The Digital change. Reasons and meanings of a new architectural expressivity

Alessia Riccobono, Giuseppe Pellitteri

Università di Palermo, Palermo, Italy

ABSTRACT: The entry of computing in architectural has produced a real revolution in architectural scenario, changing the designer's arsenals and producing new expressive trends. However, up to now it is unclear how designers have actually taken advantage of the use of software to develop new styles, it is unclear what is the relationship between programs, operations and tools provided by them, and the formal configuration of new architecture. Moreover, the only element to identify digital influence on design seems to be only what designers or critics say-so. Then, the goal of the research was to actually identify these digital influences on architectural designs by developing a framework for identifying and classifying architectural design elements that should be attributed to the methods and techniques of design computing. This framework was developed in terms of a database where to collect and classify sixty case-studies, which are prominent recent buildings and acknowledged products of digital means. The goals of this are, firstly, to verify the applicability of the descriptive framework and, secondly, to identify combinations of elements that characterize different approaches or types in current architecture. The results suggest that the use of digital tools in architecture is ubiquitous, where the conceptual starting point of designers and the improvement of the original idea are expressed in the digital domain, taking advantage of the augmented representation skills to control and manipulate form. Furthermore, it seems evident that the current digital architecture is dominated by new figurative trends, which we will identify and examine in depth, showing also common aspects and eventual criticisms.

KEYWORDS: digital design thinking; contemporary architecture; design process; digital trends.

INTRODUCTION

The introduction of computer in designer's scenario have produced a revolution in architecture. Since the commercialization of the first CAAD (Computer Architectural Aided Design) programs in the '80s, initially born to *aid* the production of *drawings,* software has progressively begun part of designer's tools. Despite at first the undoubted advantage resided in the representation power, especially the control of three-dimensional shapes, after some years of experimentation it was clear that software aided the expression of designer's creativity. Several vanguard architects were enthusiastic about the possibilities guaranteed by programs and, among them, Greg Lynn has publicly declared his favour.

> Despite the fact that calculus is more than three hundred years old, the advent of the computer allows us to be among the first architects and designers to work intuitively with a new class of shapes that are calculus-based - that is, built out of interconnected and interacting variables (Lynn 2003).

After about fifteen years of experimentation, everyone agrees that digital tools are currently used in architectural professions and that the effect of their use is rather evident on the formal and aesthetic configuration of some buildings. Hence, the aim of this research has been to identify digital influences in real architectures and, above all, to understand the several digital trends existing in our profession, also by analysing possible issues and criticisms. To reach this goal, we need a well-defined theoretical framework, in order to examine the current phenomenon with consistency and objectivity.

1.0 IDENTIFYING DIGITAL INFLUENCE IN CURRENT ARCHITECTURE

Even though an architect uses computers in a significant manner is primarily a matter of declaration and reputation, everybody can state that digital influences in a design are often easy to perceive in the overall form, as well as in some critical parts such as the building

envelope. They may indicate use of digital means to solve specific problems, e.g. represent complex geometries, or design actions constrained by the use of digital tools, e.g. frequent use of particular geometric primitives or operations. In many cases, the computer is used to facilitate representational and design actions, e.g. model complex surfaces that tend to be hard to specify by hand and may require more information than what is available in conventional orthographic projections. However, the choices and effects of digital means are presumably discernible in the design, but, upon closer inspection, it becomes evident that the main reason for recognizing digital elements in a design is the designers' or some critic's say-so.

Figure 1: Citè de la Mode et du Design, Jakob+MacFarlane, Paris, 2005-2008. Photo by Alessia Riccobono.

1.1. Research methodology: a bottom-up approach

Identifying the above digital influences in a single design is quite useful for the refinement of the framework, i.e. the definition of the repertories and the clarification of the specific forms their members may assume in a design. This can be done in either top down or bottom up fashion. Top down means the production of an extensive, possibly exhaustive series of examples for each digital element and use the results, properly classified and clustered, as templates for identification. Such a series can be produced by observing designs, collecting relevant occurrences and probably augmenting the results with plausible, possible and probable variations. Instead, we have opted for the bottom-up approach: identifying instances of the digital elements in existing designs, without attempting to complete the spectrum with additional instances. This agrees with the critique by Dorst (2008), who have denounced a certain absence of consistency and logic in researches on digital design, a lack of scientific methodology, and, at the same time, he has suggested to apply the scheme *observation-description-explanation* also to this field of knowledge.

