Florian Nepravishta
Andrea Maliqari

MODERNISATION AND GLOBALIZATION

NEW PARADIGMS IN ARCHITECTURE, CITY, TERRITORY

La scuola di Pitagora editrice

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Editor:
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Layout:
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Cover:
Andi Shameti

Publisher: Faculty of Architecture and Urbanism (FAU), Polytechnic University of Tirana

Press:
Printing House FLESH, Tiranë 2021
Rruga: "Sulejman Pitarka" Tirane, Albania

ISBN: 978-88-6542-814-6
ISBN: 978-88-6542-815-3 (e-book)

Collana FAU

Forum for Architecture and Urbanism (FAU)

Series founded and directed by Florian Nepravishta

Number three

Collana FAU

Serie **"Forum for Architecture and Urbanism (FAU)"**

Serie founded and directed by Florian Nepravishta

Forum for Architecture and Urbanism (FAU) series of scientific publications has the purpose of disseminating the results of national and international research and project carried out by the Faculty of Architecture and Urbanism (FAU) of the Polytechnic University of Tirana (UPT). The volumes are subject to a qualitative process of acceptance and evaluation based on peer review, which is entrusted to the Scientific Publications Committee. Furthermore, all publications are available on an open-access basis on the Internet, which not only favors their diffusion, but also fosters an effective evaluation from the entire international scientific community. The Faculty of Architecture and Urbanism (FAU) of the Polytechnic University of Tirana (UPT) promotes and supports this series in order to offer a useful contribution to international research on architecture, urbanism and cultural heritage, both at the theoretico-critical and operative levels.

MODERNISATION AND GLOBALIZATION

New paradigms in architecture, city, territory

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HARDWARE, SOFTWARE AND THE DIGITAL REVOLUTION: AN OVERVIEW

Giorgio Verdiani, Andrea Pasquali, Elisa Miho,Julia Demiraj,Kristiana Kumi, Megi Ballanca

Introduction

In the context of the digital revolution, the architect, the urbanist, the designers are no more allowed in operating as simple users: none of the traditional professions can keep unaltered the structure and behaviours from the past. If the professional wants to be included in the transformation, there is no way to escape the rethinking of teams, references, strategies. If not, the world will go on nonetheless this choice, but with the risk of losing precious opportunities. So, as promoters, the architects are members of teams that should exploit the possibility offered by different tools, both on the front of gathering data, analysing them, and proposing new solutions that hopefully will be tuned with the new reality. A critical analysis of the Hardware and software tools that offer the new possibility of knowledge and functioning may allow some reflecting on the new level of skills required for appropriate intervention on buildings and new urban assets in the middle of the digital revolution. Following it will be defined a specific and basic taxonomy for the main digital survey tools and the other significant hardware products allowing to integrate and enhance the architectural and urban design and restoration/regeneration scenarios as well as their state of implementation in the general architectural workflows.

At the same time, the digital tools for the representation of architecture brought a significant step in the architectural profession during the past 20 years. From some reflections about this event, it is clear that critical analysis of the software tools allows identifying new possibilities of investigation and intervention in the middle of the digital revolution. In fact, this set of tools are more and more accepted in the process of the architectural/urban definition, with gradual reduction of the operators considering the operations of digital modelling and data treatment as something "external", almost a disturbing accessory, in front of the pure architecture process. A specific taxonomy will be defined for the digital tools Reflecting on the new level of skills required for appropriate operations on buildings and new urban/regeneration assets. It aimed to analyse and design the sites and the projects, with specific attention to their influence in the final results (CAD and BIM environments, data analysis, generative modelling, imaging software, crew sourcing solutions, APP for personal devices dedicated to operators/users, etc...) as well as their state of implementation Vs main difficulties in the general architectural work-flows.

Digital survey

Documenting and acquiring a correct representation of the real is a fundamental step in any architectural and urban intervention. More and more, the creation of digital twins of the reality will make available since the start a digital 3D model of the real, but right now, the options are pretty far from such a "utopic" condition.

