Hypertext of the ecclesiastical architectural heritage of the Padova historic centre

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Abstract

It is possible to recognize the importance of knowledge of configurative geometry for creative thinking, the scientific knowledge and the practice? Do we can attribute to a geometric knowledge a founding and fundamental role for the correct displaying of the knowledge of the cultural heritage? The answers are affirmative certainly understanding that if this knowledge not only allows manual graphics processing (and, consequently, digital), at the same time rigorous and expressive, but is also fundamental for the construction of charming and realistic in motion computer images. Moreover, flexible geometry still ensures achieving a high level of expressive capacity, spendable in any other experience of architects and engineers, aimed at both the documentation and the design of complex and articulate spaces and structures. Being inadequate the only paper for the restitution of the aspects of dynamism and of going trough architectural spaces, we propose the management, in a hypertext, of drawings, surveys, maps and historical iconography, real and digital movies of CAD reconstruction (taking, as a case study, the ecclesiastical architectural heritage of the Padova historic centre); management which, in different ways, provides the highest level of completeness and speed through an analysis of different resources.

Keywords--- **configurative geometry, architectural representation, hypertext, hyper-representation.**

1. Introduction

As can be plainly seen, architecture is identified *via* its realisation and construction, establishing not only an operational relationship with the material used, but also satisfying a "living" need of human beings. If however an architecture is inhabited only by its owner and he who comes into direct contact with that building, by handling the materials and the instruments from which it is made, is considered the constructor (and the builder), it is in the transition from an initial idea of architecture to its realisation which traces out the complexity of the project process; a process that Vittorio Gregotti recognised as the distance from material concreteness when he states that the architect doesn't produce houses but rather designs them [1]. The project, in fact, considered as the point where the architect's idea is expressed and takes shape as it develops and organises itself, is nearer, in a logistical process, to the theoretical concept than to the practical execution: nearer to the world of ideas, of thought and of logic.

Architecture, therefore, conceived in the mind of the architect, finds its expression not so much in reality but rather in a mediation that represents and establishes not only spatial values, but also metric or functional ones: architecture, to become real, has to be represented. Considering the many meanings of the term "represent", the main ones can be identified immediately: mimetic-reproduction (re-present), historical-documentary (record) and descriptive (show/demonstrate), are all meanings that, even if as objective and neutral as possible, are attached to the analytical aspect of the knowledge and communication of the architecture, rather than to the project (at this point it should be noted that, in this case, representation can take on synthetic subject connotations, such as for a survey drawing in which too much neutrality and objectivity would reduce the operative significance and the planning value).

Therefore it is the meaning of "model" that connotes the representation as a further state (alongside historical, theoretical and technical) of architecture: other than including all the aforementioned meanings of representation – mimetic, descriptive and historical –, the model also takes on other more meaningful significances that qualify it as architectural double: it positions itself both as a *medium* between theory and construction as well as being a way of bringing about the piece of architecture itself, that is to say from its first idea to its realisation.

In order to represent the architecture, an ability to create a geometric model of that piece of architecture is essential.

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2. Architecture and geometry

The debate regarding the relationship between architecture and geometry, even if the focus of the issue has changed over time, is as relevant today as it was in the past: the importance of the problem is acknowledged even if over time the connection has sometimes been denied – in terms of intention if not in reality – and geometry has been considered on the one hand merely a speculative abstract science, whilst on the other that the contributions made in the field of architecture are associated with a rigid idea blocked by stereometries, that take into account only the *elementary* aspect of geometry.

In the *Prologo* of *De re aedificatoria* (1452) [2], Alberti suggests that architecture should be considered a collection of principles, and that "Symmetry" is of particular importance: it should be noted that the term *symmetry* was not meant as its current meaning gives, i.e. rigorously mathematical, but rather a more general harmony between the elements, and between the elements and the whole. Therefore only in a few cases can it translated into proportional numerical relationships [3]. According to these principles, an absolute and necessary reciprocity exists between architecture and geometry throughout the entire design process and is furthermore present at all the construction phases of the project. Through his imagination, fuelled by a complexity of visual-cultural inputs, the architect conceives an architectural idea which, although still at a cerebral level, begins to appear, form and exist. Obviously, the creative elaboration requires stimuli, rethinking and adjustment that cannot ignore the graphical verifications of the first spatial intuitions and therefore the vital contribution of geometry. It is indeed geometrical *culture* – using the term culture not only in the sense of "collective knowledge" – that aids the formation of the idea, acting as an incentive for a formal intervention into all living spaces.

