HBIM LEVEL OF DETAIL-GEOMETRY-ACCURACY AND SURVEY ANALYSIS FOR ARCHITECTURAL PRESERVATION

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ABSTRACT:

The development of advanced survey techniques in the last years is offering a wide set of tools for implementing the building analysis. In the preservation field, the use of 3D interactive models is a prerogative of few and rare excellent cases and the information contained in high-resolution virtual representation are only partially developed. In the past centuries, the representation was centred on the theoretical roles of the descriptive geometry devoted to the representation of the architectural elements complexity in the space to manage the construction site process. It has been progressively lost the past skill to managing 3D objects in the space. Being HBIM based on 3D solids representation, the theme of the 3D model comes back to the foreground. The complexity of the architectural heritage and its components is evidencing a gap of best practices, protocols and specification in the HBIM-modeling. Do-It-Yourself modeling process has been characterised by the first phase of HBIM generation in the last years. Modeling phase within HBIM is left to the single responsibility, with lack of specification on the accuracy and level of geometry.
This paper presents a first tentative to summarize the relationship among the surveying accuracy, the Level of Geometry and the Level of Accuracy (LOA) of each BIM object, starting from a series of experiences, in which advanced survey techniques were applied to condition assessment required by architectural preservation HBIM approach. The objectives of the surveying and HBIM can change for different aspects: but in the preservation context the specificity of each single objects and their complexity need to be taken into account. As in the surveying, the choice of a scale implies a range of accuracy and tolerance in the data acquisition and processing, in HBIM modelling the choice of the Grade of Accuracy drives within the Level of Geometry the scale model that is expected to be performed and required by the different actors involved by the different phases (i.e. restoration, Energy Efficiency, Finite Element Analysis, CoSiM). On the base of different experiences occurred in the last years, the specifications conventionally adopted for the surveying have been here proposed and extended to the HBIM domain, particularly in the modelling of objects, in order to classify different accuracies. A transparent choice of accuracy allows to define the LOG and to support the adoption of the proper Grade of Generation among the different options (GOG1-10) in function of the point clouds geometry and of the scales chosen by the different actors. The architectural scale together with the urban scale (Heritage Urban Level) is considered as well to keep advantage of a multi-resolution model, diversified in function of the objectives, thus of Level of accuracy (and Level of Information) and Level of Geometry.

1. INTRODUCTION

In recent years the generation of HBIM models has been characterised by the production of simplified and complex models, underlining how the lack of established methods and guidelines led to free interpretation of modeling practices and project objectives.
The versatility of modern digital tools allows several analyses, passing from large to detailed scales, using commercial and dedicated software; it requires increasing participation and data sharing among different actors involved in the conservation process.
The research carried out in the field of interoperability led to think the use of parametric models customized to the different uses, all referring to one Common Data Environment (CDE). Data are stored and updated without redundancy, and the models (BIMs) have the complexity, which is manageable and useful for each domain (Laakso, Kiviniemi 2012; Della Torre 2017). Applied to historic conservation, this means that one dataset produced by the survey will be "stored" in the CDE and available for all the actors, who will develop several interoperable parametric models (using BIM authoring sw), which will be different in terms of aims, required accuracy and individuation of the parametric objects. For example, diversified models (HBIM) will be suitable for different purposes: (i) structural analyses, (ii) energy simulations, (iii) conservation works, (iv) augmented reality presentations, (iv) construction site design, etc.
In this perspective, the problems of detail, geometry and accuracy require a new definition, as it becomes crucial that any different model is clearly labelled as for its accuracy, purpose and significance.
The examples considered in this paper starting from the architectural scale and the specification conventionally adopted for the surveying, extend them to the HBIM domain, particularly in object modelling. An explicit value to measure the Model Accuracy could help to take informed decision and to use such models with a better knowledge of their contents by the different stakeholders. For this reason, together with the architectural scale with all its richness and complexity, it is also introduced in this paper the urban scale, where the HBIM turns toward the GIS domain (HBIM-GIS): it starts from the city model accuracy, with a LOD-LOG specific for that scale, enriched by many information together with specific geometric data integration. Thus, the urban scale is analysed taking into consideration the survey of the public facades of historical site for implementing the Historic Urban Landscape (HUL) through georeferencing technique, interpretation of local stratigraphic

units and geometrical analysis at the city scale. To the different purposes different level of details can be required. HBIM level of details ranges from simplified modelling levels required from the Urban BIM-GIS purposes (i.e. Energy City Model), till to enriched city model, where the city model can be enriched historical stratified analysis and preservation purposes, requiring an higher level of detail.