Active measurement systems

It is considered an "active" measurement system, any tool producing a variation (emitting light or any other kind of emissions) capable of being used as a measuring procedure. Long range laser scanning works using a laser beam. The system measures the beam's time of flight (the time passed between the emission and the return of the reflection) or its variation in the phase of the light wave (Fig. 1). This operation allows to measure the distance. The scanner at the same time records the horizontals and vertical angles of the beam, positioning each point by polar coordinates that are immediately converted in accurate x, y and z coordinates. The point, enriched by chromatic values (based on reflectance values and/or colours from a separated camera) is then recorded into a file then available for 3D visualisation using specific programs. The more recent 3D scanner units are capable to gather up to two million points in a single second and with an accuracy of about one millimetre at 10 meters distance.

Figure 1. *A Laser Scanner unit (Cam/2 Faro X330 Phase Shift measuring technology with an operative range up to a distance of 330 metres) during the survey of Palazzo Vecchio in Florence, August 2019. Source: G. Verdiani.*

In this sense the 3D laser scanners (Bini, et al. 2012) in our time are the classical and most performant active measurement systems. With operative ranges going from few centimetres to a couple of kilometres, these systems are now on the edge of a significant transformation: the 3D laser scanner units have lowered their weight in the last 15 years, passing from 20/15 kilograms to the 1 kg of the Leica Geosystem BLK360. This weight reduction has been accompanied by the realisation of more and more performative machines, well designed and affordable by non-specialists. The simplification of the whole alignment/post-processing procedures has brought an extremely powerful tool in the hands of any professional. This is true for almost any interior intervention, while large buildings with articulated shapes may still result in quite tricky to easy management. The present direction taken by these tools seems to be the massive data gathering, even at the operative limits of most of the workstations, with the production of huge archives, where the enormous amount of data also works as a guarantee for later choices and for sure it compensates mistakes in the on-field operations. It seems not far a further better implementation of photographic processing and the development of fully implemented point clouds into the more and more frequent "Scan to BIM" definition (Biagini and Arslan, 2018).

Passive measurement systems

Terrestrial and Aerial (UAV/Drone) Photogrammetry has revolutionised the way to produce textured 3d models for many professionals, not only architects and engineers have discovered themselves capable of producing good quality 3d models from pictures. From a past where the photogrammetry was connected to the use of very complex procedures and highly specialised/calibrated cameras, these solutions recently (mainly in the past ten years) moved to point and shoot and fast (and often "black boxed") procedures.
This has moved the focus centre of the solution from the phase of the post-processing to the moment of the shooting. Any camera, a correct set of pictures will always produce a 3d model with applied textures. No matter if the picture comes from a smart-phone or a very professional digital SLR (Pucci, 2015), the model will always come out; the better the pictures, the better the final results. The introduction of highly portable solutions, like the recent "LIDAR" module in the Apple iPhone 12 Pro, has pushed the use of digital surveys to a very popular level.
At the same time, the large diffusion of drone/UAV solutions has brought the possibility to gather pictures in ways unimaginable until a few years ago.
This whole set of scanning and imaging procedures creates the best conditions for passing from the real to reliable digital twins, versatile for design studies as well as for restoration or simply for documentation and/or multimedia use (Fig.2).

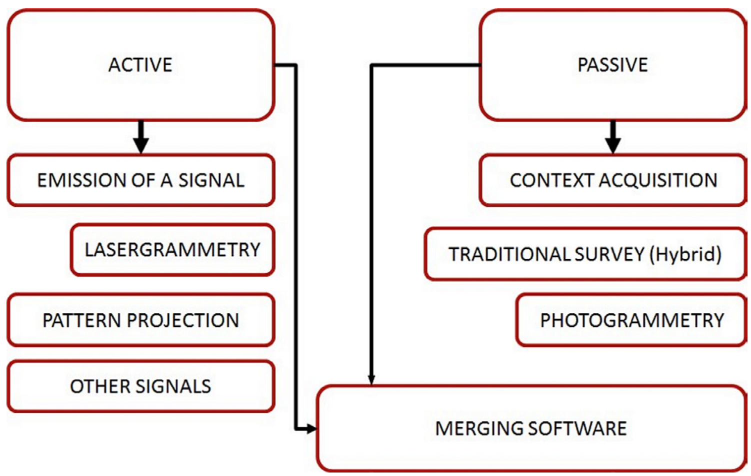

Figure 2. *General scheme for the Active and Passive measuring systems in digital survey. Source: G. Verdiani.*

