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3D modelling in Architecture: from tangible to virtual model

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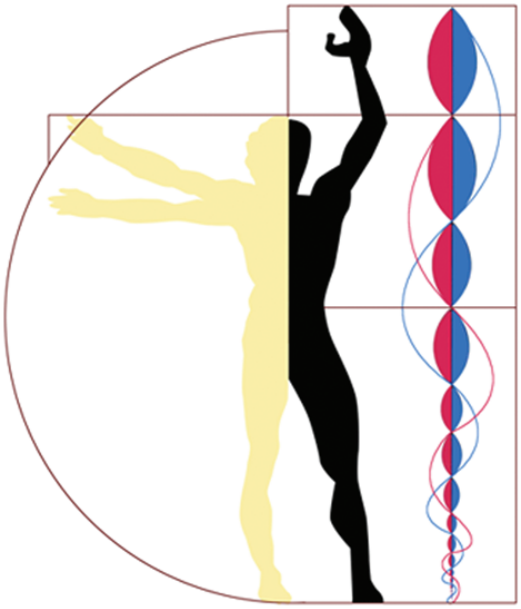
XIII Forum Internazionale di Studi

Le Vie dei Mercanti

Carmine Gambardella



HERITAGE and TECHNOLOGY

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Mind Knowledge Experience

Le Vie dei Mercanti _ XIII Forum Internazionale di Studi

La scuola di Pitagora editrice

Carmine Gambardella

HERITAGE and TECHNOLOGY
Mind Knowledge Experience
Le Vie dei Mercanti
XIII Forum Internazionale di Studi

Editing: Manuela Piscitelli

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Conference report

357 abstracts received from:

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HERITAGE and TECHNOLOGY
MIND KNOWLEDGE EXPERIENCE
XIII International Forum Le Vie dei Mercanti
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3D modelling in Architecture: from tangible to virtual model

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Abstract
Models as useful tools within architecture practice have been used for centuries. While information about their use before Hellenistic civilization is limited, we have evidence to suggest that ancient Greek society used models in their architectural practice. This trend continued until the Renaissance. After this period this trend began to decline as a result of the influential theories presented by Galileo Galilei, who demonstrated how models cannot provide a reliable structural assessment.
Current practice is once again embracing the use of 3D modeling, even if not in the tangible form rather in the virtual and digital form. Tangible and virtual 3D models used by architects have changed in type, scope and function. They play different roles within the design processes and in the project management in both new and existing architecture.
The paper presents an overview of the ethical and practical dimension of models along history and their roles in architectural practice. The analysis of the historical transformations, in particular of the legacy of Leon Battista Alberti theories and thoughts, inspires some reflections on the current applications of 3D virtual models and on their role in the design as well in the construction phase.
To gain awareness of the current uses of the virtual 3D models and their further possible developments, an overview of the transformation of the tangible models within the design processes along history will be provided.

Keywords: 3D modelling, tangible models, architectural practice, design, virtual models.

1. Introduction
From the tangible models to the virtual 3D modelling
Models as useful tools within architecture practice have been used for centuries. While information about their use before Hellenistic civilization is limited, we have evidence to suggest that ancient Greek society used models in their architectural practice. This trend continued until the Renaissance. After this period this trend began to decline as a result of the influential theories presented by Galileo Galilei, who demonstrated how models cannot provide a reliable structural assessment. Current practice is once again embracing the use of 3D modeling. Presenting the role of the model from the ancient Greece until the Renaissance and its last decline following the theory by Galileo Galilei the use of this technique and its current declination in the virtual 3D modelling are analyzed.
The importance of the models as drawing improvement
Model, as an architectural tool has been used for generations as a starting point in the architecture practice. It has allowed for members of the profession to foresee the development of large scale construction on a small scale model. This method is one of the most ancient approaches to the practice of architectural design.

2. The architectural model throughout the centuries: roles, uses and associated ideas
The use of the model in architecture has got its roots far away in the history. It is possible to find some example in the ancient Sumer society, in the ancient Egypt as well as in the Etruscan society. In both cases the models were not used in the design phase having only an "*exhibitive and votive function*"[1]. Another

[1] PIGA, Claudio. *Storia dei modelli: dal tempio di Salomone alla realtà virtuale*. Roma: Enel, 1996.

example of the use of models in the ancient times can be found in the Bible. In, *Chronicle I* it is described how the temple of Salomon in the X century BC., was built on the basis of a model, defined by the Jewish term "Tabnit"[2].

The Greek epigraphic sources show the use of models in the Hellenic world[3]. For example, Aristotele (384 - 322 a.C.), in the *Constitution of the Athenians*[4] describes how the Fifty's Council judged proposed projects of public buildings. These buildings had to be built according to models made of clay or wood. Architects were obliged to develop models in order to gain public approval and funding for their developments. These models were necessary to obtain the client's approval. Nevertheless, it is not yet clear if these models were used also during the building's construction phase. The use of clay and wooden models in the Greek world has been discussed in two passages of the *De Architectura*[5] by Marco Pollione Vitruvio (80 - 15 a.C.). Within the preface of the second book Vitruvio writes how the architect Dinocrates of Rodi[6] showed models to Alexander the Great in the attempt to get a contract.