2. SPATIAL SOLID MODELLING: THE LESSON LEARNT FROM THE PAST TREATIES AND SKILLS

Past can help. The rich production of historical treats of architecture testifies an approach adopted in surveying and representing the historical building and their components, with a 360° three-dimensional representation devoted to spatially understand dimensions, proportions among them, the geometry, construction techniques, including the art and technique of cutting the stones in the space (stereotomy), or to represent the 3D arrangement and disposition in the space. Geometry, materials and construction techniques are parts of a unique inseparable and indivisible whole subject, that is the object itself with its shaped material consistency and physical characteristics; the ancient concept of 'habeas corpus' summarizes the concept. To cite just a few examples, limiting this analysis to the XVI-XIX centuries, following the theoretic fundamentals of the descriptive geometry, simple objects, as well as complex architectural objects and constructive systems have been represented in treatises, where the single bi-dimensional representation are just part of the whole 3D spatial representation of the object: vaulted systems, covering systems, wall, arches, stairs, decorations can be founded in the many different editions of the treats by De L'Orme (De L'Orme, 1561), Guarino Guarini (Guarini, 1737), Rondelet, Viollet Le Duc to name few of them (Figure 1). What we have to recover from the past is the richness of skilled capacities to dominate the–complexity of the shapes in the spatiality, building new capacities inheriting the approach to a spatial vision intrinsically connected to the materials and their arrangements. Under this point of view, HBIM concept represents a modern system conceived to manage the construction and maintenance process, where the 3D object model is associated to materials, 3D mapping, their physical characteristics (structural, energetic, others). The question now is how to fill/bridge the gap. Retracing the thin thread that links a geometry to constructive reasons, and to the behaviour of an element within the whole system in order to maximise the preservation of the authenticity of the materials, of the construction techniques and of their functionality. HBIM can take a role supporting such bet.

3. SURVEYING DEVOTED TO HBIM 3D MODEL OBJECT ORIENTED: ACCURACY, PRESCRIPTIONS AND BEST PRACTICES

HBIM logic is revolutionising the habit of professionals of representing, managing and communicating heritage buildings. Thanks to the generation of 3D objects representing architectural elements, 2D drawings (plans, sections and elevations) are integrated within 3D models to improve the understanding of built heritage richness both from a morphological and semantic point of view.
This change requires a great effort in adopting new modelling skills to rediscover lessons learnt from the past and those capabilities substantially lost in the 3D spatial modeling.

