M. A. Schnabel (ed.), *Cutting Edge: 47th International Conference of the Architectural Science Association*, pp. 663–672.

DIGITAL EXPRESSIONISM: THE ARCHITECTURE OF COMPLEX SHAPES

Multi-case analysis, classification and interpretation

ALESSIA RICCOBONO[1], ALEXANDER KOUTAMANIS[2], and GIUSEPPE PELLITTERI[3]
[1, 3] *University of Palermo, Palermo, Italy*
{alessia.riccobono,giuseppe.pellitteri}@unipa.it
[2] *Delft University of Technology, Delft, The Netherlands*
a.koutamanis@tudelft.nl

Abstract. The research presented is about digital revolution in architecture, due to the entry of computing in a design development, which has contributed to the birth of a new figurative trend, we can call *Digital Expressionism.* 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 buildings 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 this new architectural trend, discussing both causes and cultural roots and identifying eventual criticisms and further developments.

Keywords. Digital architecture; design process; digital design thinking; multi-case analysis.

1. Introduction

The triumphal entry of computing in architectural design, experimented in the last fifteen years, has produced a real revolution in architectural scenario. Computational tools have earned favour in academia: any comparison between e.g. proceedings of similar conferences, even many years apart, reveals considerable similarities not only in the thematic clustering of papers but also in the subjects and approaches of the papers themselves (Oxman, 2006). On the one hand, there are already many generations of architects

who have had the benefit of formal CAAD education during their studies and are consequently sufficiently exposed to the methods and techniques of design computing. On the other hand, the differences between academic and professional computing priorities over the years have been such that it has been suggested that architectural computerization in practice relates more to digital design means (either basic or advanced) and hence owes more to commercial software or to low-level academic training (i.e. acquaintance with commercial software and development of practical skills). Given the current state of development in digital media, we could be justified to talk about a Post-Digital Age (Spiller, 2009). This also agrees with the reflection that, having passed the first reactions of enthusiasm or concern, we need to understand what direction architecture is taking under the influence of digital media (Picon, 2010).

Through a rapid overview of current digital-influenced architectures in terms of expressive trends, we noted proliferation of buildings with curvilinear spatial configurations, so that we named this new architectural trend as *Digital Expressionism* (Fig. 1-2); but until now it is unclear how much CAAD software have contributed to this new figurative dimension. Therefore, the first goal of the research is identifying the extent and scope of digital influences on real architectural designs. In fact, it is unclear what these influences entail and what evidence we have for their existence and significance. It seems that it is generally assumed not only that we are able to recognize these influences and their effects, but also that we all agree as to their existence. However, 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. Following the objective identification of digital influences in a design, we should be able to identify their origin, too: do they derive from academic 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.


Figures 1-2.The BMW Welt by Coop Himmelb(l)au in Munich and the New Milan Trade Fair by Massimiliano Fuksas in Rho.

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 architectural designs. Then we have to apply it to real designs so as 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 composition. Finally we must consider how digital influences contribute to a new way to intend architectural design and its formal expressions.

2. Multi-case analysis

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 that 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. We have opted for the bottom-up approach: identify instances of the digital elements in existing designs, linking them with morphological and compositional matters, without attempting to complete the spectrum with additional instances. This agrees with the critique by Dorst (2008) and stresses not the supply but the actual usage and, through that, the possible demand for digital methods and techniques and ultimately their significance in architectural design.

For a real bottom-up analysis, in order to clarify how much CAAD software have contributed on the emergence of *Digital Expressionism* with precision and overview, we have avoided *opinions* (either from academia or from practice) and focused instead on the actual *products* of practice, 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, permit us to understand the role of digital means in this evident return of *curvilinearity* in architecture with clarity and consistency, so that we can not only describe but also explain the state of the art.

2.1. INCLUSION CRITERIA

The case-studies were chosen from the high end of contemporary architecture, they are buildings well known in the academia and among practitioners and experts The cases are:

- designs 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 solely on paper because we this does not permit analysis and evaluation of many aspects, e.g. the 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 urban and geographical contexts;
- projects realized in the last fifteen years;
- no specific building type. As in the case of global scale, digital influences on current architecture are not dependent on the specific functions accommodated in the building.

2.2. 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. 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. The analytical part is split up in two parts: firstly we have to analyse the taxonomy of each project, through the recognition of its *Geometry*, *Morphology* and *Geometric Primitives* used in a design (Tab. 1). About *Primitives*, we have distinguished two different levels, first and secondary. 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 un-

equivocal; 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. Regarding to Primitives, it is clearly identified if they are digital-derived or not - i.e. NURBS Surfaces or freeform solids belong to computational domain (Tab. 1).