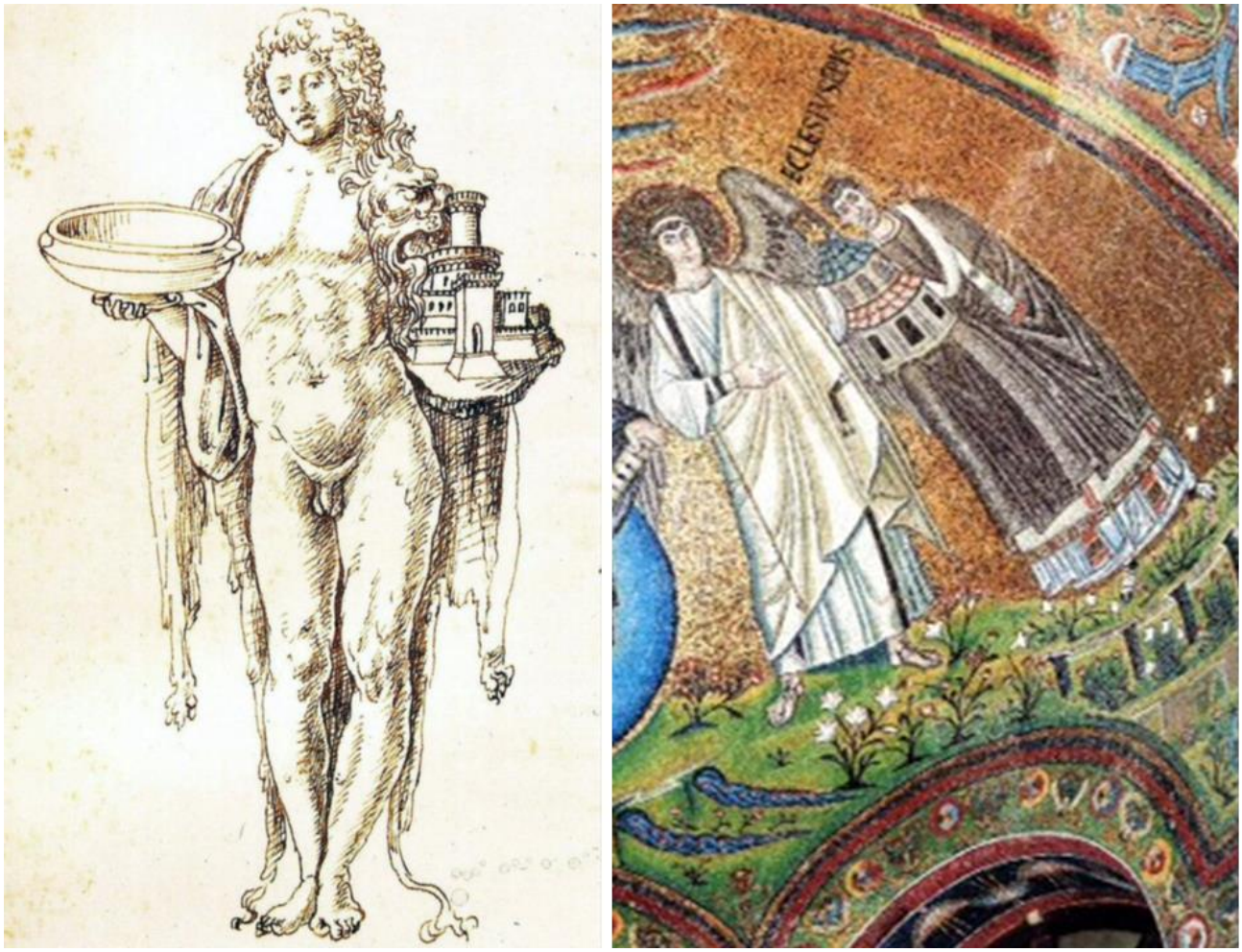

Fig. 1: The image on the left depicts Dinocrates holding in his left hand the model of the project to re-shape the Mount Athos. He holds also, his idea for a cistern for the water collecting of the city, in his right hand. Drawing, XV century, by Francesco di Giorgio Martini, in Cod. Magliabechiano II.I.141, f. 27v Location Biblioteca Nazionale Centrale, Firenze. Source:http://www.atlantedellarteitaliana.it/index.php?artwork=10939&lang=English. The image on the right presents the mosaic of the apsis of the Basilica of San Vitale, in Ravenna. Source: Angiolini Martinelli Patrizia. La Basilica di San Vitale a Ravenna. Modena: Franco Cosimo Panini Editore, 1997. («Mirabilia Italiæ», VI).

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[2] The decision of building a temple dates back to king David. Even though David started all the preparation for the temple's construction, included the model for the construction, was is son Salomone who built the temple. PIGA, Claudio. *Storia dei modelli: dal tempio di Salomone alla realtà virtuale* Roma: Enel, 1996.

[3] Nevertheless, information about these models are poor and difficult to recover because usually quoted in contexts outside the architectural one.

[4] LOZZA, Giuseppe, trans. *Aristotele, Costituzione degli Ateniesi.* Milano: Mondadori, 1991. It is a short text formed by two parts concerning the history of the Athenian state - in the first part – and its constitution at the time of Aristotele - in the second part.

[5] SCHOFIELD, Richard, trans. *De Architectura /On Architecture*. Toronto: Penguin Books, 2009.