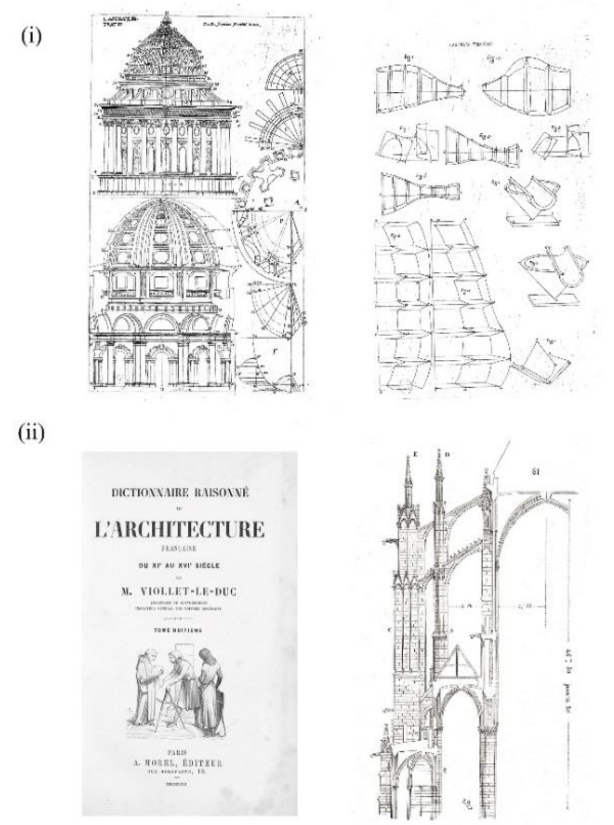

Figure 1. (i) 'Architettura civile del padre D. Guarino Guarini: opera postuma', 1737. ETH-Bibliothek Zürich, Rar (Public Domain Mark). (ii) Dictionnaire Raisonné de L'Architecture Française du XIe au XVIe siècle, Eugène Viollet-le-Duc, Édition Bance-Morel de 1854-1868. 'Arc.boutant', Beauvais cathedral.

At the same time, the high accuracy of cloud points (acquired by Terrestrial Laser Scanning-TLS or through Photogrammetric or Structure from Motion –SfM data processing as) allows catching a dense number of points describing the geometry with high accuracy (3÷5 mm), allowing the detection of a rich level of detail within that accuracy. Results allow operators representing all the richness derived from the surveyed point clouds: this is the case of profile extraction of structural elements (walls, beams, vaults, and so on) to derive out of plumb analysis, or horizontal and vertical profile sequence-based analysis to detect the shape and to support the assessment and behaviour analysis of the surfaces of walls and pillars, anomalies, and different alignments coming from different construction phases (Brumana et al., 2017). Brumana et al., 2018a highlighted different spatial solutions and construction techniques adopted for vaulted elements apparently belonging to similar vault typologies.
In this context, the gap is represented by the modelling of such richness, in terms of generative roles and accuracy.
Fixing minimal specifications and defining protocols can help to go in the direction of adopting a shared common language in the modelling phase. The result could represent a first step for a common discussion and opinion sharing among the 'geomatics and restorers' communities toward the overcome of discretional practices, that unfortunately nowadays are mostly adopted in the HBIM modeling, to cover the lack. BIM practices adopted

for new construction needs to be strongly modified to be turned toward HBIM purposes: they require to reverse the simple- to-complex BIM enrichment, to embody the complexity since the starting phase (Brumana et al., 2018b) to better support the assessment and decision making (Della Torre, 2015), to limit the unexpected expensive interruption of the construction site, adopting heritage monitoring as strategy for planned conservation across the time (Fregonese et al., 2018).

To be extremely clear on this point: BIM practices derived from the new construction lead to deal with details and accuracy in developing terms, from rough to detailed as the design and construction process goes on. Here we are proposing to think in terms of different parallel models derived from one survey, and the use of the terms "level", or "grade" do not mean any progression from one level to the next one, but just differences in terms of the detail or accuracy consistent with the purposes and the characteristics of the parametric model required by each domain.

3.1 Scales of representation, modelling and accuracy: Grade of Accuracy (GOA)

Recovering the ancient capabilities to think and draw in a spatial dimension will not be an easy process. It often happens that the level of geometry gained for the 3D volumetric representation of the single objects is sometimes derived from the skilled capacity more than from the geometric characteristic of the object itself. Moreover, the level of detail, level of geometry adopted is unconscious, sometimes adopted with no reference to the required scale and to the specificity of the object to be modeled.

This paper is a first tentative to fix some constraint in the modelling accuracy inheriting the concept of surveying detail and tolerance linked to the different common scales of representations, from which the level of detail was automatically and conventionally fixed and adopted, as in the carthographic tender specification. The so called Graphic Error (G.E) represents the minimum detail at the given scale: the choice of the 'scale' depens from: the aim of the survey - and nowadays HBIM requests -, the use of the product, characteristics of the objects, state of the art, and state of decay to be detected.

Starting from the specification criteria adopted for the surveying and fixed in function of the different required scales, such range value has been adapted to the LOA of the Model Object: the conventionally adopted graphic error definition (G.E representing the minimum detail once represented on the paper), and tolerance definition (T = 2÷3 G.E value) generated different values at the different scales. They derive from the following proportion: "1: n scale factor (20, 50, 100, etc.) = 0,2 mm: G.E. (the correspondent dimension of G.E. on the ground at the fixed scale). Traduced at the scale 1:50, for example, it means that the G.E value, the minimum detail to be represented is correspondent to 1 cm, and the tolerance admitted is correspondent to a range value of 2÷3 cm: very good achievable values if we think to the surveying accuracy! For the scale 1:20, G.E = 4 mm and T =8÷12 mm.

