by adapting [Ye 2022]. Sometimes in completely

Fig. 4. Towers in the series AI x Future Cities. Courtesy of Manas Bhatia. Source: ARTRIBUNE, <https://www.artribune.com/progettazione/architettura/2022/12/intelligenza-artificiale/> (accessed 5 December 2025).

unpredictable ways (fig. 5). As for the processes currently underway, the combination of stochastic and statistical elaborations adds analytical and generative potential, whether an intelligent system or an intelligent agent is involved. The greater autonomy of artificial intelligence compared to other expressions of digital technology is increasingly leading to consider it as a partner or copilot, rather than as a mere operational tool.

Conclusion… open

The semantic enrichment that characterizes the most advanced processes of generating and managing the representation of architectural space, thus reveals an increase syncretism in the assortment of its structural foundations, shedding new light on the notions of organization and abstraction that we placed at the foundation of the very concept of structure. A structure that, at least in the architectural sphere, seems to gradually tend back toward the *form* almost to the point of coinciding with it, or more precisely, toward the digital clone of the form. Whether it be a prefigured or a surveyed form. In either case, the formidable outcomes would seem, a fist sight, to fuel the nightmare evoked by Jorge Luis Borges with the paradox of the Map of the Empire produced by the Cartographers, which was as extensive as the Empire itself, and therefore unusable. In our case, however, we are not dealing with *static clones* traced on inextensible paper, but rather with interactive environments, designed to continue to function as operational models even after reaching the desired configuration, which remains open to further formal mutations and, more importantly for us, to further evolutions, even of a self-generative type, of the deep structural system, understood in all its semantic richness [Hovestadt et al. 2020; del Campo 2024].
In conclusion, we could say that the abundance of digital, which is now added to and integrated with the abundance of nature, seems to somehow bring us back to a threshold of a quasi-new-origin, requiring a renewed attitude –one might even say philosophical– to question, with the additional support of appropriate prompts, textual or iconic, the expanded field of the real architectural contexts, and to manage the new semantic complexities characterizing the modeling of the structures underlying the existential space.

Fig. 5. DeVain, Valentino's advertising 4/12/2025 generated with AI. Source: <https://video.corriere.it/video-virali/-inquietante-e-surreale-la-pubblicita-valentino-generata-con-l-ia-finisce-nel-mirino-dei-social/417470a0-238a-471d-a979-84704af24xlk> (accessed 5 December 2025). (Graphic elaboration by the author).

Credits and Acknowledgments

I would like to express my thanks to prof. Pierfranco Galliani, for the discussions on the topic, and for suggesting the source used for figure 5.

Author

Luigi Cocchiarella, Politecnico di Milano, Department of Architecture and Urban Studies, luigi.cocchiarella@polimi.it

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