[6] Dinocrates, was a Greek architect who lived under Alexander the Great, IV B.C.
Source: http://www.britannica.com/EBchecked/topic/163942/Dinocrates

Then, in the last but one chapter of the book X Vitruvio writes about Callia displaying his model of a technological solution, for the defensive walls of a city, in front of the authorities.[7]
It is interesting to outline how this trend is still modern. Indeed, even if the virtual models have replaced the wooden ones, they share a common function. Both are important to provide an immediate understanding of the project also to non-architects. According to Carlo Amati[8] the use of models was common between architects to show their ideas to the clients and to give real feeling of their concepts.
Based on Greek tradition the architectural models were given less credit than theoretical project ideas, despite their main role in the acceptance process of a project. On the other hand, they were considered secondary to the intellectual development phase of a project[9]. This lack of recognition has been demonstrated by the inclusion of the model within the production costs, and thereby retracting its value as an individual entity[10]. Up until the XIV century, literary sources did not provide information on the use of models in architecture. Nevertheless, models are depicted in the coins of the late-empire as well as in pictures, frescoes and mosaics of apsis of some Christian basilicas.

Fig. 2: Enrico Scrovegni offering the Model of the Scrovegni Chapel to Maria, Giotto, 1303 - 1305. Image source: http://www.forlinews.it/wpcontent/uploads/2009/12/Cappella_Scrovegni_enrico.jpg

[7] Dinocrates presented to Alexander the Great his project for a huge fortified city on the Athos mountain and a cistern for the water collecting and management. Callia presented a technological solution for the fortified wall, able to neutralize possible enemies' attack and sieges.
[8] MOROLLI, Gabriele. *L'architettura di Vitruvio nella versione di Carlo Amati (1829-1830).* Firenze: Alinea , 1988..
[9] GUARDUCCI, Margherita, COARELLI, Filippo. *Sull'artista nell'antichità classica, in Artisti e artigiani in Grecia*. Roma, Bari: Laterza, 1980.
[10] PIGA, Claudio. *Storia dei modelli: dal tempio di Salomone alla realtà virtuale*. Roma: Enel, 1996.

In the Middle Age there are many medieval depictions of models of buildings (constructed or to be constructed) offered to superior authorities such as: emperors, popes or to God. An example is the Scrovegni chapel, where Giotto depicts Enrico Scrovegni offering his building to Maria. This can be interpreted as a proof that the use of models was common. This explains why we do not find written documentation. During the XIV century, documentation of models in written sources appears once again. According to Richard A. Goldthwaite model was a kind of guarantee of the feasibility of the project as a tangible evidence, and it was also a tool to resist to pressures of those wanting to change the original design during its construction phase[11]. Moreover, in this period the architectural models served as a type of copyright for clients. In addition to this, models provided a method to engage clients in the full comprehension of the project, as they do not always understood the intricacies of architectural drawing, recognizing the importance of the projects and of the idea behind it. In addition to that, the evidence of the models played a key role to show a clear and scaled realization of the future project, without requiring capability of abstraction for the clients as required by the drawing technicalities. During the Renaissance period, the model gained a new dignity and the first theoretical settings for its development and its function were formulated. The architects of this period used models in a different and personal way locating them in different manners within the design steps. Nevertheless, the models were elaborated to gain the clients' acceptance for their development in a 1:1 scale.

In the Islamic world the use of the models was fundamental to obtain an approval for the construction of the project[12]. An example is the use of model by the Architect Sinan[13] in Turkey during the XVI century. For instance, there are written records of the model of Süleymaniye Mosque decorated by wood and ivory. It was so detailed in its construction that it was virtually identical to the original[14]. The role of architects in Islamic civilization was not limited to architectural drawings, but it was extended to the making of miniature models of buildings. This practice was common among Muslim rulers and was used in several circumstances. The use of prototypes became common practice in the Ottoman era. Wooden and silver models, such as the one of the Izet Pasha Mosque, became common. Records also mention models decorated by wax. For instance, the Ottoman Sultan Mohammed I only became convinced of constructing an Ottoman building after seeing a miniature model of it[15].

Different uses of the model in the Renaissance

As already mentioned, during the XIV century there is a huge written documentation about the use of models in architecture practice for example the model of the Duomo of Florence, the Cathedral of Milano and the Cathedral of Bologna.

Fig. 3: The image on the left presents the wooden model of the Cathedral of San Petronio, Bologna, 1514. Source: http://www.arte.it/foto/600x450/97/3923-df7ca03d-46dc-4bfa-b2cf-74a4c3d4b6cd.jpg Consulted on December 17, 2014. The wooden model on the right presents the completion for the San Lorenzo's facade, in Florence, designed by Michelangelo Buonarroti, 1518. Wooden, 216 x 283 x 50 cm Casa Buonarroti, inv. 518. Source: http://www.friendsofart.net/static/images/art1/michelangelobuonarroti-model-for-the-facade-of-san-lorenzo-florence.jpg

[11] GOLDTHWAITE, Richard. *The Building of Renaissance Florence: An Economic and Social History*. Baltimore: Johns Hopkins University Press, 1980.

[12] GULRU, Necipoglu. *The age of Sinan Architectural Culture in the Ottoman Empire*. London: Reaktion books, 2005.

[13] Sinan, called Mimar Sinan (Architect Sinan) and Mimar Koca Sinan (Great Architect Sinan), is the most celebrated of all Ottoman architects. Sinan was nicknamed "the Michelangelo of the Ottomans" because of his key role in the definition of the Ottoman architecture. Source: GULRU, Necipoglu. *The age of Sinan Architectural Culture in the Ottoman Empire*. London: Reaktion books, 2005.

[14]Source: http://www.kanyak.com/sinan.html Consulted on December 18, 2014.

[15] Source: http://www.arabworldbooks.com/Articles/architectinisl amic.htm Consulted on December 19, 2014.