When moving from the 2D to the 3D Object Model, the generative modelling tools in the case studies here presented have been driven to maintain and respect a Grade of Accuracy (GOA) in function of the virtual scale chosen: as said before in function of the necessities and purposes of the preservation plan or intrinsic characteristic of the objects, different actors' requirements and needs.

The GOA is automatically associated to the chosen scale (Table 1).

Different scales can be thus adopted in the same design phase, or after the design phase during the long life cycle management. For example, in the case of the Basilica di Collemaggio it has been adopted within the HBIM global 1:50 scale to represent the 3D wall objects, and 1:20 for the vaulted system and for the pillars arriving to the 3D ashlars BIM management.

ADOPTED SCALE	GRAPHIC ERROR G. E.=0,2 mm	TOLERANCE T = 2 ÷ 3	GOA
1:10	2 mm	4 ÷ 6 mm	GOA 10
1:20	4 mm	8 ÷ 12 mm	GOA 20
1:50	10 mm	20 ÷ 30 mm	GOA 50
1:100	20 mm	40 ÷ 60 mm	GOA 100
1:200	40 mm	80 ÷ 120 mm	GOA 200
1:500	100 mm	200 ÷ 300 mm	GOA 500
1:1000	200 mm	400 ÷ 600 mm	GOA 1000

Table 1. The grade of model accuracy correspondent to the different scales.

4. LEVEL OF GEOMETRY, GRADES OF GENERATION (GOGS) AND GOA.

The model should be developed according to the needs of the relevant domain. This requires an evaluation of the level of detail useful for the purpose. The UNI norm 11337-3-2017 (at the first release and therefore meant as still under discussion) introduced the concept that the logic of scaling LODs-LOIs generated by the design and construction process of new buildings, has to be reversed for interventions on built heritage. The conservation process starts with the survey, as the basis of any activity including recognition and investigation, and all the other activities will derive their own models from the survey data stored in the CDE (ACDat in the Italian norm). The proposed section 3 on LOG-LOI ('F and G'), related to the general schemes of the norm, has surely to be developed taking into account the accuracy issues, but the point is that the highest level of geometry is available in the CDE, and as modeling the issue is how far this high level should be conserved or simplified.

A step forward should be represented by the inclusion of the concept of model accuracy and GOA within the norms for the HBIM purposes.

4.1 LOGs (Level of Geometry)

Following the literature interpretation of the LOG levels (Bloomberg et al. 2012), a downgrading proposal of the LOGs (500-100) sequence has been articulated in the particular case of HBIM and preservation purposes, describing the Levels of Geometry according to novel scan-to-BIM modeling requirements (GOGs and GOAs).

The growing need to include different data sources such as laser scanning and digital photogrammetry (primary data sources) and historical reports, 2D drawings and so on (secondary data sources), in the generative process of HBIM models (see also Lombardini, Cantini 2017), led to introduce new levels of geometry (LOG) in the LOD specifications.
As described in Banfi 2017, GOGs and GOAs are not intended to replace the various national reference regulations but they have the primary purpose to describe how a scan-to-BIM model should be genereted, reducing the time and costs of the generative process, maintaining high GOAs with point cloud data and improving the information mapping of precise digital models.
LOGs intend to highlight how the proper creation of an HBIM model can be useful and orientable for different BIM-based analyses according to the scales and GOA introduced in paragraph 3.1. HBIM orientation requires different scale and grade of accuracy (GOA) sufficient to support the modeling requirements of each analysis and software. The choice of the proposed scales turns out to be an essential prerogative for the generation of HBIM models. The flexibility and the ability to direct the modeling for different BIM-based analysis, software and uses can pass through the adoption of different scales of representation where the GOA is oriented to the needs and requirements of the project. In particular:

- LOG 500 represents the last level of HBIM. Thanks to a proper generative process, it is possible to transfer into a parametric model the highest accuracy of the survey data stored in the CDE, in order to use it for different purposes, supporting new levels of information sharing;
- LOG 300 represents the customary generative phase of accurate 3D models from point cloud data. HBIM oriented to energy analysis or FEM (finite element model) can use this kind of modeling. Furthermore, the correct choice of a scale could be decisive also for the creation of more simplified models such as the ones for CoSIM;
- LOG 400 allows the proper orientation of HBIM models for deeper BIM-based analyses. For instance, IRT analysis, decay analysis and 3D structural simulation can require better geometric accuracy enhancing ‘informative’ value;
- LOG 200 represents the data collection stage characterised by the acquisition of 3D point cloud data from laser scanning survey and digital photogrammetry survey (primary data sources);
- LOG 100 is the first approach to the history of the buildings. Thanks to the collection of historical reports, 2D drawings it is possible to deepen the historical knowledge of the building passed down from one generation to the next

4.2 Grades of Generation (GOGs)

To gain the proper grade of accuracy in the modeling generation, different Grades of Generation (GOG) have been defined and implemented (Banfi, 2017). They span from the simplified volume generation (GOG 1-8) till to the most complex grade, introducing the new GOGs 9-10 addressed to take in account the richness of the morphology. GOGs can be seen as tool functionalities adopted in the modelling phase.

The analysis of the geometrical irregularities detected by the survey coming from the point clouds is crucial to the selection of the proper GOG.
This means that the HBIM model follows the required accuracy in function of the objectives.
GOGs 1-8 in general can be adopted to model object or portions where the standard deviation of the clouds respect to the required conceptual solids (parallelepipeds or other generative solids, for walls, or cylindrical portions, as for barrel and cloister vaults, spherical volume, paraboloids, or other generative solids) remain within the tolerance of the scale accuracy chosen (≤ GOA Tolerance).
GOGs 9 and 10, instead, are required for the generation of all the other objects or portions where the standard deviation of the point clouds respect the conceptual solids is bigger (≥ of the GOA Tolerance). The choice among the GOGs derives from a punctual check of the geometry of the objects to be represented and from the different requirements.
Some examples (walls and vaults) which can represent the different cases that can be encountered in the frame of the conservation process are hereafter illustrated showing how different GOGs are implemented, to clarify the concept.

4.3 Wall case: simplified solid (GOG 1-8) and NURBS BASED (GOG 9-10)

Different examples of wall modelling with the accuracy of GOA50 (equivalent to a scale 1:50) are here presented: the different outputs depend on the different geometry coming from the point clouds.

4.3.1 GOA50 - GOGs 1-8

GOGs 1-8 define simplified functionalities (i.e. based on extrusion, subtraction, sweep, and other modelling functionalities). Where needed it is possible to associate the different options to model for sub-portions (as in the case of openings, or irregular plan profile).
Cases of walls - for which it has been chosen a scale 1:50 (equivalent GOA 50) - with a standard deviation of the point clouds respect to the planarity check ≤ 20 ÷ 30 mm have been modeled adopting the GOGs 1-8.

4.3.2 GOA50 - GOGS 9-10.

GOGs 9-10 define complex nurbs based modelling functionalities (Banfi,2017).
At the scale of 1:50, vertical walls with a standard deviation of the point clouds respect to the planarity check of the façade surfaces ≥ 20 ÷ 30 mm (that is the tolerance range value of the survey at the scale 1:50) - for example having profiles evidencing out of plumbs ≥ 20÷30mm - have been modelled adopting GOG 9 and 10 (NURBS based objects modelling) embodying the complexity of the shape (Brumana et al., 2018a) in order to follow the geometry discretized by the point clouds.
Two different walls are considered to highlight the concept.
A wall with a warp of 57 cm. An overlapping between an object modeled by GOG 1 (parallelepiped) with GOA 1000 and an object modeled by GOG9-10 shows the main difference from a geometric point of view. A GOA 1000 could not intercept the richness of such wall with a warp of 57 cm. GOG 9-10, instead, help to create a double curved wall with all its geometric peculiarities.
The second case considered is the North wall of the Basilica di Collemaggio: due to the earthquake damages the standard deviation respect to the planarity check and out of plumbs

(~3÷18cm) required the integrated use of GOG 9 and GOG 10 in order to generate a model taking in account the morphology of the wall. Figure 2 shows the generative process applied to irregular complex objects of the heritage buildings.

