

The Colors of Black: Digital Computation as a Spectrum of Knowledge

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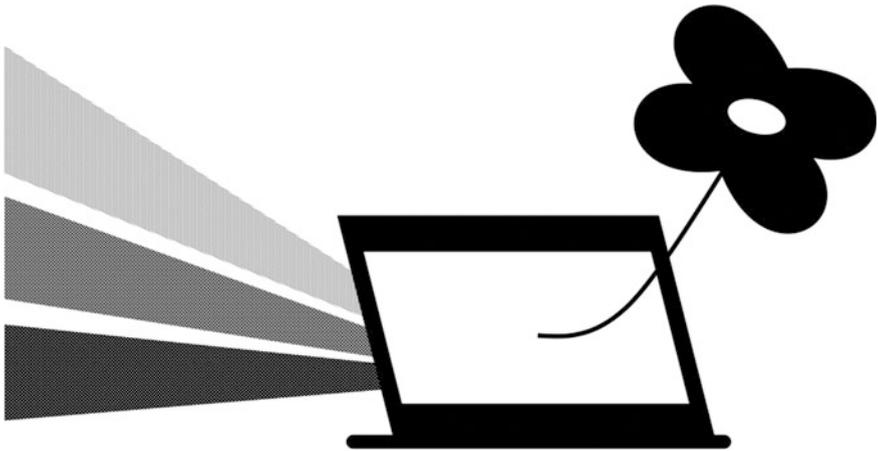


Fig. 1 Integrating computing, feeding knowledge (drawn by the Author)

1 Introduction

The title refers to the seminar *Computation is the new Black. Updating the Making of Architecture* organized by Prof. Marco Hemmerling at the School of Architecture Urban Planning Construction Engineering (AUC) of the Politecnico di Milano in

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January 2016, and the contents to some issues presented in the public speech prepared for that meeting.

Computation has always been an obsession for architects and not only in the digital era. Throughout long history, formulas, ratios, and golden proportions have worked as helpful tools and sometimes even as exorcisms against the fear of failures in building as well as in investigating architecture. Already acting, since the fight of Abacus masters against the apparent contradiction between Euclidean ‘ratios’ and perspectival ‘cross ratios’, computational needs could be also found in the origin of Descriptive Geometry, the first modern operational connector among design, industry, and construction. As Robin Evans argued [7], indeed, this discipline proposed a cross fertilization between analytic (numerical) and synthetic (graphical) approaches, conducting visual representation from the world of Art to the world of Science and Technology. However, only geometrical shapes could be accurately defined and controlled, while strategies and processes remained unrevealed. Black is Black.

The revolution of digit, instead, has offered “neutral” *units* as supportive syllables for any kind of information, manageable through algorithms. Many aspects and categories of parameters could be then incorporated and related in the body of representational models, dynamically developed, and widely shared via network. Therefore, together with spatial data, time, and any other informative dimension could increase the syncretism of the models, paying homage to the Juri Lotman’s idea of *semiosphere*. Moreover, they could be analytically recalled or re-organized at any time. Colors of Black would then appear, like those of white in a Newton’s light spectrum, that is, a spectrum of knowledge.

2 Visual Geometry as the Trailblazer

Since architectural computation is related to *form recognition*, *form finding*, and *form definition*, the role of *image* is clear in all the processes normally related to the work of an architect. Moreover, since the basic matter of architecture is *space*, the role of *geometry* is clear in the mentioned processes. Summing up, the role of *geometry of image* arises. The need for a clear understanding of the relationships among *geometry of vision*, *geometry of things*, and *geometry of image*, was from the beginning so strong as to generate a prodigious revolution inside the monolithic body of Geometry, namely, of Euclidean Geometry, that is, the *geometry of things*. Quite paradoxically, the source of discord dates back to Euclid, the same official father of Euclidean Geometry. As soon as he wrote the book of Optics, which opened the way to the investigation of the *geometry of sight*, he revealed indeed a problematic conflict between the perfect measurable world of Euclidean objects and the apparently instable and distorted world of Vision. Consequently, the controversial debate about the *verity of images*, already started some decades before with the philosopher Plato, would have been even more exacerbated [14]. Hard enough to believe, not even *perspective*, the pearl of Renaissance, relieved mathematicians

or artists, in spite of the further clarification of the geometric links among objects, vision, and (perspective) image.