Consequently, in the first part of the research we have observed and studied a lot of digital designs, trying o understand common and interesting features, then we have developed a framework of analysis to guarantee consistency; finally we have analysed several case-studies according with this framework. To develop the analytical framework, in order to search for digital influences in a design, we have based our investigation on formal and representational repertories offered by digital means, grouped under two main categories, *general characteristics*, that do not refer strictly to the use of computer, but put attention on other important points, and *local features*. The former contain two groups: the *overall geometry* of a design, which can be either rectilinear or curvilinear; and its general morphological tendency, which can vary from geometric and biomorphic to anthropomorphic and zoomorphic.

Local features have a wider scope, especially as new digital methods and techniques continuously add to them. They comprise three complementary groups, the first of which contains the *geometric primitives* and *models* used in a design: cones, cubes, cylinders,

freeform solids, NURBS surfaces etc. In this group the dual role of digital means becomes quite evident: at least some of these primitives are not bounded by computational environments; it is simply their definition and manipulation that becomes significantly easier and more reliable with digital means. Other geometrical models are inconceivable outside computational environments either because they emerged in relation to computation or because they are mathematically or geometrically hard to implement and control (Tab 1).

Table 1: The classification of case-studies, with respect to geometrical features. (Riccobono, Koutamanis, and Pellitteri 2013)

Category	**Parameters** (underlined words indicate the parameters related to the digital domain)
Geometry	Rectilinear, Curvilinear, Hybrid
Morphology	Anthropomorphic, Biomorphic, Geometrical, Zoomorphic
Geometrical primitives and models (1st and 2nd order)	Cone, Cube, Cylinder, Ellipsoid, Free-form solid, Helix, NURBS Surfaces, Parallelepiped, Prism, Pyramid, Solid of extrusion, Solid of revolution, Sphere, Tetrahedra, Torus, Wedge, None

The other two groups of local features refer to relationships and manipulations in a representation comprising such primitives. *Formal concepts* cover local, general, bilateral and multilateral relationships such as *alignment*, *axiality*, *horizontality*, *symmetry*, *verticality* etc. These underlie the arrangement of primitives in a design but are not limited by them: they are discernible as patterns and coordinating devices that may be quite indifferent as to the elements they apply to (Arredi 2006). In digital representations such formal concepts are often expressed as constraints.

Finally, *operations* like *Boolean, folding, revolution, rotation* and *repetition* serve two related purposes: firstly, the implementation of formal concepts, e.g. as in the use of reflections and translations to create symmetric forms; secondly, the transformation of primitives so as to produce generally more complex forms (Di Mari and Yoo 2012). The effects of these operations arguably determine most of the cues that allow us to recognize digital influences in a design, e.g. a Boolean combination or the adaptation of a mesh (Tab. 2).

While there repertories were initially compiled in a bottom-up manner by observing designs and correlating their features to the capabilities of digital design environments, there is also substantial support from literature, especially in some studies about the theoretical conception in architectural design, conducted through the observation and analysis of morphological features related to digital instruments (Evans 1995, Liu and Lim 2006, Oxman 2008, Wong 2010). The overall structure of the repertories and the definition of their members derives from the *Getty Art & Architecture Thesaurus* (Getty), in an attempt to add lexicographic consistency to the description of digital designs.

Table 2: The classification of case-studies, with respect to compositional issues. (Riccobono, Koutamanis, and Pellitteri 2013)

Category	Parameters (underlined words indicate the parameters related to the digital domain)
Form and compositional concepts	Alignment, Articulation, Asymmetry, Axiality, Balance, Complexity, Contrast, Disproportion, Frontality, Gesture, Harmony, Horizontality, Linearity, Monumentality, Obliquity, Plasticity, Proportion, Rythm, Scale, Simmetry, Simplicity, Unity, Verticality
Compositional Operations	Align, Boolean, Break, Bulging, Copy, Divide, Extrusion, Folding, Interrupt, Loft, Mesh, Move, Offset, Overturning, Repeat, Retract, Revolution, Rotation, Scale, Slicing, Sliding, Smooth, Stretch, Sweep, Taper, Tilt, Translation