During the XIV century there is a huge written documentation about the use of models in architecture practice. In the Renaissance architects used models as common tools in the design process. The sequence of this process is: concept/idea – drawing – model. The model as physical visualization of the project was the tool used to deliver the architect ideas to the client. Indeed, the model was an unequivocal, immediate, tangible three-dimensional representation of the building to be achieved, easy understandable also by non-architect. In the Renaissance the model has become a dynamic role as tool to be used to build the final project.

Fig. 4: Wooden model of the Duomo of Pavia,1497. Engraved in cypress, oak and walnut wood by Gian Pietro Fugazza based on the design by Giovanni Antonio Amadeo and Gian Giacomo Dolcebuono.
Source:http://mw2.google.com/mwpanoramio/photos/medium/37081815.jpg Consulted on 20 December.

In the *De re Aedificatoria* Leon Battista Alberti expressed the cultural dignity of the models within the architectural practice. Indeed, he claimed the importance of models to obtain a perfect building execution.

> *"To avoid such pitfalls, therefore, I must urge you again and again […] (to use) scale models, re-examine every part of your proposal […] tile there is nothing, concealed or open […] for which you have not thought out, resolved, and determined […]" De re Aedificatoria,* Book 9, 8[16].

About ten years later since the publication of the *De re Aedificatoria*[17], Filarete wrote his treatise *On architecture*[18]. In his treatise he dealt also with the opportunities of using models. The treatise defined a model as the final output of a project, «*disegno piccolo rilevato di legname»*[19], which is responsible for the whole design process. For Antonio Averlino, known as Filarete, the model leads to a less hermeneutic and theoretical dimension, providing a bi-univocal interaction with the drawing, fixing its ratios. In the book VII of the treatise he deals with the combined use of wooden models and drawings and how to overlap both in the execution phase. The key role of the model in architecture design as well as in the construction and building phase, during the Renaissance, is proved by Filippo Brunelleschi. Thanks to Vasari, it is possible to know the function of models for the structural analysis, in the constructive technique choices to be adopted as well as in the design phase.

[16] RYKWERT, Joseph, LEACH, Neil, TAVERNOR, Robert, trans. *Leon Battista Alberti On the Art of Building in Ten Books*. Cambridge: The MIT Press, 1998, p.313.
[17] The first five books were apparently written between 1443 and 1445. The five others were written between 1447 and 1452, if Poliziano's brief letter can be believed. Leon Battista Alberti apparently intended to publish his work, dedicated to Lorenzo de Medici. In spite of this, the first version was presented to Pope Nicolas V in 1452. Alberti gave a copy of his treatise to Pope Nicholas V because the pope was rebuilding Rome. Source: RYKWERT, Joseph, LEACH, Neil, TAVERNOR, Robert, trans. Leon Battista Alberti *On the Art of Building in Ten Books*. Cambridge: The MIT Press, 1998.
[18] SPENCER, John R., trans. *Filarete's treatise on architecture. Being the Treatise by Antonio di Piero Averlino, known as Filarete*. New Haven and London: Yale University Press, 1965.
[19] FINOLI, Anna Maria.,GRASSI, Liliana. *Antonio Averlino detto il Filarete. Trattato di Architettura.* Milano: il Polifilo, 1972.

Fig. 5: Wooden model of the Lantern of the Cathedral of Florence, by Filippo Brunelleschi. Museo dll'Opera di Santa Maria del Fiore, Florence. The model may have been made by Brunelleschi or it may be one of the models made for him by Ciaccheri in 1436. Source: http://media.vam.ac.uk/media/thira/collection_images/2006BB/2006BB3221.jpg

The importance of a model is then stressed in a passage of Vasari which points out the secrecy of the model during the project step[20]. Moreover, according to the historian Piero Sanpaolesi, the impossibility to find a

[20] MANETTI, Antonio, DE ROBERTIS, Domenico, TANTURLI, Giuliano. *Vita di Filippo Brunelleschi.* Milano: Il Polifilo, 1976.

model precise date of the cathedral of Florence, is an evidence of its development *"contemporary with the construction*"[21]. Massimo Scolari reports how models, as in the ancient Greece, were used to compete for a project.

> *"The jury[…]selected Brunelleschi's design as being the most robust and at the same time, the lightest; moreover, it permitted better lighting and formed efficacious protection against elements".* [22]

Fig. 6: The wooden model of the dome of the cathedral of Santa Maria del Fiore, XV century (measuring 100 X 90 cm central part, 55X63X35 cm side parts), is kept in the Museo dell'Opera di Santa Maria del Fiore. It includes parts of the apse and the block formed by the dome and drum, with a portion of the piers and arches underneath. Source: MARCHIN Giuseppe*. Il balllatoio della cupola di Santa Matria del Fiore*. In *Antichita' viva* 16, no 6: 39, 1977. Image source: http://insidethevatican.com/wpcontent/uploads/2013/10/2.05_130306124954-973x1024.jpg. The image on the right presents the interior of the wooden model for the Basilica of San Peter, by Antonio da Sangallo il Giovane, XVI century. Source: http://www.afterauschwitz.org/itinerari/arte/Numeri/html/img/modello_1.jpg

Some years later, Antonio da Sangallo[23] and Michelangelo Buonarroti, used the model not only for structural assessment and design purposes but also as a reference tool within the building site activities. Their models used for the construction of the Basilica of San Peter in Rome[24], were used as main construction tools. These scaled models were used by the workmen in the building site, to the construction in a 1:1 scale. In addition, the models were also tangible demonstrations of the good or bad work of the architect. Michelangelo, for example, used the model of the roof to show the accuracy of his project and the mistakes of the workmen during the execution phase, to defend his own work.[25] Therefore, it is possible to claim that the architects of the Renaissance used models as effective reference tools for construction and design.