Diagnostic: on the surface and under the surface

The digital tools for diagnostic are extremely impressive, efficient for getting "in-depth" information about the conditions of walls, soils, roofs, statues, mural paintings, frescos and so on… their capacity to inspect in a contactless mode and without the need of any kind of demolition allows to get a detailed description of the phenomena ongoing in the existing building. Thermography, Georadar, Electromagnetic, Ultraviolet, and so on… are the terms indicating quite different technologies to inspect and read the state of the reality. For all of them, it is important keeping in mind that the interpretation of the data is a fundamental step. Any diagnostic data gathering needs technical and well-skilled preparation. The support from specialists in these fields is more than ever fundamental. Studying an object from its surface, photogrammetry may be one of the main tools. The accurate 3D model generated by digital cameras can be used for creating various matches between different states of the same object. With specific hardware solutions, especially when combining a 3D laser scanner with the photogrammetry of single details [Columbu, Verdiani, 2014], it is possible to come back in place, in a different time and take again corresponding shots usable for checking the changes in shape of the surfaces. The same procedure can be applied to 3D laser scanner surveys, where the matching between scans in time should be better guaranteed when supported by a specific topographical/GPS integrated survey.
For example, checking the state of a vault or a wall previously digitised may help fully understand the state of the building and its ongoing conditions. Thermal photography, UV photography, X-Ray, Georadar and Geoelectric are the most common names indicating the technologies available for documenting the invisible aspects of a building under the surface. All these tools require specific competencies both on the front of the use of the single tool and on the front of the data post-processing and interpretation. Reading what is lying beneath the plaster (Fig. 3) could understand the presence and diffusion of water/humidity in a wall or terrain. The possibility to use Georadar tools to interpret the consistency of underground structures has brought a great opportunity in programming excavations, from archaeological digging to infrastructure. The preliminary inspection of the soil allows the reduction of costs, potential damages and better-aimed interventions. In the same way, the reading of the walls can bring excellent awareness about the present situation before programming a restoration (Carsana et al., 2011).

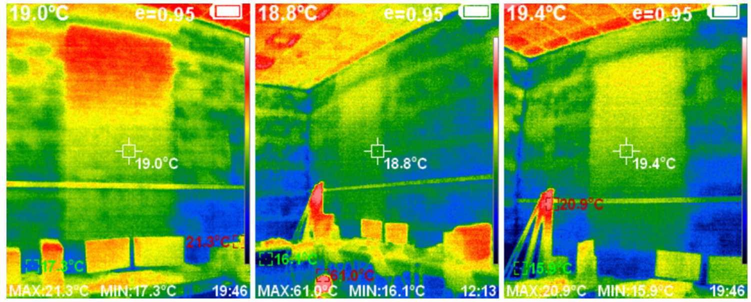

Figure 3. *Thermographic imaging showing the presence of a walled window beneath the plaster. Source: G. Verdiani.*

From digital to real

The possibility of expanding the concept of printing (from graphic sheet procedures to fully spatial models) gives a new full opportunity to exploit the digital definition of architecture. The use of physical models - of "maquettes"- has been a great solution for the materialisation of the design ideas and their checking/presentation, the production of the model directly from digital 3d models has created right now the possibility to influence two main contexts: the one, typical, of the production of scale models, where simple and/or complex shapes can be generated with easy passages, and one of the production of models and digital replicas of artworks, sites, tactile models for blind and partially sight-impaired people, that can become a part of the setup of an exhibition or in the redesign of some specific museum room. In direct relation with architecture and urban interventions, it is possible to define three main categories of physical 3D models production:
1) Subtractive model production, where the term indicates any technologies "removing" material from a raw piece to extract the final shape. Laser cutters, Mechanical cutters and Robotic arms are the most common tools of this procedure. They may look like a new step in a line of industrial machines, but their "popularisation" has simplified the previously limited access to these tools. The "cutting" machines allow the production of planar elements, from self-completed ones to entire "mounting kits". The use of robotic arms allows the production of wholly finished or partially completed models of any shape, where the limit to the complexity is only defined by the articulation of the arm and the characteristics of its working tools.
2) Additive model production. They are characterised by the large set of 3D printers developed in the last years that allow an "additive" processing of 3D models production, using various materials, like chalk, different types of plastic and resin.