Filtered from the architect poetics, a network of values is programmed – not only aesthetically speaking, but also functionally, technically and managerialy etc. – that will be expressed in the works' construction *continuum*. Also in the creative phase, architecture has its own completeness, presenting *in nuce* the characteristic of continuity: in fact, in the uninterrupted flow of thought and configurations that translate it, those spaces are highlighted, for their relational and structural aspects mediated by geometry rather than for their metric properties. It is the configurative and generative properties, from geometry itself, that stimulate the invention, in a constant exchange between rational thought and poetic expression.

Again, the transition from the conceived space to its realisation, from the idea-project to the actual building, occurs *via* the mediation of a message, whose decipher code belongs to he who communicates the idea, in our case this is the architect, and to those who construct the building. Such a *message* – in terms of notice, notion and knowledge sent out to others in written or oral forms – comes in the form of a drawing, or rather a graphical model of those configurational ideals: the code is once more geometry, that translates those ideals into a rigorous plan, likewise guaranteeing the coexistence of metric and therefore objective connotations, together with a series of relational connotations compliant with the original meaning of symmetry – that is psychological.

Initially, however, only a synthesis of the idea's totality is obtained, a schematic reduction, a model as previously stated, that acts as building instructions for the executer, and to the designer as explicit and visible support in the verification, control and perfectioning of the idea: geometry, already seen as a methodological instrument for considering the architecture in speculative projection, becomes a special code for constructing the drawing in the discontinuous model form, as support of the message along which the thought becomes a construction.

Geometry also plays a part in the latter phase, a strictly operational form of geometry, that has no place in speculative thought or on the cartographic plane – in terms of "marks on paper" –, but rather in the material dimension of the building itself and the practicality of the building yard. Contrary to popular opinion, this stage is far from easy, as the geometric culture and sensitivity of the operator comes into play here. Let's try to imagine a Medieval constructor intent on building a cross vault: he would know that the groins, from which the building work starts, form the lines of intersection of two equal dimension semi-cylindrical vaults, that are not circular but elliptical. There is a double-sided problem: the determining of the model of the said intersection, the building and sizing of two semi-ellipses, that in turn must be transformed into centerings and each drawn to a scale of 1:1. It is obvious that the practical difficulties become insurmountable without an adequate knowledge, not only techno-constructive, but above all geometric: it is indeed not uncommon to find that the centrings of the cross form two simple semicircles, relying on more arbitrary strategies for the construction of the vault's remaining parts, which obviously result in abnormal shapes from the confused and irregular positioning of the stones or bricks.

Lack of geometric knowledge is not only reflected in the construction of the building itself but also in the practical difficulties of configuring the individual elements that characterise it. The simple squaring of a stone block requires a certain technical ability, but the operation is complicated further if the masonry structure requires special cuts, as is the case of vaults or arches, of the cutting of truncated-conical block of columns or even more complex structures such as oblique or curved tunnels, flying buttresses and *trompes*, where geometric control does not stop at the correct modelling of every construction component, but rather weds itself to the total harmony of the building. Even if the art of stereotomy [4] had been long carried out empirically and passed down as on the job experience, such experience was not able to compensate for the lack of geometric knowledge, neither could the geometric authenticity of the act itself cancel the wealth of knowledge and study that led to the formulation of a real branch of geometry, known as "stone cutting".

Geometry as a principle of architecture is also part of the heritage belonging to the contemporary designer, whose projects are considered to be tied to formal and therefore restricted characteristics: in fact the adjective *geometric* is associated at the most elementary plain figures and solids, in which only metric properties appear – exactly those properties that characterise *elementary* geometry.

2.1. Prejudice about geometry

In order to understand the role of geometry it is necessary to rid ourselves of a series of prejudices: the majority of people seem to believe that geometry is merely the study of the metric properties of figures and space, properties that instead characterise *elementary* geometry. Such prejudice seems to endorse a lack of study which seems, even if unjustifiably so, bristling with difficulties and, as such, is rejected.

Geometry is therefore attributed with an extremely reduced role, that of being an instrument for the formal definition of the bodies and spaces, thus considering every other aspect of the discipline belonging exclusively to abstract mathematical study and therefore of little application to architecture. This opinion is not entirely unjustified because, despite the visible immediacy that characterises synthetic geometry, all research in this field has been long abandoned by mathematicians, favouring algebraic and analytical problems, that render the problem abstract and distant, thus limiting its divulgation and discouraging potential cognitive approaches. There arises the need for a different use of classical geometric theory, whose recognised flexibility allows an efficient adaptation to the new vision of architecture and representative space.