The analysis of designs concerning these repertories can be done in two complementary ways, *syntagmatically* and *paradigmatically* (Van Sommers 1984). Syntagmatic analysis refers to the sequence of actions by which different primitives, concepts and operations are entered in the design. Syntagmatic aspects can be of great value in computational and algorithmic studies (e.g. in shape grammars) but they are also difficult to detect in the final design and in many cases only loosely related to design thinking, as there can be various sequences of actions by which we arrive at the same results. Consequently, syntagmatic analyses tend to reveal more about contextual factors, including a designer's understanding of digital means.
Paradigmatic analysis focuses on the elements of the design, in our case primitives, concepts and operations, their existence and interrelationships without reference to temporal precedence or such mental hierarchy. This allows us to identify traces and effects of digital means in design representations, with the obvious exception of prescriptive algorithmic techniques like shape grammars. The economy and effectiveness of paradigmatic aspects made this analysis a safe starting point for this research.

1.2. Case-studies analysis and classification

The analyses were conducted in a uniform, objective manner and collected in a feature-based structured database that allows a wide variety of queries on the identified features, where each building is described by a number of predefined parameters. The use of a database has several advantages: firstly it gives us the possibility to apply a combinatorial approach, which allows us to figure out relationships among several elements in a building's description, to visualize them and to interpret the results; secondly, organizing information in a database forces us to think in a concrete way, less vague than textual discourses, according to a rigorous logical scheme, where several aspects and their interrelationships can be made explicit. The first part of data collection concerns the description of each building, through fields such as. *Building Name* and *Designer(s)*, identified as primary keys, *Location (city), Country, Date from and to, Client, Type* and *Context* (Fig. 2).

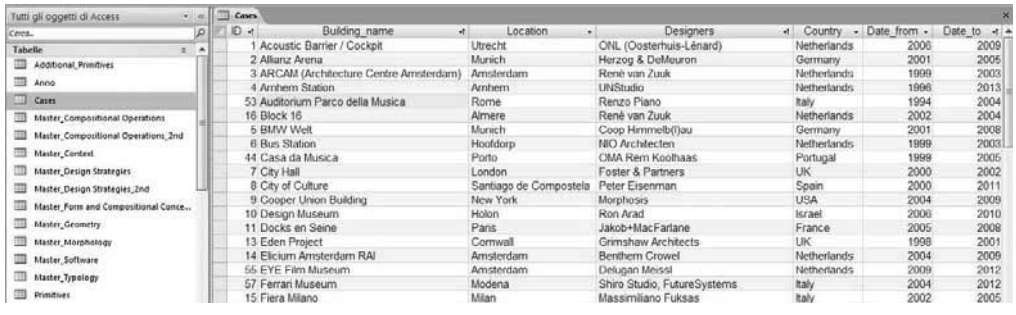


Figure 2: The main interface of the database.

The analytical part is split up in two parts *general characteristics* and *local features*, as we previously discussed in the paragraph 1.1. Furthermore, given that, despite some projects could seem affine by looking at their formal configuration, materials and overall style, their concepts could often start from very different point of view, we have defined a vocabulary of the recurrent *Design Strategies* derived by the use of digital technologies, describing and explaining each category in all specific aspects (Pellitteri and Riccobono 2012). Then we have classified each project according with these concepts on the basis of design process.

2.0 EMERGING PATTERNS. CONCEPTS AND OVERALL TRENDS IN THE DIGITAL AGE

After collecting all data, classifying architectures by settling up all parameters for each case-study, we used the database to obtain results through its combinatorial possibilities. Hence, the main operation was the setting out of several queries, through which questioning the software in order to quickly visualize the results and combinations in form of graphs, tables, reports, etc.

Analysing the result, we can note the strong predominance of curvilinear spatial configurations and the always increasing use of digital media, evident at level of geometrical primitives used

as *conceptual starting point*, where there is a strong prevalence of *Digital* ones (61%), but also at level of compositional operations used to modify and refine the initial shape, where, in general, *Folding* appears the most used (32,4%). This suggests that the design phase actually begins in the computational space: design thinking and conception are becoming more and more identified by a pervasive use of digital technology and by the geometrical and mathematical operations offered by commercial software. Looking at the formal concepts detected among the cases, in general the most represented are plasticity (11,5%), unity (9,3%) and complexity (11,2%).

