New digital trends in current architecture

A comprehensive critical examination

Giuseppe Pellitteri¹, Alessia Riccobono²
¹Dipartimento di Architettura, Università degli Studi di Palermo ²Köln International School of Design, TH Köln
¹giuseppe.pellitteri@unipa.it ²alericco@kisd.de

The research presented is about digital revolution in architecture, which has contributed to the birth of new figurative trends. The work was conducted through the definition of a framework to identify and classify architectural design elements that should be attributed to the methods and techniques of design computing, then applied to sixty prominent recent architectures which are acknowledged products of digital means. The early results suggest that a new era is coming, where the conceptual starting point of designers is often born in the digital space, taking advantage of the augmented representation skills to control and manipulate form. We will also do an overview of these new architectural trends, discussing both causes and cultural roots and identifying eventual criticisms and further developments.

Keywords: digital design thinking, contemporary architecture, design process, digital trends

INTRODUCTION
At the beginning of digital revolution, the computer was only an exclusive toy for an academic and technological elite of researchers and developers jealously guarding an expensive technology and its applications, and restricting it to their internal preoccupations. However, 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 an undoubted advantage was the extensive exploration of the architectural space and the direct control of its transformations in all phases of the project, after some years of experimentation it was clear that software aided the expression of designer’s creativity too.

Through current modelling software, you can get even more complex forms of representation: they add up to traditional graphics media and an additional system of information is directly available. It becomes a stimulus to our conceptual skills, using new media to govern the complexity and to give free rash to design creativity. Definitely, this has led the architect to a radical change of its relationship with the design. The classical conceptualizations, previous to the final form configuring and expressing architecture, go now almost in parallel with the repre-
sentation of the form itself. Nowadays 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. On the other hand, it is actually unclear how much CAAD software influenced this new figurative dimension.

Therefore, the first goal of the research is identifying the extent and scope of digital influences on real architectural expressions. It is unclear what these influences entail and what evidence we have for their existence and significance. It seems that we all generally agree to the existence but are not able to recognize their influences and effects. After a closer inspection, it becomes evident that the main reason for recognizing digital elements is what the designers themselves or some critics said. Indeed, after the objective identification of digital influences in a new architecture, we should be able to identify their origin, too: do they derive from a research or are they products of general computer literacy? In this scenario, what is the role of composition and why is architectural expressivity changing? This question is central to the role of design computing in architectural education but also points out research goals and directions that may be absent in current research (Riccobono et al. 2013).

To achieve this goal, we need first of all a coherent and comprehensive overview of elements derived from design computing, so that we can unambiguously identify them in some recent architectures. Then we have to apply it to real cases in order to verify its adequacy and, when this is done, to examine how these elements appear and are used in practice and what is the linkage with geometry and spatial composition. Finally we must consider how digital influences contribute to a new way to intend architectural design and its formal expressions, to understand what is the state of architecture nowadays: which are the most common trends? Which are the positive and negative aspects of the digital revolution? Which could it be the future of our work?

**RESEARCH METHODOLOGY: A BOTTOM-UP APPROACH**

Everybody can state that digital influences in a building are often easy to perceive in the overall shape [Fig. 1], as well as in some critical parts such as the architectural envelope, but it is rather difficult to understand when and how extensively the designers actually used the digital media in the design process (Pelletteri 2010). They might use digital means to solve specific problems, e.g. to represent complex geometries, or for design actions constrained by the use of digital tools (frequent use of particular geometric primitives or operations, for example). 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. But in many others the digital media software were used for specific and technical aspects, like the optimization of performance features or for the facilitation of construction phases.

The identification of digital influences in a single project 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. This problem could be approached in two opposite ways: with a top-down or a bottom-up approach. The first 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 digital elements directly on the existing projects, without attempting to complete the spectrum with additional instances. This agrees with the critique moved 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 our field of knowledge.

For a real bottom-up analysis, in order to clarify how much CAAD software have contributed on the emergence of Digital Design with precision and overview, we have avoided opinions (either from academia or from practice) and focused instead on the actual products, analysing sixty recent buildings clearly related to digital methods or techniques.

The analyses were conducted in a uniform objective manner and collected in a database, which allows a wide variety of queries on the identified features and where the collection of data, the classification of projects on the basis of predefined objective parameters and, above all, the interrelations between two or more parameters. They permit us to understand the role of digital means in contemporary architecture with clarity and consistency, so that we can not only describe but also explain the state of the art.