These solutions are most of the time used to produce scaled models of any geometry, but it is possible to plan these models inside exhibitions, as final design products or even for special replacement/restoration functions. The more and more simply processing for passing from the digital model to this 3d printing solution is making very popular the presence of a small unit in architecture offices, and even if it is not a machine thought for massive model production, its integration in the studio activities is only a matter of creativity.
3) Real architectural element production, which is a sort of "sub-category" of both the previous. However, it can be well defined thinking that from printing in plastic to printing in concrete, the step is not that long, on the front of using 3d printing solutions to produce final architectural elements or entire buildings, state of the art is right now still at a pioneering level. However, the interesting impact of the early experiences and the fascinating connected scenario create conditions for a well promising evolution for the following years.

The Internet of things and the architects

The definition of the Internet of things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems (Wired, 2018). Traditional fields of embedded systems, wireless sensor network control system, automation (including home and building automation) and others, all of them contributing to enable the Internet of Things (Bahga, Madisetti, 2018). The concept of IoT may appear still a little blurry, but its consistency and its options will be a critical need in the near future of urban planning (i.e. the complex system of relationships established between the people driving a car, the navigation system and the network of public transportation). The main question now should be: How IoT works? An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments (IoT, 2019). IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge devices, where data is either sent to the cloud to be analysed or analysed. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with them, such as setting them up, giving them instructions, or accessing the data.

Ambient intelligence and autonomous control do not necessarily require Internet structures. However, there is a shift in research (by companies such as Intel) (Lea, 2018) to integrate the concepts of the IoT and autonomous control, with initial outcomes towards this direction considering objects as the driving force for autonomous IoT (ResearchGate, 2019). Building on the Internet of things, the web of things is an architecture for the application layer of the Internet of things looking at the convergence of data from IoT devices into Web applications to create innovative use-cases. In order to program and control the flow of information in the Internet of things, a predicted architectural direction is being called BPM Everywhere, a blending of traditional process management with process mining and special capabilities to automate the control of large numbers of coordinated devices (IoT, 2019).

Figure 4. *Urban mobility: how some of the Digital Technology influences and will influence the planning choices.*

Domotics

The term domotics comes from the union of 'domus', which in Latin means "house", and of the Greek suffix ticos, which indicates the disciplines of application, it is the interdisciplinary science that deals with the study of technologies suitable to improve the quality of life in the home and more generally in the anthropised environments. This highly interdisciplinary area requires the contribution of many technologies and professionalism, including construction engineering, architecture, energy engineering, automation, electrical engineering, telecommunications, and design (A&D, 2019). Home automation was born during the third industrial revolution in order to study, find tools and strategies for:
a) Improve the quality of life;
b) Improve security;
c) Simplify the design, installation, maintenance and use of the technology;

d) Reduce management costs;
e) Convert old environments and old plants. Home automation plays a very important role in making intelligent equipment and systems (BTicino, 2019).
For example, an intelligent electrical system can self-regulate the switching on of household appliances to not exceed the threshold that would trigger the counter. "Smart home" means an environment - properly designed and technologically equipped- which provides the user with systems that go beyond the "traditional", where equipment and systems are able to perform partially autonomous functions. A home automation system is usually completed through one or more communication systems with the outside world (for example, pre-recorded telephone messages, SMS, automatic generation of web pages or e-mail) to allow the control and display of the status even from remote (Clichome, 2019). Communication systems of this type, called gateways or residential gateways, act as advanced routers, allowing the connection of the entire home network to the outside world, and therefore to the public domain networks . The various components of the system have connected each other and to the control system by types of interconnections (for example, local network, conveyed waves, radio waves, dedicated bus, etc.).

Urban perspectives

From the self-driving cars to the flying man, the challenges to foresee the future is again an element of the table of architects and planners (Fig. 4). The intention in making any project more and more sustainable, reversible limited in energy consumption should be mandatory. However, at the same time, the need to be "elastic" about the introduction of new players and behaviours with new paradigms in urban mobility should be considered as something not related to a remote future. Self-driving cars with AI software pilots (Tareq, 2018) may influence road design and urban assets in the long run. People receiving constant information from their personal devices and moving in the urban scenario with a layer of digital indications are a "science fiction" scene closer and closer to becoming real. At now the most immediate aspect seems the one connected to personal devices and urban mobility, the use of "familiar" tools like Google Maps for reaching a place has changed a lot in the behaviours of people, as well as the way of walking around of many others (looking at their smart-phone all the time).
However, between funny reflections and future solutions, the question is yet here: how will this way of interacting with the urban areas influence the town's design? It should never be too soon to start a severe reflection about it.