[21] SCOLARI, Massimo. *Oblique drawing a history of anti-perspective*. Cambridge: Mit Press, 2012.

[22] Ibidem, p. 187.

[23] The model of the project by Antonio da Sangallo elaborated by Antonio d'Abaco was completed between 1539 and 1546.

[24] In 1505, the pope Giulio II charged Bramante of the reconstruction of the Basilica of San Peter. He presented a project of reconstruction of the Basilica. Not totally convinced the Pope asked the point of view of Giuliano da Sangallo. He developed in 1506 the definitive project, including some of the ideas of Bramante. When in 1516 Giuliano da Sangallo died he was replaced by his nephew Antonio in the works on San Peter. In 1519 a new project was approved by Pope Leone X who followed Giulio II. Only in 1534 Paolo II Farnese charged Antonio da Sangallo to re-elaborate the project and to build a detailed wooden model. The model was made in 1:30 scale and it is the biggest model ever built in the Renaissance. The model is elaborated in order to have a tangible guarantee of the project. Moreover, it was used as communication tool between the architect and the workers. Its elaboration required more than seven years and it was developed in parallel with the construction works of the Basilica.

[25] PACCIANI, Riccardo. *I modelli lignei nella progettazione rinascimentale*, in "rassegna", a. IX, Milano, 1987.

The crisis of the model

The crisis of the model started when Galileo Galilei published his *"Discorsi e dimostrazioni matematiche intorno a due nuove scienze attenenti alla mecanica ed i movimenti locali ",* in 1638[26]. The Galileo's theories demonstrated how the models were not able to provide a reliable structural assessment.

> *"I modelli delle costruzioni sono utilissimi per valutarne l'aspetto, ma inutili perché si possa trarre qualche conclusione sulla loro resistenza."*[27]

Which translated means*:*

> *"The models of the buildings are very useful to evaluate the appearance, but useless to draw assumptions about their strength."*

The theory started a crisis of tangible models. Their purpose was relegated to represent an aesthetical preview of the project and its perception, denying their capability as tools for structural analysis.

Fig. 7: The Discorsi e Dimostrazioni Matematiche, 1638. Source: http://www.christies.com/lotfinderimages/d50841/d5084169x.jpg

3. 3D Virtual model

The historical consideration of the model's practice is useful to understand the impact of the computer-aided design in the 1980s that has radically transformed their generative process. 3D modelling is a procedure of graphic representation of an object in three dimensions in a virtual space. It is based on algorithms, employing dedicated software using, as starting point, data coming from 3D surveys or from other sources of information. Currently the techniques of 3D modelling can be divided into: manual modelling with 3D computer graphics; procedural modelling and modelling based on real measures (with data coming from 3D scanning). The manual modelling with 3D computer graphics consists in the creation of three-dimensional models based on imagination or imitation, not on survey or real data measurement. This technique is principally used for the representation of scenes and figures, both still and moving, through complex surfaces, based on math formulas and algorithms designed with specific software (Sketch-up, 3DStudioMax, Maya, etc.,)[28]. The second technique is the procedural modelling that generates 3D geometries using commands and functions of extrusion, on the basis of automatic or semi-automatic methods (for example through software like City Engine) including an analytical and a generative phase. The analytical phase entails the definition and the use of a vocabulary of shapes and rules classifiable for the designing phase and the indication of formal archetypes to assemble many geometrical elements on the basis of similar algorithms. The generative phase entails the reproduction of complex architectural or urban structures (i.e. housing, palaces, temples, churches, fortifications, bridges, aqueduct, etc.,).

[26] GIUSTI, Enrico. *GALILEI GALILEO. Discorsi e dimostrazioni matematiche: intorno a due nuove scienze attinenti la mecanica ed i movimenti locali.* Torino: Einaudi, 1990.
[27] Ibidem.
[28] They are especially used in movies, television, architectural and engineering and in many scientific sectors.

Fig. 8: Point cloud coming from 3D scanning. These data are the first step for a 3D model based on real measures. The image presents the 3D point cloud to be used for the tridimensional reconstruction of the 352 Somerset building in Ottawa, Canada. The capturing data phase employed a Total Station Leica TS11, a Laser Scanner Leica Scan Station C10 and the software Cyclone, used to merge and manage the different scanned Point Clouds. The project has been developed by Professor Mario Santana Quintero, Architect Davide Mezzino and Architect Ken Percy of the Carleton Immersive Media Studio (CIMS), Carleton University, Ottawa.

Finally, the modelling based on real measures obtained through a 3D survey in the field of the historical-artistic studies for the conservation and use of the Cultural Heritage has the following purposes:

- creation of digital archives allowing the re-unification of resources distant from each other and the possibility of consulting and studying masterpieces, monuments and urban complexes from remote positions;
- metrical investigation aimed to the knowledge of the dimensions, shapes and ratios of the resources in order to be able to elaborate comparative studies between monuments and contexts;
- investigation of the original constitutive materials and of those required for restoration;
- diagnostic studies before a particular intervention;
- assessment, analysis and monitoring of different kinds of pathological degradation (chemical, physical, micro-climatic and accidental);
- simulation of specific physical phenomena on the building surface (or single part of it) for the prediction of effects, for instance: the exposure to atmospheric agents, artificial light, the deposits of dust and the prediction of the static behavior of buildings or urban contexts under particular stress conditions (i.e. catastrophic events);
- planning of routine and special maintenance;
- restoration project, giving a visual data base with a layered referencing of data coming from diagnostic surveys and from the different steps of the intervention and, consequently, chance to simulate integrative or reconstructive hypotheses (i.e. the determination of the methodologies to follow and the use of materials and products);
- communication and cultural dissemination, exploiting the potentialities of 3D visualization for information, not easily understandable by the direct contact with the monument and the context in which it is inserted[29].