Finally we focus on *Design Strategies*, linking the results that we have previously obtained about morphological features and composition with designer's conception and methodology. The goal is to be able to understand the existing relationship between form, composition and, above all, design ideas, expression of current times and then related with the digital era at level of form, cultural soul and connection to information technology. Comparing this results with what we have already obtained by the analysis of digital operations and primitives with respect to our trends, we can identify some transverse movements in which we could subdivide our digital-influenced architectures.

2.1. Digital Expressionism

Table 3: The main features of *Digital Expressionism*

Geometry	*Operations*	*Concepts*	*Design Strategies*
Curvilinear	Digital Domain	Plasticity, Unity	Complexity, Artistic Fact, Blob, Flows, Fluidity, Folded Surfaces

This trend gathers architectures with a strong morphological approach, where building envelope, often with curvilinear configuration, is treated as an art work, refining, folding and shaping surfaces (Tab. 3). This appears linked to the main change caused by digitization of architecture, related to advances in representation field and its consequences. Indeed the easy three-dimensional control guaranteed by software has meant a change in the ways of exploration and conception of architectural space. Nowadays it seems that morphological approach to architectural design takes over and the architectural design starts often from the curvilinear manipulation of shape through several different techniques, that could be both algorithms to generate shape or simply operations allowed by commercial software, pushing to the limit the potential of software to search for often unusual spatial configurations (Fig. 3). Patrik Schumacher, director at Zaha Hadid Architects and theorist of architecture, has understood that this new approach has lead us towards a new style:

> We are confronted with a new style rather than just with a new set of techniques. [...] Avant-garde styles might be interpreted and evaluated in analogy to new scientific paradigms, affording a new conceptual framework, and formulating new aims, methods and values. (Schumacher 2009)

Figure 3: The Admirant Entrance Building in Eindhoven, The Netherlands, Massimiliano and Doriana Fuksas Architects. Photo by Alessia Riccobono.

2.2. Hi-Tech Evolution

Within this category, we have inserted those buildings where the generation of the shape is digitally derived from the optimization of one or several parameters, e.g. environmental, procedural, structural, and so on (Tab. 4). The main protagonists of this tendency are some architects of Hi-Tech tendency with a strong technological approach, who have adapted their design methodology to new software when digital media appeared in professional practice (Fig. 4). The building shape can arise both from the creation of autonomous forms by starting from the optimization of different parameters, or, instead, due to the modification of a primitive, by starting e.g. from a sphere, a cube, a parallelepiped and progressively modifying it, deforming it by following approximations, until it reaches the best possible configuration. Norman Foster, one of the main characters of this approach, in an interesting intervention on DLD Conference in 2007 spoke about the possibilities of digital technology and on the necessity to solve building problems through it.

> As an architect you design for the present, with an awareness of the past, for a future which is essentially unknown. [...] I think that digital revolution now is coming to the point where, as the virtual world, which brings so many people together here, finally connects with the physical world, there is the reality that has become humanized, so that digital world has all the friendliness, all the immediacy, the orientation of the analog world. Probably summed up in a way by the stylish or alternative available here and again, inspired by the incredible sort of sensual feel. A very, very beautiful object. So, something which in the '50s, '60s was very exclusive has now become, interestingly, quite inclusive. [...] And I think it's very tempting to, in a way, seduce ourselves -- as architects, or anybody involved with the design process -- that the answer to our problems lies with buildings. Norman Foster (2007)

Table 4: The main features of *Hi-Tech Evolution*

Geometry	*Operations*	*Concepts*	*Design Strategies*
Curvilinear	Digital Domain	Complexity, Articulation, Plasticity	Performance optimization, Mathematical Derivation

Figure 4: Eden Project in St Austell, Cornwall, England, Grimshaw Architects, 2001. Photo by Jürgen Matern (Creative Commons, CC-BY-SA).