The etymological meaning has been lost that gave geometry the primitive role of *measuring the land* - when, in Ancient Egypt, it was necessary to reinstate the borders of agricultural terrain, wiped out by the periodic flooding of the Nile. Those basic principles took on a whole new meaning *via* the Greek philosophers, who discovered the numerous properties that the figures possessed – in particular conics [5] – and which led to the formulation of a general and complex theory, of which *Elementi* [6] by Euclide, and another treatise (particularly significant to us), by the same author, entitled *Ottica* [7], are valid testimonies. Subsequently, a series of different but just as important properties other than the metric ones were discovered, specifically known as *projective properties* [8]: these properties, formulated in a relatively recent period [9], but already understood by fifteenth century artists - the most relevant contribution coming from Piero della Francesca, under the title *De prospective pingendi* [10] -, allowed for the development and codification of that rigorously scientific method (because it is based on the geometric and optical theories of Euclide) named by him *prospectiva artificialis*. The projective properties are, in fact, those that the figure maintains when projected onto a plane, exactly those that allow the recognition of the shape and an evaluation of size and distance, despite the apparent deformations with which the objects and space present themselves in our vision.

Recently more intrinsic *topological properties* [11] than the *metric* and *projective properties* have come to light: these, apparently less evident than the others – and for this reason discovered later – are in reality acknowledged with extreme immediacy: topological properties are in fact those that the figure retains even when it is subject to such significant transformations, such as continual deformation, that it loses all other properties, both metric and projective [12].

2.2. Hypertext of the ecclesiastical architectural heritage of the Padova historic centre

Given that geometry has now overcome its aforementioned limits through the discovery of more general and profound properties in addition to its metric ones, geometric language – which, as we have seen, assists the entire design process – has become the most appropriate instrument for the definition of the structure of architectural spaces as they take shape: geometric structure, identified *via* a gradual process of abstraction and characterised by the mutual relationship between the parts, builds up a significant matrix of any piece of architecture.

Therefore teaching methodology for geometry and its development takes on a basic and fundamental role in the training and education of engineers, architects or anyone else involved in managing architectural space.

It is essential to recognize the importance of knowledge of configurative geometry for creative thinking, scientific knowledge and practice. Furthermore it is possible to attribute geometric knowledge with a founding and fundamental role in the appropriate display of cultural heritage knowledge: this knowledge not only allows rigorous and expressive manual graphic processing (and, consequently, digital), but is also fundamental for the construction of charming and realistic *in motion* computer images. Moreover, flexible geometry still ensures a high level of expression, usable in other contexts by architects and engineers, aimed at both the documentation and design of complex and articulate spaces and structures. Due to the inadequacy of paper as a resource for the restitution of the aspects of dynamism and of moving through architectural spaces, we propose the management, in a *hypertext* [13], of drawings, surveys, maps and historical iconography, real and digital movies of CAD reconstruction - taking, as a case study, the ecclesiastical architectural heritage of the Padova historic centre -, management which, in different ways, provides the highest level of completeness and speed through an analysis of different resources (fig. 1).