[29] MEZZINO, Davide, RINAUDO, Fulvio. GIS and 3D modeling for Cultural Heritage. In TAMBORRINO, Rosa. *Telling the history of the city in the age of the ICT Revolution*. Rome: CROMA - Università di Roma Tre, 2015.

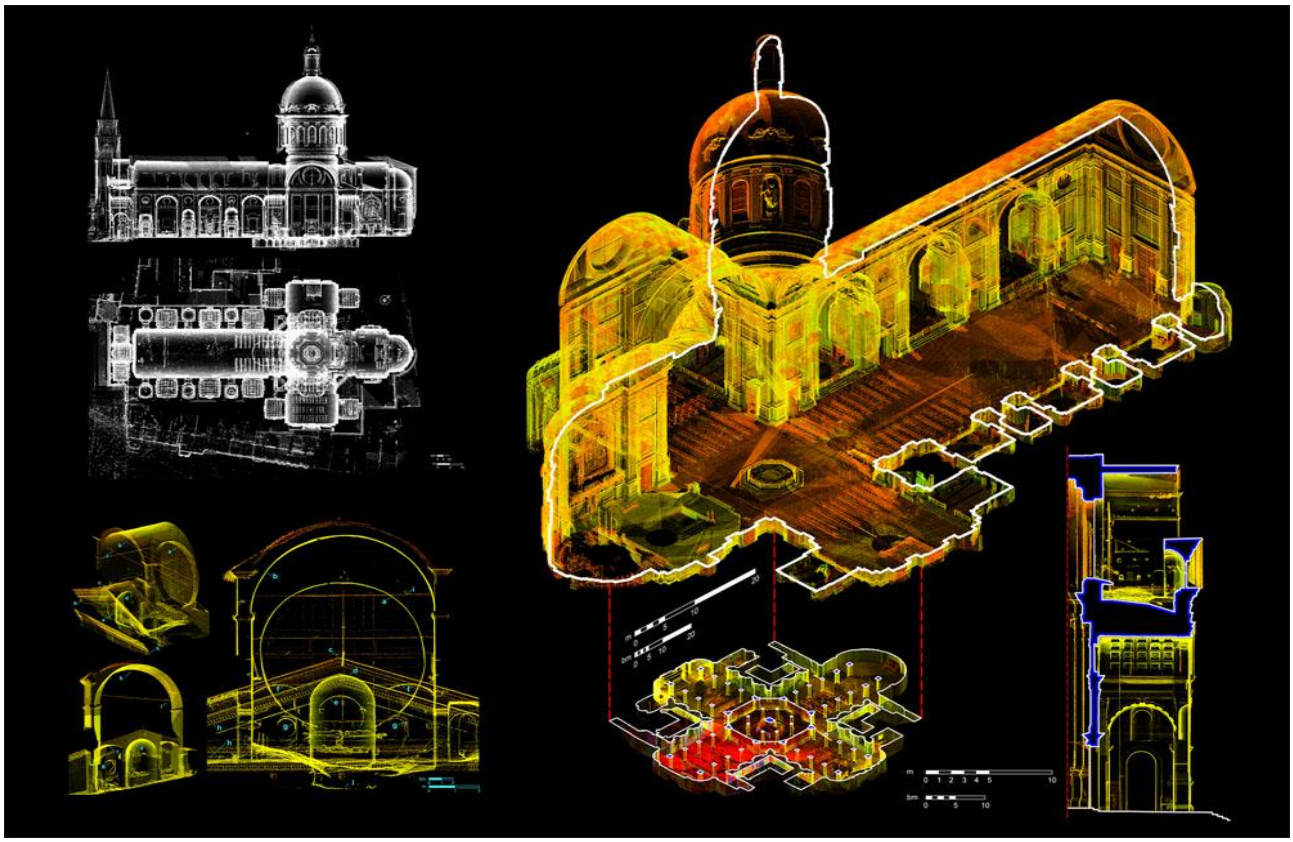

Fig. 9: Example of 3D modelling based on real measures. 3D model of the Church of Sant'Andrea, Mantova, developed by the University of Ferrara's Research Department Centre for the Development of Integrated Automatic Procedures for the Restoration of Monuments (DIAPReM). The modelling is based on real measures (with data coming from 3D scanning). Image source: http://www.unife.it/centri/diaprem/Settori%20di%20ricerca/esempi/Rilievoarchitettonico.jpg

In conclusion, 3D virtual modeling can be used for different kinds of analysis to better visualize and understand the design ideas. In addition, it allows the reconstruction of historical buildings as well as ancient urban and rural landscapes providing an understanding of their actual development and their modification over a certain period.

4. The Homo Universalis's legacy

The legacy of Leon Battista Alberti: writer, architect, humanist, philosopher, towering genius and *homo universalis*[30] remains a legacy that continues to influence current concepts of architecture. His principles on urban planning, foresight in scripting architecture[31], care to the use of models in architecture as well as the role of history as a progressively and constantly growing experience serving to orient design choices, make relevant his theories in current architectural debates. Leon Battista Alberti used[32] and theorized the employment of models. In the *De Re Aedificatoria*[33] he gave the model a role of fundamental importance within the creative process of the architect:

> *«[…] I will always comment the time-honored custom, practiced by the best builders, of preparing not only drawings and sketches but also models of wood or any other material […]» De re Aedificatoria,* Book II, 6[34].