**Inclusion criteria**
The case-studies were chosen from the high end of contemporary architecture. They are:

- architectures where the influences of digital tools and culture are strongly evident;
- high-quality buildings, testified by the publication on international journals. We have chosen not to include projects that exist only on paper, because this does not permit analysis and evaluation of many aspects, e.g. the real relationship with the environment or tectonic issues;
- buildings from all over the world, since the effects of digitization on current architecture have been not dependent on local culture;
- projects realized in the last twenty years; no specific typology. As in the case of global scale, digital influences on current architecture are not dependent on the specific functions accommodated in the building.

**Database Structure**
To make easier our analysis, it was chosen to collect all the information related to these buildings in a database so as to ensure consistency: each building is analysed in the same manner and the results are described in the same terms, thanks to some predefined parameters [Fig. 2]. The use of a database has several positive aspects: 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. The description is completed with photographs, drawings and dimensional data. After this first descriptive part, we deal with the real analysis and close examination of the cases.

To develop the analytical framework, in order to search for digital influences in a building, we have based our investigation on formal and representational repertories offered by digital means, grouped under two main categories, general features, that do not refer strictly to the use of computer, but put attention on other important points, and local features.
General features regard the taxonomical analysis of each project, through the recognition of its Geometry and Morphology. Local features have a wider purpose, 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 project: 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.

About primitives, we have also distinguished two different levels. In the first level, it is possible to choose among the several parameters with a forced selection, so that the primitive detected is one and unequivocal; you cannot pick both parallelepiped and sphere, because always one is prevalent on the other. For this reason, we have admitted a second level where to identify the other elements which participate to composition, with the possibility to choose more parameters [Tab. 1].

Following this taxonomic exploration, the analysis continues with the other two groups of local features, regarding the role of composition in the design process. Firstly, we focus on the recognition of the formal concepts, which cover local, general, bilateral and multilateral relationships such as alignment, axiality, horizontality, symmetry, verticality etc. These underlie the conceptual arrangement of primitives but

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

Table 1
The classification of case-studies, with respect to geometrical features. (Riccobono, Koutamanis, and Pellitteri 2013).
are not limited by themselves: 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.

Then we focus on the compositional operations (Di Mari and Yoo 2012), which serve two related purposes: the implementation of formal concepts, e.g. as in the use of reflections and translations to create symmetric forms, and the transformation of primitives to produce generally more complex forms. 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]. Even in this case, it was previously defined which operations were born in the computational domain and which not.

While these repertories were initially compiled in a bottom-up manner by observing the several cases 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 tools (Evans 1995, Liu and Lim 2006, Oxman 2008, Wong 2010). The choice of the parameters used in each category was based on the Getty Art & Architecture Thesaurus [1], in an attempt to add lexical consistency to the description of digital designs.

The analysis 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 entering 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.

### QUERIES, RESULTS AND INTERPRETATION

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

We have queried the database to show the related prevalence per each category. Referring to Geometry, we noted the high prevalence of the curvilinear one (67%), which confirms our first impression and cases selection. In turn, the strong tendency to-

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameters (underlined words indicate the parameters related to the digital domain)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Form and compositional concepts</strong></td>
<td>Alignment, Articulation, Asymmetry, Axiality, Balance, Complexity, Contrast, Disproportion, Frontality, Gesture, Harmony, Horizontality, Linearity, Monumentality, Obliquity, Plasticity, Proportion, Rythm, Scale, Symmetry, Simplicity, Unity, Verticality</td>
</tr>
<tr>
<td><strong>Compositional Operations</strong></td>
<td>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</td>
</tr>
</tbody>
</table>
wards designs with curvilinear configurations is accompanied by a rigid geometrical control, testified by the high percentage (70%) of geometrical parameter in the category Morphology.

At level of Primitives, where we have identified two orders the most represented is NURBS Surfaces (25%); it is also significant that, filtering our results through the variable Digital-not Digital, there is an high prevalence of digital primitives (60%) in the first level, but not in the second level (only 24%). This suggests that the conceptual phase begins in the computational space with a primitive, rather than with e.g. a sketch (Dorta et al, 2008), but subsequent primitives used in the composition are conventional and not digital [Fig. 3].