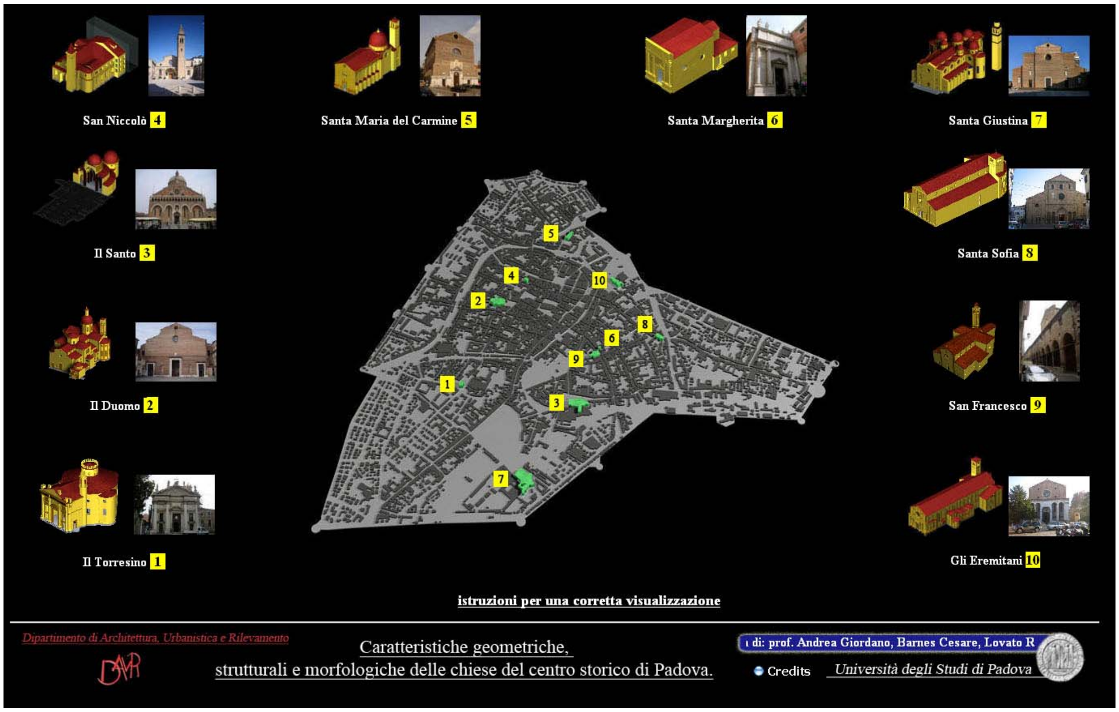

Figure 1 Starting page of the Hypertext

And this hypertext would become a *hyper-representation*: if in fact, the hypertext - unlike the more classical and canonical form of knowledge, the text, whose information comes, to the reader, in a linear and sequential form - is a free interactive and associative link between information placed at various points of the same document, the hyper-representation becomes a structure composed of nodes - ie written information and graphics, which may appear in the form of text, image or whatever - and of links, namely the interconnections that allow you to connect nodes with each other and therefore the same information, with the possibility of directing and guiding it, depending on the representative intentions that hyper-representation itself is finalized with (figg. 2, 3).

Conclusions

If we consider this instrument for representation not only as a way of reproducing or imitating reality, but also for recognising its enormous analytical/cognitive potential, that is its fundamental role as an instrument of knowledge for getting what is real to take shape, it is possible to understand that the most interesting quality of any cognitive *medium* (classical-representation or hyper-representation) is not its capacity for imitation but rather simulation and interpretation and, consequently, its ability to create possible worlds: the aim of the hyper-representation (as for drawing) lies therefore in its creative potential.

