The evolution of representation in architecture

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ABSTRACT:
This paper proposes an overview on the relation between representation, technology and architecture methodologies. Focusing on disposable digital tools, it reaches the new tools of virtual immersive 3D architectural environments. It also addresses the concepts of operative 3D, augmented reality and robotic manufacturing, thus introducing a system of digital tools that enables users to step inside a 3D virtual reality environment, built as a virtual building prototype, and to use all data instructions directly with the construction industry. This paper questions therefore the traditional processes and perceptions in architecture and draw present and future advanced state-of-the-arts methodologies. As a result, future and tradition in architectural design methods are challenged. Recognizing the permanent tensions between traditional and innovative processes, possible methodological changes are put in perspective, namely the fields of technical representation, building construction and design processes.

KEYWORDS:
Architecture; Representation; Technology; 3D; Methodology

1. Evolution of Technology and Representation

1.1. Introduction to Space, Perception and Representation

The abstract theories explaining what is space and how it is perceived in Western cultures have been evolving towards other important issues of perception connected with more dynamic and sensorial approaches. From the Aristotelian vision of space and time as *categories* "that enabled the classification of sensory knowledge" (Tschumi, 1996, pp29), Descartes proposed space as an absolute object, master and container of senses and bodies[1]. Spinoza and Leibniz questioned later if it was inherent to the whole existing things[2] and Kant, "returning to the old notion of "category"", described it as "an ideal internal structure, a prior consciousness, an instrument of knowledge" (Tschumi, 1996, pp29).

By this time, in the late XVIII century, Gaspard Monge had developed in Paris, at the *École Polytechnique*, the basis of Descriptive Geometry, a representation technique of three-dimensional objects on a two-dimensional support through a system of coordinates X, Y and Z[3]. In this representation, an abstraction independent of any concrete relationship to the real world, a three-dimensional object is projected in two mutually perpendicular plans, a horizontal and a vertical one, according to an orthogonal projection system. The result of this method is the two-dimensional representation of a three dimensional object.

With the wide diffusion of the Beaux-Arts design methods, starting from the *partie*, sketched by hand in plan and perspective, the design was then *projected* in a way that, as stated by Jean-Nicholas-Durand, "the plan is considered first, then the section" and "the elevation is no more than the result of these two"[4] (Emmons, 2012, pp299). By the late 1850's, axonometric projections were introduced, allowing, with shadows projected at a forty-five degree angle, a representation technique with a highly accurate sense of depth[5].

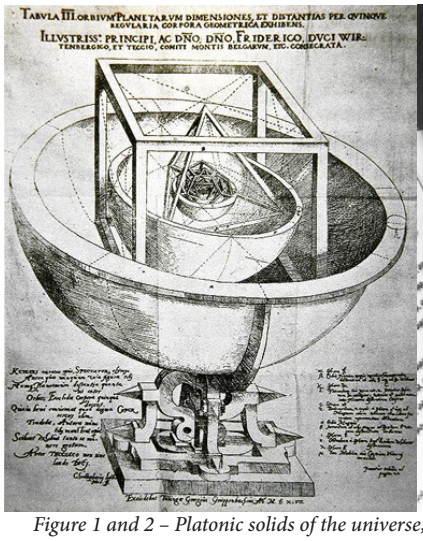
In the late XIX century, the notion of space had evolved from a metaphysic concept and Hildebrand, Schmarsow[6] and Riegl[7] considered it to be an artistic idea. Already in the XX century, Einstein would link it to the notion of time, and proposed a measurable three dimensional continuum that still reaches present time.

At the end of 1920´s, the diagram emerged, shifting to a more scientific approach to design, that didn't depart from an eclectic design, based on a prior proper style, but from one that was summoned by a complex of design circumstances. Within Western architecture, *spatium* evolved in the XX century from an literally interior space to an idea of setting limits or making room[8]. It is therefore a representation of an abstract intellectual idea, a meaningful emptiness, of a certain quantity of the m^3 that involves us, that can be developed and interpreted as a preposition, a "felt volume" (Tschumi, 1996, pp30), space of senses.

Form, materials and space were now connected to human perception studies at architectural schools and the former analytical architecture lessons made way for new introductory courses, where new students learnt about perception and language. By mid-century, the dissemination of photography, cinema and home television allowed for a new image culture. At offices and design schools, photomontage and collage techniques were introduced as innovative communication tools[9].