Architecture and robots

What does it mean to think of a design compliant with AI and Robots? The two words at know are more and more present and recurrent in the common talking, but how they will influence the architecture is yet not that clear.
Thus, it is possible to imagine the integration of AI and intelligent informatics solutions in mechanisms, architectural details, and how certain spaces will be able to enter into a relationship with the users. The classic science fiction idea of a virtual manservant receiving the house owner is just anticipated by the recent introduction of Amazon's Alexa and similar solutions. At the same time, the more and more common use of the Arduino and similar microcomputers in design projects (Ridolfi, 2019) is creating the premises for self-autonomous mechanisms operating in favour of the functions of public spaces/housing. At the same time, experiences and premises to possible future development are recently traced by artistic installations (La Biennale, 2019) (Fig.5) and landscape design proposals (Hurkxkens, 2019).

Figure 5. *A robotic arm operating an art performance at the Biennale di Venezia in 2019, "Can't Help Myself" artwork by Sun Yuan and Peng Yu.*

CAD, or that Middle-Aged professional...

When talking about CAD it is impossible to talk about "new" technology: with a story started in 1963 (Verdiani, 2019)(Fig.6) it would be like naming "new" the Computer Mouse, the "Lava Lamp" or the "Smiley Face" (all are been invented and/or distributed from this same year). But everything is relative when is about time and tools,

but nothing can remain the same without obsolescence when everything around is changing.
So, the traditional CAD solution has been "eroded" little by little by other tools and integrations, while its central logic was trying to keep the solidity and the continuity with procedure of "direct" results. The original abstraction of the "desktop" where the CAD was the "technical drawing sheet", supported by the procedure of "I want a line, I draw a line" is until now too robust and well working to pass the way to innovations. Thus, there is no doubt the renewals and updates have brought this category of software to be more and more versatile, usable, generalist or specialised accordingly to the needs of the users. Being at the bases of many architectural processing, tools like Autodesk AutoCad (Autodesk, 2019), VectorWorks (former MiniCAD) (VectorWorks, 2019), and Bentley MicroStation (Bentley, 2019) bring on a solid tradition, where the XYZ axis is turned with the Z toward the operators like it was used to happen on the paper sheet: drawing the plant of the building and later rising up the fronts and the sections. So, no substantial changes on this front, but the user should keep in mind how many CAD is built around a quite simple central logic with enrichment of solutions all around; they grow in a long time-line following needs and new solutions, but in a series of branches that sometimes may appear quite a maze to be solved than a clear procedure, and at the same time considering that the old and well-structured procedure they have always used maybe not the more practical, and that the reason that it "works" does not necessarily means that it is "correct" from the point of view of the efficiency and the quality of the final results.

Figure 6. *The first CAD system, Sketchpad by Ivan Sutherland, 1963, developed at the Massachusetts Institute of Technology.*

3D Modelling and rendering

Architectural object communication, or any category of project, has consolidated the practice of digital virtualisation. Whether it is the rationalisation of an idea through a direct modelling process, in the case of a project, or the digitalisation of reality through reverse engineering, for the study of reality, the common work-flow is always divided into two phases. The first is the composition phase (or management for the BIM platforms), and the second, finalisation through the computation of the image rendering process. Attention is to be placed on the relationship between these two phases, which appear to be totally linked and dependent on each other. This ratio will allow the optimal result to be achieved with minimum effort and time. With this, it is considered essential for the modelling and rendering work project, useful for ordering the steps and understanding the most pivotal and secondary steps. Beyond that, today, the modelling phase can be developed either on dedicated modelling software or BIM platforms, depending on the product to be obtained. At the same time, the resulting rendering process can be calculated using different mathematical methodologies, with peculiar and recognisable differences.

Biased vs. unbiased

Since the born of Computer Graphics, one of the most significant issues has been the communication of the product, created by the programmer or the artist, to its consumer. The software platforms for creating the virtual world, or the 3D object, always had unlimited possibilities of navigation, easy depending on the preparation of the operator. The finishing point of the work or research has always been achieved by creating constraint systems useful to focus the user's attention on the particularities of the product sought by the developer who provides the finished product through them. The workflow on modelling software or managing 3D elements has always integrated image rendering engines to finalise the activity. In the scene of software houses, which over time have developed modelling and rendering platforms or only rendering engines, there are two types of calculation algorithms, based on Biased or Unbiased methods (Cgviz, 2019). These typologies differ enormously in the final coding of