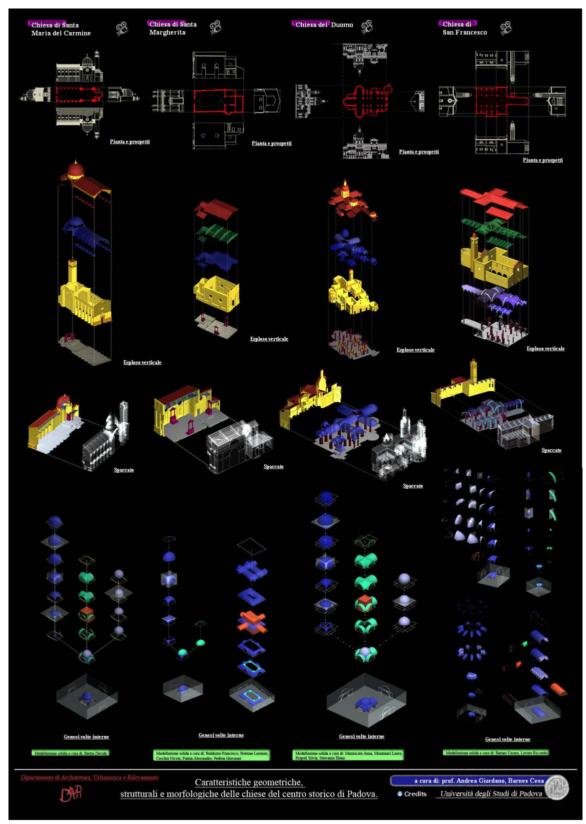

Figure 2 Interconnections

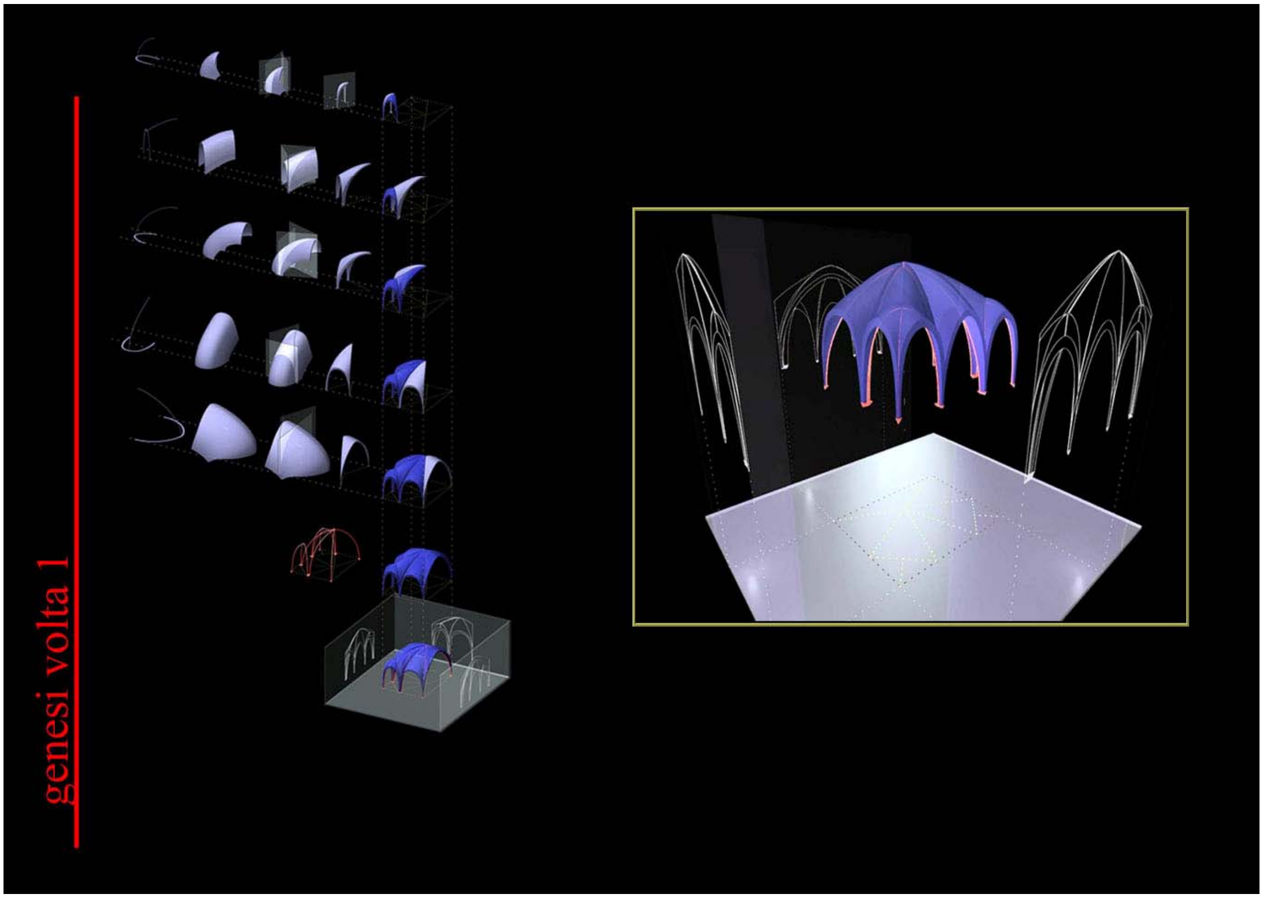

Figure 3 San Francesco church genesis of composite vault hyper-representation

References

[1] Cfr. GREGOTTI, Vittorio, *Il territorio dell'architettura*, Feltrinelli, Milano 1977.

[2] Cfr. ALBERTI, Leon Battista, *De re aedificatoria*, Firenze 1948, anastatic reprint Milano 1966.

[3] PACIOLI, Luca, *De divina proportione*, anastatic reprint Milano 1982.

[4] The first eighteen century text on stereotomy was written in 1728 by Jean Baptiste de La Rue, in which we find tables of such exceptional graphical quality that Monge used in his course on the applications of descriptive geometry for stone cutting (J. B. de La Rue, *Traité de coupe de pierres*, Paris 1728). The one by Frézier (A. F. Frézier, *La Théorie et la pratique de la coupe des pierres et des bois, pour la construction des voûtes et autre parties des bâtiments civils et militaires, ou Traité de stéréotomie à l'usage de l'architecture*, Strasburg 1737) is the most complete. Cfr. SGROSSO, Anna, *La geometria nell'immagine. Tra Rinascimento e Barocco*, Utet, Torino 2001; GIORDANO, Andrea, *La geometria dell'immagine. Dal secolo dei Lumi all'epoca attuale*, Utet, Torino 2002.