4.4 Model validation: Automatic Verification System (AVS)

An example of a complex vaulted system modeled with GOGs 9-10 is illustrated in Figure 3. The automatic check of the grade of accuracy obtained by the model respect to the surveyed cloud points is illustrated (in this case it has been adopted a GOA20 due to the complexity of the shape given from the umbrella vault and from the earthquake damages).

The validation of the process is easily checked by the modeling functionalities of modelers and BIM tools. The verification of the accuracy of the modeled object respect the surveyed point cloud is obtained through the Automatic Verification System (AVS) of the GOA gained from the modeling phase.

Scans-to-BIM NURBS-based Object surfaces processing have been introduced to get a GOA of the model respect to the point cloud contained in the order of 2÷4 mm for the damaged structures. For this reason, it becomes mandatory to declare the reference scale adopted for all the HBIM Objects and the AVS, by inserting the LOD and LOG with GOA adopted within the properties of the HBIM. Figure 7 shows the development of new properties for a complex vaulted system modelled by GOG 9&10.

A case of GOA 20 (a grade of accuracy of the model equivalent to a scale 1:20) is here shown in the case of a vaulted system. Vaulted systems are generally more complex than the classification of the typology usually considered: detailed surveying of intrados and extrados, together with thermal images analysis are allowing to decode shapes that are more complex than the conceptual solids coming from the literature (Brumana et al., 2018a). In order to detect the richness and creativity of the solutions adopted by the construction techniques, the proper GOA has been tuned from GOA 50 to GOA 20. Obviously under the specification upper described above in relation to the objectives.

We have also to add that, given the short distances of indoor contexts, the terrain pixel of the photogrammetric image block (conventionally set = E.G G.E/2for the different scsles scales) is very high: it ranges from 1÷2 mm, then the richness of the data acquired is coherent to scales that ranges from 1:20 till to 1:10, without any additional effort (time and cost) in the surveying phase.

The precision of the point clouds allows the extraction of vertical and horizontal profiles with high accuracy (2÷4 mm). On the surveying side even if we assume that a scale 1:50 is enough in the reality the precision is the one relative to 1:20/1:10.
GOA 20 means that the model accuracy vault elements or domes or other components (as the octagonal columns in the case of the Basilica di Collemaggio) respect to the points will be contained within the tolerance at that scale (T 20= 8÷12mm). This scale implies that modelling the objects with such precision (richness) requires not just a reliable modeling of the intrados and extrados (where available) but also additional analysis (i.e. IRT) that are addressed within the LOG400 (BIM based analysis): this way the richness of the shape coming from the 3D textured model, contributes to derive a deeper more in-depth knowledge on the construction technique adopted, on its behaviour, and to boost the preservation and conservation actions.