Figure 7. *Same 3D digital model, rendering in Biased (on the left) and Unbiased (on the right) graphic engines.*

the visual characteristics. For this reason, they appear to be quickly and highly distinguishable (Fig.7). From this, their different and opposite peculiarities allow their optimal choice depending on the most relevant result. In mathematical terms (simplifying the concept), the difference between the types is the way to achieve the "physically correct result" (Treddi.com, 2015).
The Biased rendering engine allows the image to be obtained through calculation settings that simulate the physical components of the real world, allowing the user to choose the quality and quantity, up to the exclusion itself of one or more parts. Among these components, the most significant is calculating the behaviour of light. Generally, in Biased engines, we find the possibility of varying definition parameters of Global Illumination, Caustics, refraction or reflection comportment up to the Sub-Surface Scattering. These components can be varied, altering the accuracy of the final scene and bringing the result as close as possible to the full simulation of reality but leaving out, by simplifying or reinterpreting, the visual components that distinguish and characterise it. The setting of the calculation parameters allows the user to check the speed of the calculation process in addition to the visual code to be obtained. This gives elasticity to the Biased engine control of the time/result economy. The Unbiased render engine uses more complex calculation algorithms. It replaces or integrates the simulation components of the Biased engine, using much more precise physical and optical models, also introducing luminous interactions between the elements of the scene. In the end, the most effective implementation is always on the calculation of lights, where physical effects improve from spectral dispersion to optical aberration. However, this implementation generates a more rigid, or limited, control of the settings of the components; this is due to the vocation of the calculation process to achieve the result as close as possible to the reality, causing an increase in timing. More correctly, shifting the control of the time/result economy from the user's control (as it was in the Biased engine) to the component characteristics of the hardware hosting the process (ChaosGroup, 2016). The current situation sees the Biased engine growing in the accuracy of the definition of physical behaviours, giving the operator the possibility to choose a very advanced photo-real representation, raising the level of calculation accuracy of the simulation components. With results that are not distorted compared to reality and averagely short calculation times, or in any case always quickly controllable. While the Unbiased engine finds a strong reduction in the calculation times, always significant but necessary to obtain the most precise photorealism.

Photorealistic vs. non-photorealistic and "from representation to understanding"

The management of the virtual environment and the 3D objects contains in it is disseminated to the public through the image rendering process. At the end of the modelling and management phase and the rendering process, the operator chooses the visual coding of the final image: this coding is just the style of representation (Fig.8).

The representation methodology of the rendering occu-

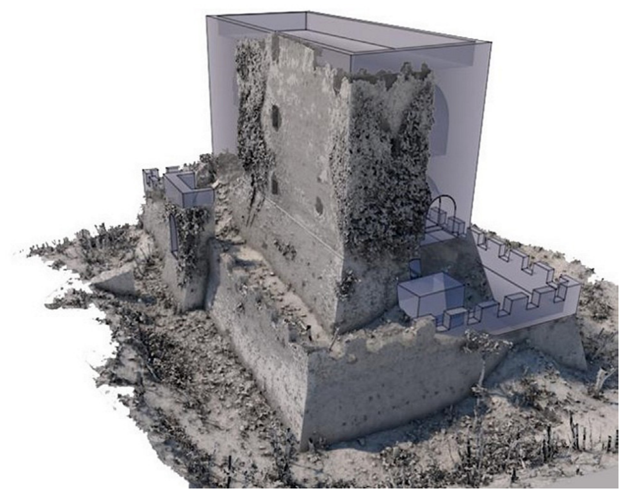

Figure 8. *Forte Giove, Elba Island, Italy, mix of photorealistic and non-photorealistic images aimed to help understanding the past aspect of this ruined fortification (A. Pasquali, A. Mancuso, M. Pucci).*