1.2. CAD Evolution

In the beginning of 1960 representation began to be associated with the new computer technologies. In 1963, Ivan Sutherland developed a graphic interface technology called *Sketchpad*, where a user could develop virtual drawings through the use of a digital pen[10]. During the next decade, *computer-aided design* (CAD) programs would slowly spread, and in the 80´s AutoCad[11] was launched. Despite of the technological innovation approach, CAD drawings were usually sophisticated 2D drawing tools, only allowing 3D construction and 3D rendering views in other computer environments that ran parallel to the 2D one.



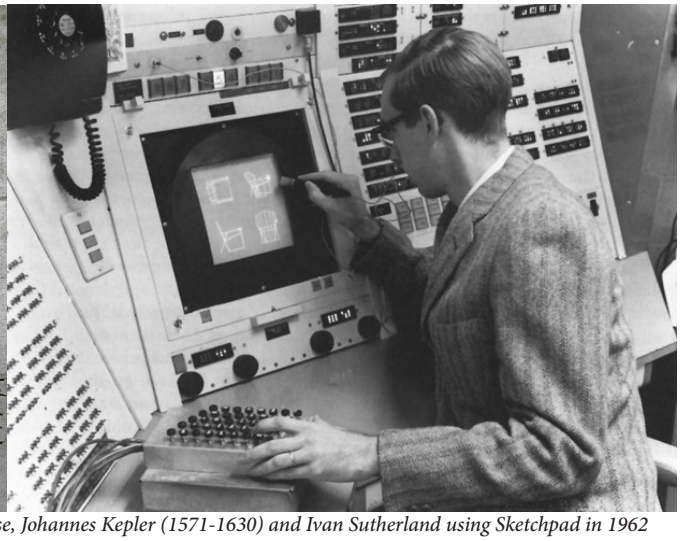


Figure 1 and 2 – Platonic solids of the universe, Johannes Kepler (1571-1630) and Ivan Sutherland using Sketchpad in 1962

However, at the end of the 1980s arose a new representation technology of three-dimensional objects, the Building Information Modelling (BIM)[12]. Still based on the method of Monge, its major innovation was the fact that it could integrate comprehensive building information and display the represented object in its virtual three dimensions, and observable from any possible point and angle. We overpassed the previous CAD software and begun to create three-dimensional operative virtual models with an extensive level of information (e.g. Autodesk Revit[13]). Through the use of this type of programs, it was now possible to develop an architectural project with clear awareness of its three-dimensional shape and easily detect, still in the design process, complex situations that until then were difficult to predict and required a strong mental effort of elements' combination.

A concrete example of the usefulness of such programs is the distribution of an air conditioning facilities project throughout a large-scale building. As it is known, this type of systems can hardly spread in a linear way across the building's entire length. Representing it under a system of representation based on plans, sections and elevations was quite a complex task and more likely to contain errors of continuity. With the open access to BIM programs, despite the building systems' complexity, their project becomes even quite easy to control. It is possible to preview it as it will be build, in its three dimensions, and follow its whole continuity. It can be watched isolated on the computer screen, without any additional elements that could interfere with it's clear interpretation and fitted in the building, together with all the other building's specialties and elements.

CAD programs would in the next years merge with *computer-aided manufacture* (CAM) and *computer numeric control* (CNC), and would also integrate new generative processes, based on variables and algorithms and improve and enlarge digital design and representation tools with virtual reality environments and *computer aided three-dimensional interactive applications* (CATIA).

1.3. Virtual Reality and Immersive Digital, Interactive and Augmented Environments

With the gradual and increasing interest of new geometry spaces[14], where the plans that define it abandon their usual orthogonal nature and become a game of multiple relationships that can ultimately lead to a single connected surface (with the ability to adopt infinite variations), the traditional representation systems are no longer satisfactory to translate and communicate the complexity inherent to these kinds of spaces.

The evolution of architecture representation to the domains of *virtual reality* (VR) and *immersive digital environments* (IDE) reached, in turn, new and more significant capabilities in regard to the understanding of virtual spaces of architecture. Unlike the aforementioned approximation techniques

of reality such as collage, photomontage or rendering, the access to immersive virtual reality technology enabled not only the development of visual products of designed spaces but also true intense experiences of those spaces.