If we look at compositional level, it is evident that a high percentage of designs used operations totally digital (81%), where folding (33,8%) dominates both as an expression of the ability to reliably control complex surfaces by computer and of certain tendency to abandon straight and regular geometries [Fig. 3]. Preferring curved lines, sloping planes and organic spatial configurations is one of the fundamental evidence of Digital Expressionism.

This attitude is arguably also confirmed by the relevant presence of operations like loft and bulging. As regards formal concepts, most of them cannot be called strictly digital. However, the popularity of concepts like plasticity (12%), complexity (10,1%) and unity (9,7%) confirms the feeling that architectural products of this trend are often intended as artistic expressions.

Looking at the Figures 3 and 4, we can assert that the digital attitude is pretty evident in both morphology and composition. Design thinking and conception are becoming more and more identified by a pervasive use of digital technology and by geometrical and mathematical operations offered by commercial software. Proliferation of curvilinear geometries and plastic spatial configurations appears related to the main change allowed by digitization of architecture that is linked to representation, but not just to it.
EMERGING TRENDS IN THE DIGITAL AGE
The last part of analysis is devoted to map the conceptual criteria based on each case. Despite some projects could seem affine looking at their formal configuration, materials and overall style, their concepts could often start from very different point of view. We can recognize these conceptual strategies only by tightly studying what designers say in projects description and identifying, e.g. which software were used to conceive design. Hence, we have defined a vocabulary of the recurrent conceptual strategies derived by the use of digital technologies, describing and explaining each category in all specific aspects. Each architecture was classified according these several categories and we have considered that some buildings might have more than one classification. Among the categories identified, we find blob, term coined by Greg Lynn (1998), which refers to digitally designed buildings that have an organic and bulged shape, as an amoeba, and grid, traditionally a Cartesian structure that generates static and rational shapes, but that computationally deformed becomes instrument for designing forms and spaces unpredictable and changeable. Other used identifying terms, which here we limit to list, are: fluidity, flows, diagram, pattern, artistic fact, deconstruction, folded surfaces, mathematical derivation, natural derivation, performance (Pellitteri and Riccobono, 2012).

Comparing those results with what already obtained by the analysis of digital operations and primitives, it is possible to identify some transverse movements in which we could subdivide the digital-influenced architectures.

**Digital Expressionism**
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. 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. Since the origins, prerogative of architectural design have always been the extensive use of visual methods and techniques in composition and each radical discovery in representation field had always constituted a revolution in the architectural design thinking.

Nowadays it seems that morphological approach to architectural design takes over and this starts often from the curvilinear manipulation of shape, pushing to the limit the potential of software to search for often unusual spatial configurations. It does not mean that curvilinear geometries and complex surfaces were not used and not experimented in the past; rather this trend seems the right continuation of the expressive tendencies born in the Post War, with personalities as Eero Saarinen, Hans Scharoun, Felix Candela. The main difference with respect to the ‘60s is the extreme facility to conceive free forms, without minding about their geometry in the first stage, and to progressively refine the configuration according to aesthetical, structural, functional needs. This is undoubtedly a pro, but it is a contra at the same time: facility and speed can make designers loose the way, not considering aesthetical, contextual and tectonic and other relevant factors.

**Hi-Tech Evolution**
This category includes buildings in which the generation of the shape is digitally derived by optimizing one or several parameters, e.g. environmental, procedural, structural, and so on. When digital media appeared in the practice, some architects with a strong technological approach had adapted their design methodology to new software. Starting from the optimization of one or more parameters to
increase building performances, the new software allows the creation of autonomous architectural forms, arising directly from the optimization of different parameters. Another approach to build performance is to obtain the final shape through the modification of a primitive (e.g. from a sphere, a cube, a parallelepiped), which will further deformed by following approximations, until it reaches the best possible configuration. This trend was called by some critics Performative Architecture (Kolarevic and Malkawi 2005), even if it not properly a new attitude. In fact, looking at the protagonists of this kind of methodology, we find Norman Foster [Fig. 5], Nicholas Grimshaw, Renzo Piano, who are the same protagonist of the so-called Hi-tech trend in the ‘80s. It seems we are looking at a natural evolution of a trend, that through the possibilities of digital design has pushed until the limit the building technology, creating an old expressivity in terms of material - almost always steel structure with glass walls - but new regarding to the envelope’s shapes.