Table 1.The classification of case-studies, with respect to geometrical features

Category	Parameters (underlined words indicate the parameters related to the digital domain)
Geometry	Rectilinear, Curvilinear, Hybrid
Morphology	Anthropomorphic, Biomorphic, Geometrical, Zoomorphic
Primitives (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

Following this taxonomic exploration, the analysis continues with the recognition of the formal *Concepts* (Arredi, 2006) that underlie the arrangement of primitives in a design. Finally, we focused on *Compositional Operations* (Di Mari and Yoo, 2012), which 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 (Tab. 2). The effects of these operations arguably determine most of the cues that allow us to recognize digital influences in a design. 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 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 (Liu and Lim, 2006; Wong, 2010). The choice of the parameters used in each category was based on the Getty Art & Architecture Thesaurus (Getty), where any query for a single term reveals the associated hierarchy and allows the addition of all relevant elements to each category.

Table 2.The classification of case-studies, with respect to compositional issues

Category	Parameters (underlined words indicate the parameters related to the digital domain)
Form and composi-	Alignment, Articulation, Asymmetry, Axiality, Balance, Complexity, Con-

tional concepts	trast, 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

3. Results and interpretation

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

Firstly we queried the database to show the related prevalence per each category. Referring to Geometry, we note the high prevalence of the curvilinear one (67%), which confirms our first impression and cases selection. In turn, the strong tendency towards 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 identified two orders the most represented is NURBS Surfaces (25%); it is also significant to note 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.

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 in the computer and of certain tendency to abandon straight and regular geometries (Fig. 3). In fact, 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 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.

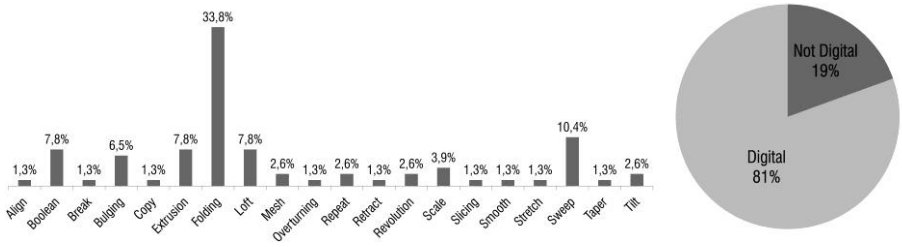


Figure 3. Compositional operations: prevalence and digital attitude

In conclusion, looking at the synthesis done in Tab. 3, we can assert that *digital absolutely takes control*, 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. Furthermore 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 solely on it. Now we will do a short overview, exploring this tendency from several points of view.

Table 3.The the main characteristics of Digital Expressionism

GEOMETRY	Curvilinear
OPERATIONS	Digital Domain
CONCEPTS	Plasticity, Complexity, Unity

4. Digital Expressionism: between computation and cultural references

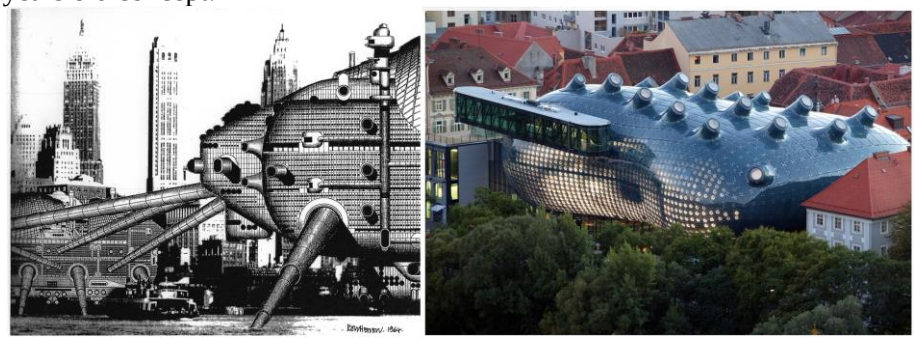
Since first Sutherland's digital drawing system, passing through software initially born for other fields of industry and later borrowed by architectural practice, until huge diffusion of CAAD programs, it is undeniable that the main change of digitization of architecture is related to Representation. This is probably the main aspect of digital revolution, because a significant change in methods of representation means a change in the ways of exploration and conception of architectural space. In fact, one of the main prerogative of the architectural design is the extensive use of visual methods and techniques in the development of a composition (Koutamanis, 2000) and each radical discovery in representation field had always constituted a revolution in the architectural design thinking. But what happened when the potentiality of software, initially born for Aerospace, Automotive and Military Industries, is made available to Architecture?

Our cases reveal that the morphological approach to architectural design takes over and conception starts often from the curvilinear manipulation of

shape, pushing to the limit the potential of software to search for unusual spatial configurations. It does not mean that curvilinear geometries and complex surfaces were not used and not experimented in the past, e.g. thinking of Eero Saarinen, Hans Scharoun and Erich Mendelsohn. On the other hand a tool, that gives an extraordinary geometrical control, makes us able to think free-forms without concern about geometry in the first stage, with the possibility to progressively refine them according to aesthetical, structural, functional needs. The actual interest of designers seems morphological curvilinear deformation, rather than the creation of *new* forms. In fact, despite a declared refuse of traditional Cartesian geometry, so much that some critics tend to identify several projects under the category of *non-Euclidean* shapes, architects prefer often to start from *known* and to proceed towards *unknown*, through geometrical deformation. This is translated in a presumed idea that *everything is possible* and *producible*, which denotes the risk to deal with architectural design as *product design*, therefore considering other parameters, rather than other aspects that normally belong to architectural design, *in primis* the physical context of a building.