Within the main IDE systems, the ones that stand out are, mainly, the media rooms, "a physical facility where the user's terminal is literally a room into which one steps"[15] (Steenson, 2012, pp269), such as the *Cave Automatic Virtual Environment* (CAVE)[16] and the *Head-mounted Display* (HMD), which consist of one or more displays embedded in a kind of virtual goggles that send information directly and only a few millimetres away from its user's eyes. A good example of this kind of technology is the recently announced Oculus Rift[17], demonstrated at the 2013 International CES show at Las Vegas[18].

Figures 3,4 – CAVE and Oculus Rift digital IDE

Though very close to the type of experience they provide, these technologies are actually slightly different.

The CAVE, a reference to the Plato's Allegory of the Cave[19], is a room made of four, five or six screen walls where digital information is projected in a way that the user, or users, get surrounded by the projected environment. Through the use of liquid crystal shutter glasses, the user that stands inside the room has the ability to convert the projected stereoscopic images into an immersive three-dimensional space that grants him an incredible sense of presence in the virtual reality world.

In the case of the CAVE-HOLLOWSPACE of the *Centro de Ciência Viva da Mina do Lousal,* located in the Grândola county, district of Setubal, Portugal, the chosen enclosure environment was the scenario with four screen walls: one front wall with 5.6 meters, two side walls with 3.6 metres and the floor surface which, contrary to the previous ones that are back-projected, is directly projected from a top structure. The whole system consists of a total of 12 synchronized projectors[20]. Once inside the room, the user interacts with the projected virtual environment with the aid of the aforementioned 3D converter glasses and a small human-computer interface (e.g. Wii remote[21], Kinect[22]), which allow him to control the environment he is located in.

The Oculus Rift, on the other hand, is a small-sized headset object that is placed right in front of the user's eyes, where two optic displays project exclusive stereoscopic images for each of the user's eyes and, in so doing, simulate the 3D virtual environment and the feeling of body immersion in space. Unlike the experience of the CAVE, where the user stands mainly still and it's the space that *walks* towards him, with the use of these HMD, the inclusion of a positioning sensor system and the necessary levelled and obstacle free ground surface, the user is able to undertake any random voyage through the previously built 3D architecture virtual model.

In this technology, wherein the used 3D virtual model is essentially the same one that is used to produce the common hyperrealistic photomontages or virtual walkthroughs presented in two-dimensional formats, the major difference is that the user is directly projected into the virtual space. Once inside, he will study and experience the space of architecture in the same way that he is used to do with those of

the real world. He will be able to make his own decisions (with almost total freedom)[23], choose where he wants to look or decide which path he wants to follow. An experiment conducted with the same trust that we got used to assign to our day-to-day experiences, in first-person, in a mechanically, intense and subjective way. "A novel form of spatial representation…which substitutes for the actual experience"[24] (Steenson, 2012, pp269).

With access to this kind of technology, when someone seeks an architect in order to design his *castle*[25], he no longer has to interpret the traditional plans, section and elevations, nor look into printed photomontage or virtual walkthroughs on the computer's screen. He will be able to stand in his yet to come living room, go, on foot, from there to the kitchen, visit the bedrooms and, by doing so, get a much clearer understanding of those spaces and if they really are as he truly expects them to be. In fact, with the access to this kind of technology, the greatest discrepancies between the representation of the virtual space and its subsequent physical construction depend mainly on the development level and visual detail of the former.

Let us now consider a space that, instead of being a static object, unchangeable in its geometry and all other parameters that define it, has the capability to evolve, take on new shapes and develop an interactive relationship with the person who experiences it. In any such space, the user is compelled to forsake the usual comfort position he has become accustomed to assume as the controller of space and to adopt a relationship that is not a monologue (between a subject and an object), but a true and genuine dialogue. A unique and constant communication between two active participants, where each one is able to act and react to the stimuli of the opponent and that projects the user's experience into unprecedented virtual world levels either in a mechanical or perceptual-cognitive and sensitive ways.