**Diagram Architecture**

This trend was not born with digital technologies, but with their huge diffusion the sense and use of architectural diagrams was modified [Tab. 5]. Let’s start from the term: diagram in architecture it is usually thought of as graphic tool (Bijlsma, 1998), that is the translation of a series of possible relationships between the parties in a drawing, but it can’t be attributed either to the type, nor even to a sketch. The term derives from Greek διὰ (through) and γράmma (something written). Although it is usually made up of points, lines and surfaces organized in two-dimensional or three-dimensional patterns, it may include data, legends, text, and then relate different aspects at the same time, crossing data, connecting functions and needs. Digital diagrams, often integrated in some software or add-on, have become an operational concept tools.

It is often happened that what was initially mapped as diagram, e.g. for function or users movement, in the final phase of project become the base of formal configuration. This way to proceed is very common in designers like UN Studio [Fig. 6] and Rem Koolhaas, but we have not to forget that the first to use digital diagrams, conceived as deformed grids, was Peter Eisenman, one of the most important architects of avant-garde and Deconstructivism.

**CONCLUSIONS**

The first thing evident in our multi-case analysis is that there is no easily discernible the digital approach concerning methods and techniques used. In con-
Contrast to the assumptions underlying design computing research and teaching, there is no predefined process or even clear strategies for each particular problem. The application of digital means seems opportunistic and generally dictated by contextual or cultural reasons - as many decisions are in architectural design (Till, 2009). Such reasons may result in-to-effective, innovative solutions that serve well goals relating to function, performance and, more often, visual impact. Computational media produces the novel forms of Digital Architecture that attract the attention of a wide public and presents opportunities for combining different aspects and elements in ways that interest the architectural public. From our sample, it is evident that digital means are used for differentiation: just like modernists avoided decoration, digitally influenced designs seem to prefer curvilinear forms, even if tactics and concepts may have very different foundations. This seems to be done to indicate their opposition to earlier architecture and show clearly that the design is (partly) motivated by design computing ideas as expression of the future.

Prominent designs 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. Our sample verifies the claim that digital means have become a ubiquitous part of architectural design tools and have irremediably changed the architects’ way-to-design. Despite the existence of many algorithms and programs currently used, their architecture is not able to leave the visual approach out of consideration. Indeed, the main advantage given by the computer is the possibility to work visually in real time on 3D-shapes, by seeing what effects are produced by their actions. On one hand this fact has speeded up the design operations, but on the other hand the risk to “run into a loop”, endlessly modifying the geometrical configuration, appears quite real (Riccobono, 2015). Increasing the number of younger architects who have had the benefit of early exposure to the computer and formal education in design computing (even if it is restricted to practical skills), it is unavoidable that digital influences at the morphological level will keep increasing. From our research it is still unclear whether this will be accompanied by increased compositional awareness and more intensive use of digital methods in synthesis (as opposed to representation).

This new style of digital-influenced architecture 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 the profession. Indeed, during the development of a project, it could happen that some architects will tend to keep merely the style or the formal configuration of some fashion designs, forgetting and not considering other aspects, such as cultural references and contextual choices (Pellitteri 2010). In many projects as those reported in this
research, where the taxonomic values are strong we can see that designers tend to develop their own style, conducting to a simple reproduction of beautiful forms. Up to now, just by giving a superficial look at architectural websites like Archdaily.com [2], where anyone can upload their own projects, we can note strong similarities in some professional projects with international firms’ ones.

Academic research and teaching may be rich in compositional studies and approaches, but if digital means enter practice primarily as design representations, it is inevitable that emphasis will be on what can be done with software rather than on how and why. In the war between conceptualization and morphology, actually the second seems to have the best. Consequently, each design project serves as a testbed firstly for morphological development (which tends to produce similar results to other designs) and secondly for experimentation with primitives, concepts and operations.

At the end of the game, despite of a general expressionist tendency, we cannot anymore talk in terms of language, style or aesthetic values. What the digital revolution has effectively produced is a free way to intend the project, with endless geometries, materials, building systems present at the same time and in the same places, without any consideration about a shared Architecture’s Identity.

REFERENCES
Arredi, M P 2006, Analitica dell’immaginazione per l’architettura, Marsilio, Venezia
Lynn, G 1998, Folds, Bodies & Blobs: Collected Essays, La lettre volée, Brussels
Pelligteri, G (eds) 2010, L’involucro architettonico. Declinazioni digitali e nuovi linguaggi, Fotograf, Palermo
Pelligteri, G and Riccobono, A 2012 ‘Towards which expressive horizons?’, Proceedings of SIGraDi 2012, Fortaleza, pp. 84-88