The architect presents the importance of a context in models in order to understand its spatial relations.

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[30] BURCK, Hardt. *La civiltà del Rinascimento in Italia*. Roma: Newton Compton, 1974.

[31] CARPO, Mario. *The Alphabet and the Algorithm*. Cambridge: the MIT press, 2011.

[32] Even if all his models have been lost.

33 The Alberti's work is a humanist treatise devoted to architecture, very densely erudite. According to the trend of the recovery of the classics, driven by the rediscovery of the Vitruvian treatise by the Florentine humanist Poggio Bracciolini in 1414, "*the treatise has been written with the aim of organize the architecture discipline".* Source: RYKWERT, Joseph, LEACH, Neil, TAVERNOR, Robert. trans., *Leon Battista Alberti On the Art of Building in Ten Books*. Cambridge: The MIT Press, 1998.

34 RYKWERT, Joseph, LEACH, Neil, TAVERNOR, Robert, trans. *Leon Battista Alberti On the Art of Building in Ten Books*. Cambridge: The MIT Press, 1998, p.34.

"[…] these models…will examine clearly and consider thoroughly the relationship between the site and the surrounding district, the shape of the area, the number and order of the parts of a building, the appearance of the walls, the strength of the covering, and in short the design and construction[…]" De re Aedificatoria, Book II, 6[35].

The importance in the analysis of the impact of the new intervention and the role of the model to understand the spatial relationship outlines the importance of the representation of the context in the model. This consideration is still current for virtual 3D models. In fact they usually depict only the building without delivering a comprehensive understanding of the project and its possible impacts.

"When examining the model…nothing should be attempted that lies beyond human capacity, nor anything undertaken that might immediately come into conflict with Nature. For so great is Nature's strength that, although on occasion some huge obstacle may obstruct her[…]she will always overcome and destroy any opposition or impediment[…]" De re Aedificatoria, Book II, p. 35

Alberti considered models as the best tools to study and develop an idea as well as the finest tools to improve drawing documentation. Moreover, the model was conceived as a tool to test the distribution features of a building and to meditate on its position, orientation, location of the main walls, appearance of the facades and suitability of the roof. The model is a good and flexible tool to change, move, review and rethink the designing choices until everything fits together. In the book IX of the *De re Aedificatoria,* he claimed how models are useful to correct the imperfection of the ideas and how they should be used for practical purposes such as the building site organization and management.

"I have often conceived of projects in the mind that seemed quite commendable at the time; but when I translated them into drawings, I found several errors in the very parts that delighted them into drawings, I found several errors in the very parts that delighted me most[…] finally, when I pass from the drawings to the model, I sometimes notice further mistakes in the individual parts, even over the numbers." De re Aedificatoria, Book IX, 10[36].

"Questions such as these should be projected and debated by the use of models; these models should be employed not only at the outset but also during construction, so that on their advice we may determine in advance what is necessary and make preparations in order to avoid any hesitation, change, or revision after the commencement of the work, and so that we may form a concise overall picture of the whole, in order that appropriate and useful materials might be procured, stored, and made readily available." De re Aedificatoria, Book IX, 9[37].

Furthermore, he stated the importance of a model for the design choices, for the understanding of the spatial relations as well as for cost analysis. He claimed that models allow calculation, experiments, cost assessment, providing information about width, height, and depth of the structures of its composing elements. According to these considerations, in the Book II – materials - he stressed the importance of the model in providing a precise indication about the costs of each building elements.

"(the model)[…]will provide a surer indication of likely costs – which is not unimportant – by allowing one to calculate the width and the height of individual elements, their thickness, number, extent, form, appearance and quality, according to their importance and the workmanship they require. In this way it is possible to form a clearer and more certain idea of the design and quantity of the columns, capitals, bases, cornices, pediments, revetment, flooring, statues, and everything else relating to the construction of the building and its ornamentation." De re Aedificatoria, Book II. P.34[38]

Here it is evident that there is a connection with the current virtual 3D modelling systems such as the Building Information Modelling (BIM) system and its management features. In this case the word "modelling" does not mean only a three dimensional geometry but it is a combination with descriptive semantic information. It seems evident here how L. B. Alberti would have approved the BIM system for a comprehensive management of an architectural project. This system consisted of an integrated approach including parametric design and a tridimensional model integrated with a semantic database. BIM as the ancient models described by Alberti, is used for the cost analysis and archiving of every building element that has a geometrical as well as a semantic description.

[35] Ibidem, p. 34.
[36] Ibidem, p. 317.
[37] Ibidem, p. 314.
[38] Ibidem, p.34.

5. Conclusion

According to Branko Kolarevic the models of design "*capable of consistent continual and dynamic transformation*" are replacing the classical architectural drawing[39]. Therefore, can we speak of a digital revival of the model? In contemporary architectural design, digital media is increasingly being used as a tool to generate, visualize and control new and existing architecture. Alberti believed that the project could be developed only through the construction of a miniature model because he believed that an idea which exists only in the mind was essentially imperfect. He believed that the perfection in architecture could derive only from the model, (even though he claimed that the model should be completed not only by the architect himself but by other specialists[40]).

Fig. 10: Symbolic representation of the transformation of the use of models, from the tangible to the virtual ones, within the design processes along history. Image source: author's elaboration.

[39] KOLAREVIC Branco. *Architecture in the Digital Age design and manufacturing*. New York: Spon Press, 2003.