If the experience of static space systems via IDE was already extraordinary, it will probably be through the use of this technology that a full representation and experience of interactive architectural virtual spaces will be achieved. If we consider the possibility of representing a space of this kind in two-dimensional formats like plans, sections and elevations, we will quickly realize that it is almost impossible to include all the necessary significant information to allow its full understanding. The space does not have one, but multiple shapes and it's only through the introduction of the user's variable into the experience equation that space and its consequent representation begin to change. Spaces like these hardly allow reductions, abstractions or representations other than the ones that reproduce it, including all its three dimensions and the unfolded evolutions that characterize it.

To think and project a space of this nature it is not longer satisfactory for the user to be projected into the space itself or for him to freely roam through the space of architecture. In these spaces, it will be imperative for the user to interfere with the space that surrounds him. To play with its geometry, change it, reform it, reorganize it and, by doing so, since a new reality has appeared ahead of him, to rethink any possible moves that he had formerly thought.

But yet another level of the relationship between real and virtual has emerged in the last recent years: The one of *augmented reality* (AR) and the old science fiction – but now more than ever realistic – concept of *hologram*. A *real world* reality that, in the inability to be more than what it actually is, is enhanced by its fusion with the one classified as virtual. Once again, the barrier that separates physical and virtual fades and the two realities get closer. However, contrary to what happens in the IDE's, where the 3D immersive systems and the quality level of the represented project are the ones that bring both realities closer, in these cases of augmented reality and holograms, it´s the virtual reality that invades the material world, converting it into a hybrid space where both realities share the same environment.

The technologies previously described, in which the virtual world experience blends with the one of the real world, are the ones which will probably, among diagrams, prevail one day as decision tools and the common architecture methodology of space definition. Once we overcome the barriers that have limited and led us for many years to transform the communication of a three-dimensional space into two-dimensional representation methods, perhaps a new era in the culture of representation is about

to open up to the discipline of architecture. Many abstract representations of architecture spaces may fade away giving rise to new methods of space thinking. The architect may even get the opportunity to get rid of the traditional tools that he got used to employ during this process and assume a *man-to-space*[26] relationship, where space actually arises in front of him, coming from nowhere but with the exact forms, relations and proportions that he wants it to have.

There are nevertheless several doubts and questions that arise at this stage of foreseen brave new worlds[27]. Will the architect be able to update the traditional methods of thought and design that he has become accustomed to using during the exercise of the search for space? Will the architect be able to incorporate such a new and radical approach to the construction processes of architectural spaces, a methodology where the main study of space is done from inside the space itself? Is it feasible, practical?

2. Future and Tradition in Design Culture and Representation

> "Today, we have bodies which are both liberated from place and inseparable from it. This kind of double corporeality can either transform or not transform architecture. While part of it works to bring about reform, the other part keeps change at bay. Ultimately, however, I believe that the body freed of place must inevitably change the nature of architecture. That change will take the following two forms. First, the transformation of our physical senses will alter the nature of architectural space. Second, the development of communications media will cause architecture to collapse in its incompleteness".
> (Toyo Ito, 2000, pp1434)

> "If we lose our traditions, I believe that we have no future"
> (Wang Shu, 2012, pp739)

2.1 Tradition and Technology

One can consider that technological developments propose a new universe of practice and also of though, as this grows from an overall adaptation to new cultural values. However, the availability of new technologies and artifacts also raises a resistance to change, as if one finds it difficult to keep up with the technical vertigo, like if it was too sudden for our day-to-day routines and senses.

Therefore, there is a permanent tension between tradition and innovative processes.

In architecture, this tension also relates to a fracture between tradition and technology. As Reyner Banham wrote in the 60´s, "'architecture' defined in terms of its professional history versus architecture as the provision of fit environments for human activities"[28]. A tension between history and science and "professional knowledge" (Vidler, 2012) and a disciplinary opening towards other scientific methodologies.

Nevertheless, one of the compelling data changes that the architecture faces nowadays is a progressive need for technological proficiency. Technology as BIM allows a more accurate assessment of various quantitative aspects of construction, like understanding the exact amount of building components, their spatial, structural and infrastructural coordination, cost control and overall performances (in energy and environmental terms). In addition to the advancement of 3D representation, it gives an overall greater visibility to the buildings inner space, enhancing the communication among all design and building agents.

This introduces a new kind of *accountability*, which can help clarify the design assumptions and eases critical review by other building partners.