What was the still pending question? Just *computation*: although the graphic procedure was clear, as well as the related physical phenomenon of projection/section, the analytical side of the problem of how to calculate the perspective distortion of any set of points was still to be defined. Thanks to the work of some giants of Western science, from Girard Desargues and Blaise Pascal to Jean Victor Poncelet, the problem was not completely codified until the XIX century. The understanding of *cross-ratio* (or *bi-ratio*) as a projective invariant, finally provided a convincing computational solution to the long-existing brain-teaser, but the cost was undoubtedly high: the official birth of Projective Geometry as a separate branch from Euclidean Geometry. By the way, Topology had already shown new geometric ways of thinking of space, by denying the fifth postulate of Euclid, while other geometric branches would have been developed over time. However, despite the strong impact of the new theories, Geometry kept its profound unity, re-defining its foundations on the bases of a wider set of axioms, as Felix Klein pointed out in the *Erlangen Programme*. Back to our purpose, an excellent way to mitigate the friction between real space and image was the use of Orthographic Projections, intuitively shown since the origin of representation and officially codified only at the end of the XVIII century by Gaspard Monge. Saving parallelism and proportions according to some given conditions, and offering the opportunity to generate *bi-jective* representations, this system made metrical computation easier to master, reason why it soon became the *symbolic form* of the First Industrial Revolution, and is still valid nowadays.

Satisfactorily enough for the applications, from a theoretical point of view, this was actually a hybrid solution. Indeed, real world continued to follow the computational principle of *ratio*, while the world of projective image was based on the computational principle of *bi-ratio*. In other words they were brothers, but not twins. Finally, a unitary hypothesis seemed to emerge from the Le Corbusier's treatise *Le Modulor* [9], which is just quickly outlined in (only) one illustration, namely the Fig. 31 in Chap. 4 of the first volume, partially recalled in the Fig. 74 of the Chap. 7. As we know, the two volumes are totally dedicated to the search of golden proportions in the true objects, but in the mentioned image *golden ratio* is also proposed as a criterion for computing optical foreshortenings in the visual perception. Based on this hypothesis, and in relation to Architecture, Euclidean and Projective spaces could be considered as based on the same metrical structure, and the *golden ratio* as the universal computational unit to achieve visualization, configuration, and construction, so reducing the traditional huge "trouble with numbers", as Robin Evans defined the classical dichotomy between metrics of space and metrics of image.

Actually, although fascinating, the *golden ratio* has never become *the* architectural unit in use. Architects basically continued to refer to the hybrid system (half visual-half metric) of the orthographic projections, especially during fabrication and building construction. Wonderful drawings finalized to construction can be found anyway, even before the codification of the Monge's procedure, like those by

Philibert De L'Orme in XVI century [6], as well as those by Amédée François Frézier in XVIII century. A key step towards more complex parameterizations was the use of orthographic views as a base for structural calculation, that is, *graphic statics*, where the invisible geometry of loads was integrated with the visible geometry of space. Extraordinary examples of the claim for this union between *aesthetics* and *statics* are the *tableaux* of the project of Gustave Eiffel's Tower as well as many other projects developed by engineers between the XIX and the XX century. In such examples, drawings and diagrams work together in such a way that changes in one layer imply changes in the others as well. In other words, we can consider such examples as the closest ancestors of parametric design. More difficult was the attempt to introduce computation in the whole architectural design process, since it is based not only on physical issues but also on many other sets of inputs, therefore requiring a wider holistic approach. Great help in this field came from Humanities during the XX century, especially from Semiology, namely with *Structuralism* and *Post-Structuralism*. The focus of this approach was on the identification of elements, relationships, and hierarchies in the observed systems, whether linguistic, social, or anthropologic and so forth. In the middle of the XXI century, *Architectural Structuralism* and *Post-Structuralism* arose, which emphasized the role of structures and hierarchies among structures, in architectural space as well as in design processes. Constructed results like *Nakagin Capsule Tower* by Kisho Kurokawa or *Habitat 67* by Moshe Safdie clearly show this approach. Few years before, a graphic synthesis among space, statics, and music, had been achieved in the *Philips Pavilion* project by Le Corbusier and Iannis Xenakis. Soon this approach expanded further, opening new perspective towards phenomenology, deconstructionism, and so forth, but the basic idea of a structure as representative of a process survived, ready for the decisive marriage with *digital algorithms*, from which present *digital computation* comes.

What is, again, the fascinating breaking news? In our opinion, *image*. Or better yet, *imaging*. That is, the possibility to visually control and manage several sets of parametric structures, testing, matching, and combining them in real time, with a direct feedback in terms of spatial organization and information data. In this sense we see *image* in the history as a *trailblazer* to computational design. What also confirms our identity as “visual animals”, as John Barrow clearly pointed out in the book *Cosmic Imagery: Key Images in the History of Science* [1].