[5] Archimede di Siracusa (287-212 a. C.) and Appollonio di Perga (?-190 a. C.) made an important contribution to the subject. For the first cfr. CHASLES, Michel, *Aperçu historique sur l'origine et le développement des Mèthodes in Géométrie*, Bruxelles, 1837, anastatic reprint Sceaux 1989. The second was the celebrated author of *Trattato delle Sezioni coniche*, whose version in Latin dates back to the end of the XIX century. Cfr. FREGUGLIA, Paolo, *Fondamenti storici della geometria*, Garzanti, Milano 1982.

[6] The work obtained by us is certainly not in its original form, but it is the version that the accademics consider the most reliable and complete is the editio princeps of Basilea (1533). Cfr. DE ROSA, Agostino, *La geometria nell'immagine. Dall'Antichità al Medio Evo*, Utet, Torino 2000.

[7] Cfr. OVIO, Giovanni. (a cura di), *L'ottica di Euclide*, Milano 1918.

[8] The new properties –the ones that do not change with the projection and are therefore called projective are as follows: *three point co-linearity* (the projection of three aligned points remain three aligned points, or rather each line projects in a line); *three lines belong to a bundle* (the projection of a bundle of straight lines remains a sheaf of straight lines, possibly with centre at infinity); *one point belongs to one line*, straight or curved (this involves the projection of tangents in tangents and secants in secants;

the invariance of the number of common points or more

[9] straight line or of *a sheaf of four straight lines* (the relationship of two simple relationships between segments defined by four points of an orientated straight line, or between the angles defined by a sheaf of four straight lines; the bi-relationship is the only projective invariance of a metric nature).

[10] During the nineteenth century there was a decisive move towards the maximum mathematical generalisation of perspective, with the codification of projective geometry through the work of the Swiss mathematician Jean Victor Poncelet. His conclusions were inserted -as already seen with Monge- into a previous speculative area which, through alternative investigations into perspective by some academics and brought about latent anticipation. This extraordinary mathematician, from the study of Monge's work and probably that of others such as Desargues and Pascal, was able to set out the most general principles of all modern methods of geometric representation, discovering those properties, defined as projective properties, that the figures do not lose through projection from a point onto a plane even when they have lost all or part of their original metric properties. Cfr. PONCELET, Jean Victor, *Traité des propriétés projective des figures*, Paris 1822.

[11] Piero della Francesca (1410?-1492), *De prospectiva pingendi*, critical editino by G. Nicco Fasola, Firenze 1942.

[12] Mathematician Ferdinand Möbius (1790-1860) remains one of the academics involved in the new branch og geometry known as *analysis situs*, and more commonly known as *topology*. Cfr. MÖBIUS, Ferdinand, *Sulle superfici a una sola faccia*, Lipsia 1858.

[13] Given that at the base of every geometrical theory lies the concept of *equivalence,* let us remind ourselves that in elementary geometry this concept coincides with congruency: a figure is equivalent at another if it conserves its metric properties – shape and dimensions -, that is to say those properties that remain unchanged by rigid motion such as translation and rotation; in projective geometry we have seen that the equivalence between two figures is guaranteed when one is the *projection* of another and therefore maintains the projective properties; *topological equivalence*, or *equivalence for homeomorphisms* is even more evident than the second case even if its invariant properties are more intrinsic and profound than the previous ones: the main information giver of this type of equivalency is the connection order. It should be remembered that the most important surfaces studied in elementary geometry (cones, cylinders, spheres etc) are *connected*, and it is worth mentioning that any two points of such a surface can be joined together via a curve belonging to the surface; this condition does not apply to the two layer hyperboloid (or elliptic hyperboloid). Cfr. SGROSSO, Anna, *Topologia e architettura*, in "Op. cit.", n°45, Napoli 1979; GIORDANO, Andrea, *La geometria dell'immagine. Dal secolo dei Lumi all'epoca attuale*, Utet, cit.

[14] The term *hypertext* - very topical today, because now everybody knows one of the largest models, the World Wide Web - has deeper and older roots, based on the innate human tendency to acquire innumerable knowledge and information and to be able to categorize and organize it in complex structures, physical and mental, and to be indexed to facilitate future access to curves etc); *the bi-relationship of four points* on a them. The hypertext is essentially a *text form* that allows any *reader* to get to know a lot of information, or in a predetermined way set by the author or, better yet, in a more casual and free way, entrusted to the reader.