pies the range that goes from the technical drawing to the research of photorealism, passing through complex graphic codes. This is commonly simplified with the visual distinction of photorealistic and non-photorealistic. Following the previous paragraph reasoning, it is possible to connect the visual code to the choice of the optimal rendering engine to obtain it. In fact, a Biased engine, which at present can reach highly accurate photorealistic levels, is the only one capable of computing more graphic representations (DAZ3D, 2015). Depending on the software house, some Biased render engines allow both the calculation with flat colour effects and the generation of lines, ordered according to the technical standards of representation. This is combined with the possibility of saving in vector or z-depth image formats, which will allow further management of the image file with other specific software. The Unbiased engine is the maximum security for achieving true photorealism, with the only problem of calculation times concerning the final disturbance of the image (quality), and therefore its pleasantness in being observed. With this specification, which of the two ways of representation is the most suitable? For sure, the final product should already be defined at the time of the work-flow planning. On most rendering engines, the non-photorealistic (or graphic) representation is strongly influenced by the mesh topology (or NURBS organisation). As in the photorealistic calculation process, the exclusion or reduction of secondary scene components may favour the decrease of the calculation time. The desired communication guides the choice. The non-photorealistic choice may be best suited for technical descriptions or focusing on peculiar components, while photorealistic choice will bring the image to a complete perception, mainly more romantic or direct. It is, therefore, possible to simplify the reasoning, combining the non-photorealistic with the ability to provide clear information. The photorealistic with more immediate perception, moving the observer in the "trick" of simulation of the most familiar reality, opening a perception of the rendering subject connected to the memory and the experience of the viewer: this may free the ease of use of the image to a generic public and, at high levels of processing, ending in indistinguishability between real and virtual images. The evolution of the rendering engines has brought a significant change: in the biased and (largely) in the unbiased images, what comes out is a representation of the idea quite close, if not corresponding, to the real aspect of the realisation. This moves the significance of the image from a mere representation to the field of evaluation a nd reflection. If a space comes out "dark" or some elements appear awkward, it should be not a matter of "retouching" or "correcting" the image (which thing is extremely well accepted from a graphical point of view), but the occasion to re-edit and rethink some parts of the project to allow a better result. In a certain way, the rendering phase moves itself from the very ending phases to any decisional moment of the processing.

BIM, Building Information Management (or something like that)

The popularity of this acronym is just the first element to testify the extreme relevance of the step it indicates in the actual decade. Behind the many words that can be found (a simple Google search using "Revit BIM" as criteria produce about 20 million results). It is important to keep in mind two very simple facts when approaching and while treating the argument in the professional and academic debate: 1) the BIM is not a single software but a whole procedure, and it involves multiple operators, its most difficult step to take is acting the "centrality" of the 3D model in between them. 2) the production of the 3D model at the kernel of the process is not "drawing" the architecture. It realises a "digital twin" of the project to be used for the management and realisation of the project itself, the level of abstraction between real and digital is reduced. A fact that can be difficult to understand and manage for many professionals well used to basic CAD procedures.

Generative Modeling... What?

Are the architects well inclined to informatics abstractions, scripting, and programming? Optimistically is it possible to answer: "some of them". Thus, the set of software based on "procedural, parametric and generative" procedures is becoming more affordable by operators with traditional building processing in their minds. In Generative Modelling, inputs based on numerical and geometrical values are moved to define elements based on the interpretation of parameters. These procedures have brought two significant results, the development of an innovative series of buildings and the development of versatile tools for studying and implementing the analysis of places. The large diffusion of free plug-ins like Grasshopper (Grasshopper, 2019) for Mcneel Rhinoceros 3D and the recent commercial implementation of Autodesk Revit by Autodesk Dynamo (Autodesk, 2019), have brought powerful tools

Figure 9. *King's Cross Station, London - 2012*
Arup, John McAslan and partners, a good sample of generative modelling applied to architecture.

for developing fully generative projects in the context of previously "traditional" 3D modelling practice (Fig. 9). On the front of the architectural production, it is worthy of mention the realisation of sensational results from the Melbourne Rectangular Stadium by Cox Architects and Planners, built-in 2011 (Cox Architecture, 2019); to the China Pavilion for the EXPO 2015 in Milano by Studio Link-Arc (Link Ark, 2018), to arrive at the recent Morpheus Hotel in Macau, by Zaha Hadid Architects (Zaha-Hadid, 2019) and the Galaxia Burning Man Temple, by Mamou-Mani London (Mamou-Mani, 2019), both completed in 2018. On the front of the studying and analysis, the most significant are: the experience conducted by the Autodesk office and research space at the MaRS Innovation District in Toronto, wherein 2016, they brought on a project named "The Living Autodesk Studio" based on the application of generative algorithms to the production/solution of interiors on the base of pre-defined parameters (The Journal of the American Institute of Architects, 2018). At the same time, the development of powerful tools like "City Engine", released in 2008 and recently acquired by the software house ESRI (ESRI, 2019), and open tools like Cheetah, integrating Grasshopper for McNeel Rhinoceros 3D and presenting itself like "A Plug-in for Configurative Urban Design