2.3. Diagram Architecture

The diagram architecture is not born with digital revolution, but it has assumed new meanings and new procedural ways after the comparison of computers in professional practice. We reported a definition of what a diagram is, made by Ben van Berkel and Caroline Bos, founders of UNStudio, an pioneers in the use of IT in architecture and digital diagrams (Tab. 5).

> The diagram is not a metaphor or paradigm, but an 'abstract machine' that Is both content and expression. This distinguishes diagrams from indexes, Icons and symbols. [...] Diagrammatic practice delays the relentless intrusion of signs. thereby allowing architecture to articulate an alternative to a representational design technique. A representational technique implies that we converge on

> reality from a conceptual position and in that way fix the relationship between idea and form, between content and structure. When form and content are superimposed in this way, a type emerges. (Van Berkel, Bos, and UNStudio 1999)

Digital diagrams, often integrated in some software or add-ons, have become an operational concept tools. Indeed, it often happens that what was initially mapped as diagram, e.g. for users movement, in the final phase of project become the base of formal configuration. This way to work with diagrams is shared by several architects, as, we reported before, UN Studio, but also Rem Koolhaas, Delugan Meissl (Fig. 5) and, above all, Peter Eisenman, whose diagrammatic approach is more related to digital deformation of grids.

Table 5: The main features of *Diagram Architecture*

Geometry	*Operations*	*Concepts*	*Design Strategies*
Curvilinear (50%) Rectilinear (50%)	Digital Domain	Complexity, Articulation,	Diagram, Grid

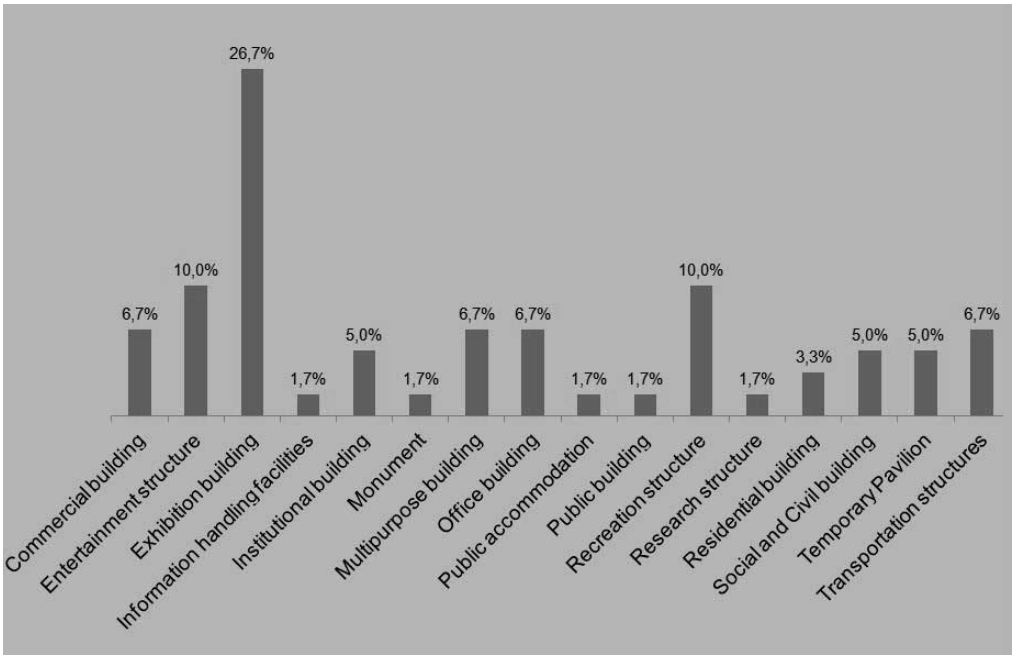
Figure 5: EYE Film Museum in Amsterdam, The Netherlands, Delugan Meissl Associated Architects. Photo by Alessia Riccobono.

3.0 DESIGNING IN A DIGITAL WORLD

Following the identification of the main digital trends, we would linger on some general issues, recognizable in all our tendencies, that have affected current digital-influenced architecture.