From the construction industry point of view, the digital system enables a much more complete correspondence between construction and design. At the same time, it also demands a new set of technological and space/design analysis skills. Moreover, CAD / CAM processes ensure ease and speed at non-standard element production, which allow, from a technological and economic point a view, a whole new set of geometry forms and new materiality. Also, the improvement of robotics associated with construction, provides a direct connection between CAD instructions and robotics and anticipates a disturbing perfectly match between architectural representation and building production.

However, one can still ask about the real impact of technology on earlier stages of invention and not only on production processes.

2.2 Design Methods

Architecture operates on reality in a complex mode: it mixes levels of information, introduces ideological and emotional elements and enables the discovery and the accidental. This *operating system* runs considering an accumulation and an overlapping of facts, objectives, sensations and images. It aims to achieve internal integrity, which will merge contiguous information and objectives (including multidisciplinary ones) within a unified view of a formal item, which has a corporeal existence and a spatial presence. It is a quest for balance, where technical effectiveness coexists with authorial expression.

The underlying methodology is an argument-research approach that finds and builds an internal mechanism of coherence of its own act – a thesis, so to say. This exploratory process is a practical reflection, an in-action thinking, in which the arguments are both a prior idea and an analytical and typological construction. They can also be a selective organization of a number of intuitions and discoveries made by chance. As stated by Álvaro Siza, design goes forward between inducements: "the project of a home comes in different ways. Sometimes it comes suddenly, others painfully slowly. Everything depends on the ability and capacity to find stimuli – difficult and definitive walking stick of the architect" (Siza, 2009, pp25).

Thus, a design concept is an operative tool. It is the set of assumptions (or a core), on which the internal coherence procedures converge. Design research revolves around these premises, either to validate, accentuate, or just to lighten them. Drawing, modeling and rendering, in all possible different forms and media, can be its instrument, giving sense to the proper name *project*, which overlaps a technical system of representation and a creative process, by which one studies and resolves the physical form.

In fact, architectural design usually evolves in drawing stage, in a way that conciliates plastic (formal) and linguistic (written) knowledge as a research tool. Hence design is both an action and a piece of research. And at the end it can inclusively exist without its necessary material construction.

The orthogonal projection system enables, as we have already pointed out, an abstract representation of space and the perspective technique allows an immersive and natural vision of the idealized form, projecting therefore the idea of the architectural object[29].

But, as a research process tool, drawing is used in several different design moments: for analytic studies, for conceptual approaches, for presentation, detailing, building information and, as a communicative tool[30]. The whole process is built upon systematic and overlapping verifications over representations, where drawings are the very first construction of a proper particular architectonical reality. This introduces another dimension to representation: it allows for a personal expression related with what architecture should be[31].

In drawing this is perceivable by the graphic expression. Either hand drawings, codified 2D projections, perspectives, photomontages, or virtual and physical models are instruments for design production as

they set a specific authorial view upon architecture. Therefore, these tools are implicitly translating and questioning the designers thoughts. And, as research tools in a multistage process, they can be used in diverse moments, for different purposes and with different expressions and results.

Digital techniques advancements are once again pushing forward a reorganization of these tools: as noted before, the digital techniques can provide a full immersive visualization, operating inside the 3D virtual environment. These outlooks introduce new possibilities: design can proceed directly into three dimensions, eventually building a full model *ab initio*, allowing 2D and 3D views simultaneously.

This proficiency accomplishes full 3D representation and operability, enabling reversing the so far natural order in the design stage: the 3D model will be constructed as 2D projections are built following the needs of the process' data communication. Ultimately, with the large-scale CAD / CAM processes, one could theoretically consider whether the traditional 2D representations will someday be disregarded for building construction.

However, this methodological inversion is not an absolute novelty. Educators and architects have for some time now, taking advantage of scanning software of physical models such as CATIA. In this procedure, the design progress (with all tools deemed necessary) converges in a conceptual stage toward one main solution in a physical 3D model. The model is later scanned; gathering all data into a virtual 3D model and allowing a new stage of design, toggled between hand and computer drawing and physical and digital models.

Nevertheless, so far each tool has its own particular relevance. In fact 2D general drawings allow a stand still overall image, that is printed in paper and overlooked as in a drawing board. Similar to the ancestral *ichonographia*[32] (Emmons, 2012, 298) it shows the overall space-pattern, involving design with old ideas of sequence, proportion and balance. Likewise, collage and hand drawing are used as fast and informal tools for graphic expression and formal research. Hand and pencil are a natural and yet not surpassed interface, challenging digital media.