3 Tactile as a Visual Extension

Digital Process Design also became as important as (and of course intrinsically related to) Object Design and Construction. Together with definitely encouraging brotherhoods between theory and praxis, it finally freed architects from at least two long lasting nightmares: paradoxes of “representational clones” evoked by Borges, and dreads for “uncanny valley” effects noticed by human-like robot designers. It was clear, indeed, the dominion of architects on the new virtual architectural clones, which

are modifiable at any time. Last but not least, the benefits of the dialog between *analog virtuality* and *digital virtuality*, according to the Pierre Lévy's clues about "virtual", soon had increasing effects on the hybridization between tangible physicality and immaterial information inside the built architectural environment, claiming a wide expansion of architecture towards the world of the *internet of things*. Furthermore, let us say, with reference to architects and inhabitants, towards the *internet of bodies*.

Originally, space composition and construction were synesthetic matters for human beings, where any process was based mainly on the coordination between vision and touch, and of course on the other senses. Later on, the need for agile operational testing models pushed human beings to choose graphics as the main supportive tool. Thousands of years have been spent using graphic models to simulate architectural composition and construction, and at least more than two millenniums struggling with the dialogue between geometry of space and geometry of image, as we mentioned before. In the past, physical *sculptural* operations were translated into *pictorial* codes, that is, tracing lines on a sheet. Operations like cutting, moving, drilling, and others, could be only represented as pictures but not as actions. As we know, an analogue *graphic menu* consists of a set of points and lines, together with rules, compasses, and various kinds of templates. Physical modelling, enormously more affine to the real process of construction, has efficiently flanked graphics, but maquette-making has never surpassed drawings. As we often see, in our academic educational work too, physical modelling is quite a demanding activity, and in addition, it mostly requires preparatory geometrical drawings as well. However, sometimes, quick-sketch models are extremely supportive for spatial understanding and orientation. In general terms, compared with the visual and metrical control provided by drawing, physical modelling clarifies *spatial topology*, implying a more direct simulation of the compositional and constructive process. We all know, indeed, how very helpful and irreplaceable the power of tactile manipulation is.

Well, *digital graphics* is where the visual and the tactile powers of representation finally meet, showing image and process at the same time. Paradoxically, toolbars are undoubtedly graphic, showing palettes where physical actions and motions appear sublimated as graphic icons together with purely graphic commands (revenge of painting) but operational devices, including the mouse, work in a properly said three-dimensional space (revenge of sculpture). We see in this a *tactile extension of sight*. It was clear since the beginning, dating back to Ivan Sutherland's *Sketchpad*, that computer graphics was born not merely to clone painting but to finally conquer the space.

4 Data Versus Form Versus Knowledge

After early enthusiasm for the high-performance shape manipulation and rendering offered by digital means, architects started deepening the relationships between architecture and information technology even more. Among the leading examples

in Europe, the work of Ludger Hovestadt's research group at the ETH of Zürich could be mentioned. In charge of the CAAD chair since 2000, he drove research on a new track, inspired by the motto "our credo was not *virtual reality* but *back to reality*". The result was a very rich series of analyses and design experiments carried out on various scales and aspects of architectural project and construction. An interesting picture of the start of this work is given in the book *Beyond the Grid—Architecture and Information Technology. Application of a Digital Architectonic* [8], where in spite of the declared non-theoretical ambition, a basic organization of the matter emerges. Starting from investigations on patterns, the team focuses on architectural elements and systems as well as on construction, indicating *global design* as a final goal. Significantly, they liked to define their field of interest in terms of *applied virtuality*. Although at a first listening this definition could sound like an oxymoron, we soon realize that it actually makes sense as one of the most urgent and promising fields of investigation. In a wide sense, in fact, virtualization is the essence of any project as well as of any model of knowledge, independently of its analogue or digital consistency.

The power of algorithm is the main feature in this story, offering extraordinarily refined simulations in search of the best possible architectural solutions. Of course one point would be how to control and dominate this powerful operator. Another key aspect concerns the way we choose and translate natural inputs into appropriate and effective parameters. And finally how all this turns into a buildable architectural shape. Therefore, the need to have various sets of expertise at work is clear, side by side, beyond the machine, and consequently a change of style in the approach to the architectural project. Apparently only based on technical restraints, these experiences claimed from the outset the need for a cultural change.