3.2 Museums as new iconic buildings

By analysing our cases, it is surprising to see the great quantity of Exhibition buildings (27%), that comprise both museums and centres where the main scope is the dissemination of information, through the exhibition, such as trade fairs, temporary pavilion, etc. Other prevalent categories are *entertainment, transportation, multipurpose* and *recreation*, in total 33,9% (Graphs 1). Filtering these types recognized through the variable of geometry, we can observe a very high presence of buildings with curvilinear configuration.



Graph 1: Absolute prevalence in the category *type* and *context*.

This datum appears very significant in order to understand our contemporary culture and society. In fact, while in architectures such as offices the formal experimentation remains more limited by the function - and we should also report the absence of digital influenced buildings in the categories commercial buildings, industrial, public accommodation, etc. - the digital expressiveness gains the upper hand. Architects have the freedom to fully play with morphology in relation to museums, stations, multipurpose buildings, architectures featured by more flexible spaces, where functions are sometimes not well distinguished, by often impressive dimensions and, above all, buildings with a great cultural value for the community and the cities, where there are often required elements of novelty, iconoclasm, non-conformism, majesty.

What is surprising about digital influenced architectures is that the majority of them are referred to functions connected to sharing information and communicating culture and belonging. Buildings where people can identify and admire the *mise-en-scene* of own passions, i.e. in the cases of automotive museums (BMW, Porsche, Mercedes, Ferrari), in an atmosphere of grandiosity and celebration (Fig. 6).

Without fear of making mistake, we can assert that museums are the new *Icons*: as in the Past, at least until the Industrial Revolution, the major role to propose new representative buildings, avant-gardes in the upcoming architectural language and style, was covered by sacred institutions or governments, in the current times it seems this role belongs to who wants to share culture, both in public and private sector.

Figure 6: BMW Welt in Munich, Germany, Coop Himmelb(l)au. Photo by Alessia Riccobono.

3.3 Same expressivity, different contexts

Our analysis reveals that architects maintain the same approach with respect to diverse physical context - it seems that is indifferent if we are in an old city, inner city or rural area, etc. - with percentages more or less balanced. Also the geographical area seems to be indifferent and this is the evidence that we are dealing with a global tendency. Then, architectures are often treated as *objects* rather than *buildings*, positioning these "friendly aliens", as Peter Cook (2004) defined his Kunsthaus design in Graz, with the scope to attract people who want to admire - or criticize - their art work. As we have already discussed about museums and type, everyone competes to acquire an architecture that express the latest innovations in terms of style, materials and overall image. For this reason we can explain and justify the tendency to acquire new fashion architectures, particularly evident in those countries where the economy is in growing - Middle East, China and Orient in general. The buildings are statements to have become part of the capitalist system and, then, have to express a certain sense of belonging. Moreover in these countries there is still less attention to the urban context with respect to what happens in Europe, where, as far as possible, it was tried to preserve the historical and cultural roots.

CONCLUSION

The use of real-world, prominent designs of our casuistry shows these digital influences in critical, high-risk situations where designers tend to pay more attention to project success, client requirements and overall appeal than to any computational principles and approaches or to the context, which is almost always ignored. As a result, we consider that our sample verifies the claim that digital means have become a ubiquitous part of architectural design tools and that their current common use has caused the birth of new figurative trends. Moreover, with the increasing number of younger architects who have had an early exposure to the computer and have an high level of practical skills in design computing, the use of digital design methodology will keep increasing.

One of the main issue of digital-influenced architecture resides in the fact that this new *style* is formally based on free expressions, without a *canon* or a *style*. We think that this recognized digital trends, driven by international firms, introduces new degrees of complexity in profession. Indeed, during the development of a project, it could happen that practitioners will tend to keep merely the style or the formal configuration of some fashion designs, forgetting and not considering other aspects related to design conception, such as cultural references and contextual choices. For this reason, projects as those reported in this research, where the taxonomic values are strong and where the designers tend to develop their own style, could conduct to a simple reproduction of *beautiful forms*. Up to now, just by giving a superficial look at architectural websites like Archdaily.com or Europaconcorsi.com, where practitioners can upload their own projects, we can note strong similarities in some professional projects with international firms designs. Hence, we would conclude this treatise with a series of open questions. Will architectural scenario become analogue to Fashion or Industrial Design? Will we choose our future style as we normally choose a clothes? Probably only the time can give us the right replies, but now it seems fundamental that architecture will begin to question about that.

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