In fact, the role of sketching in the earlier stages of design still remains fairly impervious to digital processes. Since the speed and the ambiguity of the media enables freely interpretation from imagination[33]. It also allows a direct relationship between body and expression, a work of *body mind*[34].

To sum up, new tools emerge for 1:1 scale vision of a wholeness design, as if one has access to the architect's mind. However, its ability to change the *modus operandi* of the creative process, surpassing the sketching and two-dimensional outlook is yet unknown. Still, one can ask: does digital offer new advancements to already existing tools, pushing up reorganization, or is it completely surpassing the already existing tools?

3. Future Trends and Provisional Conclusions

A common perception is now arising, according to which there will be a gradual dilution between reality and virtual realm. This vision results from a sense of progressive internalization of an array of immaterial values, which frees individuals from their old limits of corporeality and sense of place as a result of the broad use of new communication technologies that enable the individual to transcend the space and time where he stands.

We become acquainted with the instantaneous with overlapping images, dwelling the intangible (or living in multiple dimensions, as in David Cronenberg's *eXistenZ*). So, we can imagine a new kind of architecture in line with new arising values: a far more homogeneous, transparent, ephemeral, intangible and mutable space that questions the traditional material substance and the perennial qualities of architecture.

It should also afford the coexistence of the virtual and real realms in the same universe. This has to do with the prospect of incorporating digital information on building elements, introducing changes to the built environment, either by physical form variation or by carrying virtual elements into real space, such as images, color, light, graphic information, or others. In other words, a virtual presence in the real world experience that blends the nature of both realities and transforms itself in an actual augmented reality.

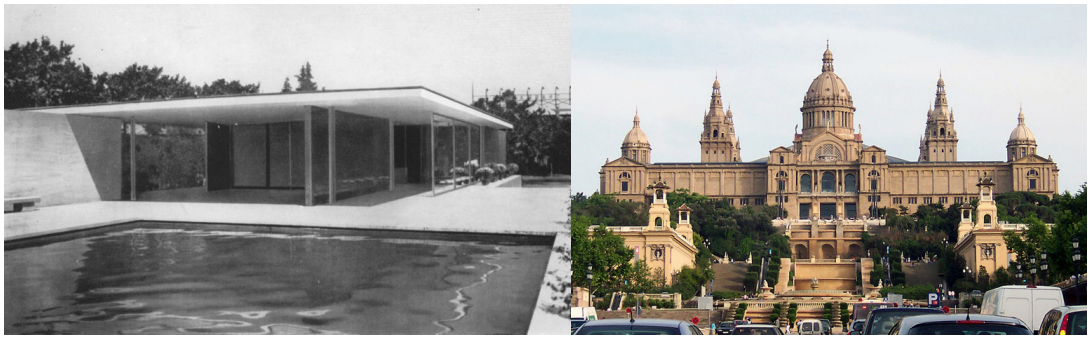
An idea of this scenario is given in movies like *Minority Report* (2002). In the architecture world one example is the filmic representation of Greg Tran on *Mediating Mediums*[35]. In this film we can see how, in Harvard, the line between websites and real life can be blurred, and desktop interface becomes a kind of architectural feature *perse*, reconciling it with craftsmanship and raw hand touch. In this perspective, material and immaterial are combined into a new world, simultaneously virtual and real.

Concluding, in such reality, all tools will probably be used, reorganizing design stages, encouraging research and opening new doors to perception. Physical and virtual realms will be blurred; building construction will grow technologically opening up, as said before, to new ways of *making room*.

Figures 5,6 – Minority Report and Mediating Mediums

Just like a global cultural world, where global and local coexist, there will be a predisposition for all types of technology within a wide range that goes from digital to analogical, from virtual to material and from industrial production to the humanistic imperfection of craftsmanship.

Remembering that "technology itself will not rescue us from our circumstance, we just can´t draft a new world and print it out" (Jacobs, 2013), ultimately, architectural objects embodies ethical and political values, whereby technology will always be a tool and not a purpose in itself.