Parallel to these pioneers and their genuine research, the market started developing products in search of new professional standards. As a result, Building Information Modelling, that is BIM, emerged, where letter M could also stand for Management, as Steve Race states in the well known book *BIM Demystified* [12], meaning how very important collaboration and human control are in this field. In spite of the recurring opinion about BIM, technology is not its only strength. Even more decisive, although apparently hidden, is methodology. As we know, architecture involves many fields, and architectural academic curriculum is one of the most rich of different disciplines, including Humanities as well as Art and Science. This variety implies that an architect has to work as a kind of movie director, where characters are disciplinary specialists and the movie is architecture itself. In the past, this connecting role only depended on the personal abilities of the architects, who collected inputs from everybody, taking them into account and synthesizing them in their projects. Digital systems support the architects better in this nowadays, by recording, combining, integrating, and activating the given sets of data, but the creative freedom of the architect's risks to be inhibited if they are not adequately aware and skilled to manage such complex databases. In the afore mentioned book, Race himself affirms that BIM is, in the end, and we could affirm the same for the whole field of computational design, "a state of mind".

Here is where *Structuralism* shows its heritage and, at the same time, a claim for a close connection with the tradition of *Encyclopaedia*. They both, indeed, deal with the aim of organizing knowledge. Looking at the problem from an academic point of view, it is easy to understand that computational design and BIM can be seen also as organized archives, which though, different from the past, are not static but based on a dynamic and interactive indexing. In this sense, we are nowadays dealing with a new connection among *data*, *form*, and *knowledge* in architecture, engineering, and design.

Consequently, apart from its professional impact, computational design can really inspire a new dynamic taxonomy of knowledge, and BIM can be seen as a modern system for building up the archives of knowledge, suggesting in addition stronger interaction with other areas of interest, first of all GIS, which would require a separate dissertation. And, of course, computational design can offer efficient new bases to education, both as a tool and as a reference paradigm. As we tried to point out in the three volumes *The Visual Language of Technique* [4], specialization and expansion of knowledge from the XVII century onwards has worked in favor of the disciplinary “ivory towers”, while the unifying power of digital seems to invite our academic and professional communities to build up “virtual bridges”. Considering the present global scale, this will be an urgent point of the future educational strategies, again in the words of Steve Race, aiming at “educating people but also government commissioning teams”, together with students, and of course, teachers.

5 Final Gloss

When on this topic, we normally end up asking questions about the future. Concerning expectations, apart from diatribes, like the one superbly undertaken between Nicholas Carr [3] (*The Shallows. What the Internet is Doing to Our Brains*) and Howard Rheingold [13] (*Smart Mobs: the Next Social Revolution*), thanks to the exponential power of the network in the world-wide-web, “process” itself is supposed to be the main topic nowadays, and in a way our main invisible competitor, as prophetically announced by Derrick De Kerckhove in the book *Architettura dell'intelligenza* [5].

The whole result of the trend, as depicted above, and the most welcome as well, would not only be about improving architecture making, but most of all in empowering our imagination, let us say, to push ahead the limits of *architectural utopia*, aiming at leaving a better and healthier architectural environment to next generations. Of course on this huge ocean of information we are required to take the helm and trust, feed, and update our original “cybernetic” aptitude as navigators and explorers, amazingly echoing the ancient Greek verb κυβερνώ.

But where is our thumb line in this ocean? In attempting to answer this question, we propose to seek help from Italo Calvino's [2] *Six Memos for the Next Millennium*, where in relation to Literature he said that since the mission is to tell stories, nothing happens without words. So we could observe that, since our

mission as architects to build places for human beings and understand places of human beings, no matter how much our powerful and sophisticated tools show, nothing happens in architecture without space. Let's then continue by suggesting that as much as words require grammar and syntax together with ideas, architectural space design and construction require Geometry together with inspiration and information.

Looking at any architectural database or construction process, indeed, the role of Geometry is clear as a connective-skeleton for any information sets: double check? delete it, and the spatial system “melts”, simply disappearing. However, to make it effective in the present era, it needs to be revitalized, together with *Drawing*, which is its major driver, at least in relation to architectural geometry. As a university educator, indeed, I feel a penetrating question mark about *what does drawing mean nowadays in relation to architecture? How (and of course what) can we teach it?*

All in all, something inspiring could arise from looking at the “colors of black” as a metaphor of interdisciplinary, that in our case would mean the power of the network of knowledge based on digital computation: referring again to Calvino, something aiming at supporting and enhancing either our figurative (let us say *εικαστικός*) or our imaginative (let us say *φανταστικός*) abilities.

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