But on the other hand, despite at first impression the morphological approach could consist only in an obsessive search for the figural goodness, we have to report that this new architectural trend has its root in those artistic and architectural tendencies born in the second half of the XX Century, essentially known as early Post Modernism and utopian and visionary architecture. If we make a comparison between some analysed cases and some utopias' project, we could note several strongly assonances, especially in terms of figurativeness. This is also confirmed by some interviews or writings of designers themselves, who often mention characters like Archigram, Lebbeus Woods, Bruce Goff. This was an interesting research front to further deepen. In fact, studying the some utopias' project dated to the second half of XX Century, it was surprising to note that the figurativeness they represented is not so far from some project of the Digital Era. The works of Lebbeus Wood, especially those contained in the book Radical Reconstruction and dated to the first 90's (Woods, 1997), seem have had a great influence in some digital project of F. O. Gehry and of the Viennese studio Coop Himmelb(l)au. Furthermore, beyond the purely figurative factor, some of protagonist of that cultural movements has designed buildings that now are become manifestos of the digital-influenced architecture. The most evident case is the Kunsthaus in Graz (Fig. 4-5), designed by Colin Fournier and Peter Cook, one of the founders of Archigram (1999). Some drawings produced by them in 1964 may well be sketches of the realized building, completed in 2003. The Graz's Kunsthaus, that is recognized as manifesto of the Blob Architecture (Lynn, 1998) due to its appearence and to explicit inten-

tion of designers who called it the *friendly alien*, in reality puts on stage a 30 years old concept.



Figures 4-5. Archigram, Walking City (1964) and the Kunstahus in Graz (2003) by Peter Cook and Colin Fournier.

6. Towards future: criticism and further developments

The first thing evident in our multi-case analysis is that there is no easily discernible approach concerning digital methods and techniques. In contrast to the assumptions underlying design computing research and teaching, there is no predefined process or even clear tactics 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 into effective, innovative solutions that serve well goals relating to function, performance and, more often, visual impact. Computational media produces the novel forms (Pellitteri, 2010) of Digital Expressionism 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 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.

This also relates to *belongingness:* our sample exhibits high occurrence of acknowledged digital elements like folding, which undoubtedly indicates the popularity of the particular operation but also arguably serves as a badge of not only modernity and awareness of current trends but also of belonging to a specific even if vague tendency.

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 and how rather than on 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 different primitives, concepts and operations and their possible combinations. This may suggest an ongoing transition from possible and popular combinations to permissible combinations on the basis of yet fuzzy morphological criteria and variable contextual relationships.

At the end of the game, it remains that, 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

Archigram, 1999, *Archigram*, Peter Cook ed., Princeton Architectural Press, New York.
Arredi, Marina P., 2006, *Analitica dell'immaginazione per l'architettura*, Marsilio, Venezia.
Di Mari, A. and Yoo, N., 2012, *Operative Design: A Catalogue of Spatial Verbs*, BIS Publishers, Amsterdam.
Dorst, K., 2008, Design research: a revolution-waiting-to-happen, *Design Stud*, **29**(1), 4-11.
Dorta, T., Pérez, E. and Lesage, A., 2008, The ideation gap: hybrid tools, design flow and practice, *Design Stud*, **29**(2), 121-141.
Getty, "Art & Architecture Thesaurus". Available from: <http://www.getty.edu/research/tools/vocabularies/aat/> (accessed 15/07/2013).
Koutamanis, A., 2000, Digital architectural visualization, *Automation in Construction*, **9**(4), 347-360.
Liu, Y. T. and Lim, C. K., 2006, New tectonics: a preliminary framework involving classic and digital thinking, *Design Stud*, **27**(3), 267-307.
Lynn, G., 1998, *Fold, Bodies & Blobs*, Lettre volée.
Oxman, R., 2006, Theory and design in the first digital age, *Design Stud*, **27**(3), 229-265.
Pellitteri, G., 2010, *L'involucro architettonico. Declinazioni digitali e nuovi linguaggi*, Fotograf, Palermo.
Picon, A., 2010, *Digital culture in architecture : an introduction for the design professions*, Birkhaeuser, Boston, MA.
Spiller, N., 2009, Plectic architecture: towards a theory of the post-digital in architecture, *Technoetic Arts*, **7**(2), 95-104.
Till, J., 2009, *Architecture depends*, MIT Press, Cambridge, Mass.
Wong, J. F., 2010, The text of free-form architecture: qualitative study of the discourse of four architects, *Design Stud*, **31**(3), 237-267.
Woods, L., 1997, *Radical Reconstruction*, Princeton Architectural Press, New York.