[40] This opinion agrees with the Alberti's conception of the Architect, who believed that architects role is fundamentally theoretical, consisting of the harmonic configuration of the functionality and solidity requirements.

Therefore, it is possible to interpret these ideas as an Alberti's legitimation of current 3D printing techniques for the elaboration of a scaled model as well as the current virtual 3D descriptive models. Following this idea it is possible to claim how he would have approved the 3D virtual models according to their adaptability of :

> *"[…]examine, with the advice of experts, the work as a whole and the individual dimension of all the parts, and […] any farther, to estimate the likely trouble and expense" De re Aedificatoria,* Book II, p.34

The proposed overview of the transformation of the use and importance of tangible models within the design processes along history, has been useful to gain awareness of the current uses of the virtual 3D models and their further possible developments. For instance, the model that Alberti suggests should be plain and simple «*nudos et simplices*»[41]. He condemns the celebrative models full of ornaments and paintings, considering them as deceptive.

> *"Better […] that the models are not accurately finished, refined, and highly decorated, but plain and simple, so that they demonstrate the ingenuity of him who conceived the idea, and not the skill of the one who fabricated the model" De re Aedificatoria*, Book II[42]

This consideration is still actual. It is possible to recognize the Alberti's assumption about the importance of a *"plain and simple*"[43] model within the current use of 3D models and rendering. Alberti's concept is against a representation delivering an improbable visualization, with unreal colors and shadows, and a misleading depiction. Quoting L. B. Alberti:

> *"striving to attract and seduce the eye of the beholder, and to divert his attention from a proper examination of the parts to be considered, toward admiration of himself ", De re Aedificatoria*, Book II[44].

In another passage, he describes the differences between architect and painter, expressing his concept of technical architectural drawings.

> *"The difference between the drawings of the painter and those of the architect is this: the former takes pains to emphasize the relief of objects shading, but takes his projections from the ground plan and, without altering the lines and by maintaining the true angles, reveals the extent and shape of each elevation and side […] "*[45].

This raises a reflection about the current level of accuracy in virtual 3D reconstruction and its role in the design and construction process. In fact, in the conservation field, for instance, the documentation and design phases require increasing high detailed and photo-realistic models. According to this trend, is this kind of photorealistic models always necessary in practice?

If a high level detailed model can be useful for the comprehension of a building and in the dissemination of its features, some questions should be answered:

1. What is the usefulness of a detailed model in the conservation practice, particularly if compared with a time/cost analysis?
2. In which cases is it better to have a simplified model that could be integrated with additional time and cost effective processes (i.e. photography, sketching, etc.)?
3. Can a simplified model satisfy the same requirements of a highly detailed model in the architectural conservation practice? What do we gain from it?

Following Alberti's teaching, maybe a simplified model could be considered to satisfy the requirements in architectural conservation practice as well as a highly detailed model.
According to William W. Braham and Jonathan A. Hale, through the course of the nineteenth and twentieth centuries architects have become largely technocrats.[46] Therefore, being aware of the change brought about by the relationship between technology and architecture, how would it be possible to rethink the role of the model and how has it changed in its ethical dimension as well as in its uses and application?

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[41] ORLANDI, Giovanni, PORTOGHESI, Paolo. Leon Battista Alberti, *De Re Aedificatoria*,. Milano: il Polifilo, 1966.
[42] RYKWERT, Joseph, LEACH, Neil, TAVERNOR, Robert, trans. Leon Battista Alberti, *On the Art of Building in Ten Books*. Cambridge: The MIT Press, 1998, p.34.
[43] Ibidem, p. 34.
[44] Ibidem, p. 34.
[45] Ibidem, p. 34.
[46] BRAHAM, William W., HALE, Jonathan A. *Rethinking Technology A Reader in Architectural Theory*. New York: Routledge, 2007.

The proposed reflections aim to consider the level of accuracy and the detail of the virtual 3D models to understand and drive the architectural practice. The digital revolution redefined the way models may be conceived, produced and used, defining a new relation between technology and architectural production[47]. New experimentations could be carried on in order to check if a more simplified conceptual representation can provide a good projects control capability and effectiveness of getting results such as good building quality and fast execution time.

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[27] Web: http://www.atlantedellarteitaliana.it/index.php?artwork=10939&lang=english Consulted on December 14, 2014.

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DICHIARAZIONI SOSTITUTIVE DI CERTIFICAZIONE E DELL'ATTO DI NOTORIETA' AI SENSI DEGLI ARTT. 46 E 47 DEL D.P.R. 28 DICEMBRE 2000, N. 445.

I sottoscritti Davide Mezzino e Tatiana K. Kirova, in qualità di autori dell'articolo "3D MODELLING IN ARCHITECTURE: FROM TANGIBLE TO VIRTUAL MODEL", consapevoli delle sanzioni penali nel caso di dichiarazioni non veritiere, di formazione o uso di atti falsi, richiamate dall'art. 76 del D.P.R. 28 dicembre 2000 n. 445, dichiarano che:

- l'"*Abstract*", il paragrafo 1 "*Introduction*", il paragrafo 2 "*The architectural model throughout the centuries: roles, uses and associated ideas"*, il paragrafo 3 *"3D Virtual model"*, il paragrafo 4 *"The Homo Universalis's legacy"*, il paragrafo 5 *"Conclusion"*, sono da attribuirsi a Davide Mezzino;

- il paragrafo 1 *"Introduction"*, è da attribuirsi a Tatiana K. Kirova.

Data 29/09/2022

In fede,

Davide Mezzino

Tatiana K. Kirova