& Planning" (YouTube, 2013), has opened to the urban interventions the opportunity to apply rapid and efficient solutions, to study the situation of a place and analyse the variable transformations in relationship to multiple parameters. As demonstrated by the very recent software, the automatic procedures can little by little be integrated for better efficiency in the design process. It is the case of Finch, a tool to automatically generate floor plans based on the constraints of a site. Architecture studio Wallgren Arkitekter and Swedish construction company BOX Bygg collaborated to create this parametric tool, which "seeks to help architects understanding the potential site limitations in the early stages of the design process" (Architizer, 2019); and by TestFit (Clifton, 2019), a software capable of adapting various building solution from their volumetric definition to the elements of service, like the best fit of a parking area to a lot.

Diagnostic and simulation tools, from the structural aspects to the environment

The development of software solutions to study and analyse reality allowed a great improvement of all the procedures aimed to understand the behaviour of structures, decay, environment, complex human and/or natural phenomena. In all the cases, these tools need a clear understanding of the real, both in terms of shape and consistency and in terms of the procedures used to study and analyse its behaviours. In all the cases, these tools need a clear understanding of how a structure works and studying the way the environment works related to the structure. By introducing architects to structural simulation in Autodesk Revit (Autodesk, 2019), the learning process is modified to work with visual thinkers—developing a stronger connection to the design process and improved direct feedback (visual in nature) to the ramifications and potentials of design decisions.
The understanding of simulation tools is required to provide an additional level of vision to the architect. These tools give decision support to create a wider array of informed design alternatives. At now, these tools appear quite various but may be resumed in two-three main groups: 1) Simulation of the structural behaviours, with the analysis of the condition of the building or when stimulated by external phenomena like winds or earthquakes. 2) Simulation of the environment, from the solar radiation to the air movement across spaces to the propagation of sounds. 3) Other kinds of simulations, i.e., the "Virtual Crowd" tools, simulating the movement of a crowd, which may not be so striking in front of other simulations but may bring very interesting reports about the design choices.
All these software solutions may be found with a stand-alone solution or as plugins/integration of existing major CAD/modelling/BIM solutions. It is important to keep in mind that the simulation's quality and reliability will be poor or consistent and realistic according to the quality of the data/information available and the accuracy of the model used for the simulation.

Conclusions

Figure 10. *Two fully graphic presentations in Microsoft PowerPoint format commenting this paper can be downloaded from www.laboratoriolia.com/IFAU2019/PPTX_00.pptx (it is possible to scan the QR codes here upon for direct link)*

This rapid summary enlists a wide series of tools, sometimes coming from different disciplines, but all aimed to influence the way of designing and planning architecture and the city. Is it an interesting challenge or not? How many architects consider the chances of contemporary technologies as something to be exploited appropriately in their interventions?

Obviously, there is no need to dive into the digital world as a new victorious conqueror of the world. However, a profound reflection about what the hardware tools offer and require in terms of opportunities, methods and strategy should be a fundamental step in reconsidering professional teaching and evolution. At the same time, an "elastic" approach to the most advanced innovation should be made with a calm disenchantment, guiding the professional and academic choice to proper results and trying to produce the most in terms of comfort and stress-reduction for all the people living across the new digital layer existing in all the contemporary cities.
The Software solutions for urban and architecture planning and/or analysis are continuously growing and are

focusing on procedures aimed at the "digital twin" logic step by step. The realisation of the digital model seems the opportunity to make less empirical the building process, enhancing the results, giving new options, augmenting efficiency and safety, reducing the costs. However, it is not a priceless miracle. It asks for understanding, learning, efforts in creating a new common ground between professionals and tools. The award is extremely interesting, especially in the scenario where the digital twins do not stop their usability at the completion of the courtyard but keep on overlaying the real for managing, dissemination, maintenance, and communication scopes.
As a condition, it needs the full participation of the operators of the building process and where Architects and Urban Planners should be driving the path, with proper research, experiences and sharing, starting from the Academy.

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Finished publishing from
La scuola di Pitagora editrice
Via Monte di Dio, 54
80132 Napoli - Italia

October, 2021

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ISBN: 978-88-6542-815-3 (e-book)