Figures 7,8 – Comparison between The Barcelona Pavillion and the MNAC building, both built for the 1929 Barcelona Universal Exposition

Nevertheless, science has been, along with Humanities, one of the main areas dedicated to the knowledge and study of Man. Once finished, the results and interpretation of these studies become relevant, in at least two different approaches. While, on the one hand, the result is the expansion and deepening of the hitherto current knowledge of Man, on the other, these results are used to define, through concepts of otherness, the knowledge and consciousness that Man has, or had, about himself at a given time and space.

In this context, the technological state of the art of a society reflects, not only the limits of its tools and technical skills but also the state of evolution in its thought at that time and space as compared to other past or future times and spaces. And since that, besides himself, are the creations of Man that best communicate what he and his society once were, we could say that, during the development of these creations, we should make use, whenever possible, of the most appropriate resources at our disposal, in order to reflect what we actually are in an intellectual, technological level.

Endnotes

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[2.] *Idem, Ibidem*.
[3.] Emmons, P. 2012: *Drawing and Representation*, pp. 299.
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[10.] Steenson, M. W. 2012: *Computing, Computer-Aided Design*, *Media*, pp. 302.
[11.] Smith, D. K. 2007: *An Introduction to Building Information Modeling (BIM)*, pp. 12
[12.] Autocad is a computer assisted design software by Autodesk
[13.] Autodesk Revit is Building Information Modeling Software by Autodesk
[14.] As in John Rajchman *Novas Geometrias, Construções*.
[15.] Richard A. Bold, *Put-That-There: Voice and Gesture at the Graphics Interface*, in Paul Emmons Drawing and Representation.
[16.] Dias, J. M. S, Costa, V. C. and Pereira, J. M.: 2010 *Tecnologias CAVE-HOLLOWSPACE para a Mina do Lousal.*
[17.] The *Oculus Rift* is a headset of virtual reality for video games - www.oculusvr.com.
[18.] CES stands for *Consumer Electric Show*, takes place once a year in Las Vegas, USA, and is broadly considered the most important electronic and digital tech show in the world.
[19.] Pape, D. 2004: Electronic Visualization Laboratory, *http://www.evl.uic.edu/pape/CAVE/oldCAVE/CAVE.html*
[20.] Dias, J. M. S, Costa, V. C. and Pereira, J. M.: 2010 *Tecnologias CAVE-HOLLOWSPACE para a Mina do Lousal.*
[21.] Wii remote is a controller for the Wii video game console by Nintendo.
[22.] Kinect is a motion sensing input device by Microsoft.
[23.] As previously mentioned, the user is conditioned by free obstacle available area.
[24.] Robert Mohl, *Cognitive Space and the Interactive Movie Map: An Investigation of Spacial Learning in Virtual Environments*, Molly Wright Steenson *Computing, Computer-Aided Design*, Media
[25.] "The house of an Englishman is to him as his castle". Sir Edward Coke (1552-1634).
[26.] As in the term 'man-to-man'.

[27.] As in Aldous Huxley's book *Brave New World* and with the same dubious sense that the author wishes to maintain.
[28.] Reyner Banham quoted by Anthony Vidler in *Troubles in Theory: Technology vs Tradition*
[29.] As noted by Joaquim Moreno at *Desenho Projecto de Desenho.*
[30.] As noted by Alberto Carneiro at *Desenho Projecto de Desenho.*
[31.] As noted by Rafael Moneo and Joaquim Cortés in *Comentarios sobre dibujos de 20 arquitectos actuals.*
[32.] *Ichonographia* as derived from the ancient Greek *ichnos*: path, trace, vestige; and *graphia*: drawing. It means a kind of a footstep on earth.
[33.] As noted in Kendra Smith *Architects Drawings: A Selection of Sketches by Famous Architects trough History.*
[34.] As *bodymind knowledge* by John Chris Jones at *A Theory of Designing.*
[35.] Greg Tran, *Mediating Mediums*, at www.gregtran.com.

Figure 1 – Accessed at *http://mathsimulationtechnology.wordpress.com/*, on 22-01-2012, public domain.
Figure 2 – Accessed at *http://www.upf.edu/*, on 21-01-2012.
Figure 3 – © Dave Pape. Acessed at *http://commons.wikimedia.org/*, on 15-01-2012.
Figure 4 – © Oculus VR, Inc. Accesed at *http://www.oculusvr.com/*, on 16-01-2012.
Figure 5 – Minority Report, 2002, Steven Spielberg
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