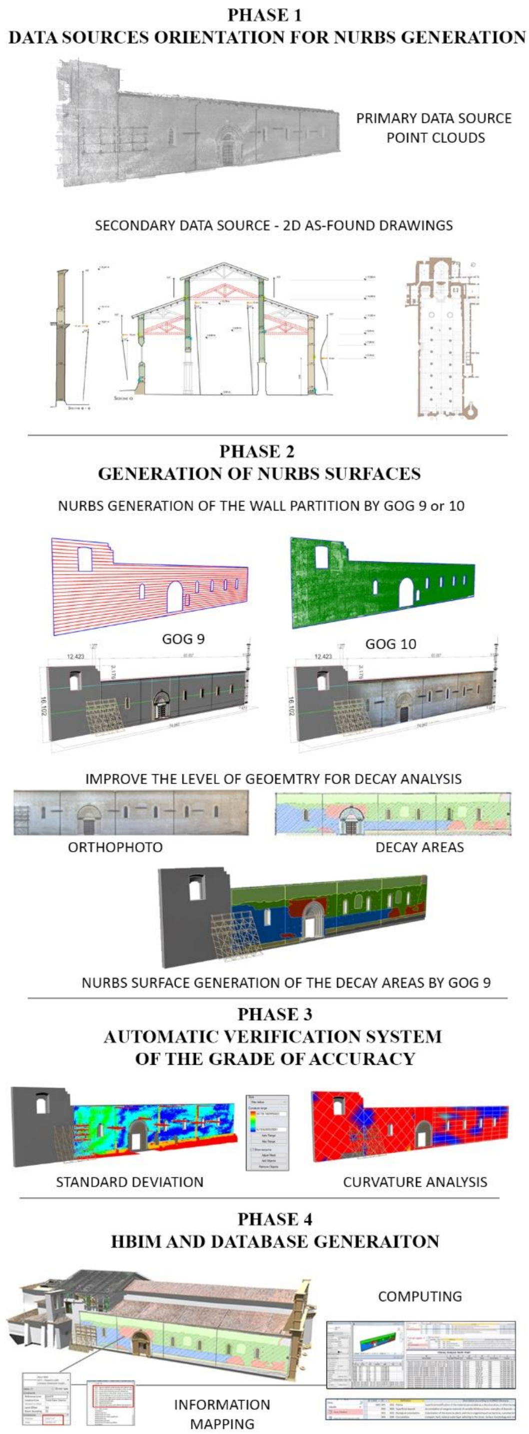

Figure 2. The generative process applied to the North wall of Basilica of Collemaggio. The fourth phases allow to transform dense point clouds in informative models with GOA 10.

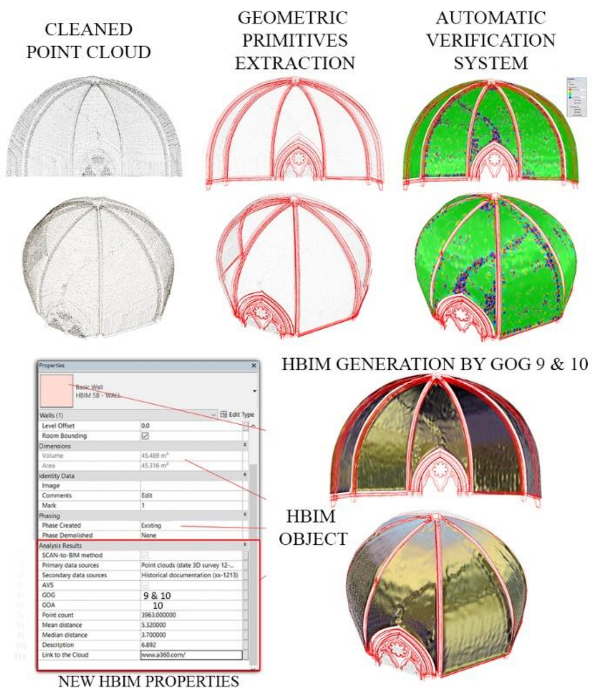

Figure 3. The generation of new HBIM object based on a scan-to-BIM process needs new parameters to communicate to different users the GOA20 achieved during the generation.

4.3 City model and building facades at the HUL (LOA100-200- 500)

Even if under the modeling functionalities the difference is among the simplified GOG1-8 and the shape-adaptable GOG9-10, the decision of the adoption depends from the real geometric shape detected by the point clouds and from the chosen scale. It is evident that there is a relation among between the objectives and the shape to be represented.
If we survey a place with all the building facades to manage the safety exits and fluxes, it will be adopted a GOA equivalent to a scale 1:200, or others, consequently the tolerance value limit among the simplified GOGs1-8 and the GOGs 9-10 decreases from the 20÷30mm (LOA50) toward 40 ÷ 60 mm (LOA 100) or 80 ÷ 120 mm (LOA200). The modeled object will be simplified respect to the LOA50. The shape will result simplified. Such façade walls will be represented with different models in function of the scales (thus in function of the required LOD): in the case of the HUL urban scale (1:1000, 1:500, 1:200), as an extrusion enriching where needed the LOA of the fronts with the stratigraphic units' analysis and mapping (LOA50), as illustrated by the Figure 4.

5. HBIM TO HUL: STRATIFIED CITIES LEVEL OF INFORMATION AND GEOMETRY

Since the 70s, the role of the historic centers, defined as set of relationships among human activities, spatial organization, buildings and their surroundings, increased its importance in local policy addressed to protect the peculiarities of this environment. With the further introduction of the notion Historic Urban Landscape (HUL), by the Vienna Memorandum in 2005, the stratified city center was assumed as expression of tangible and intangible values. Among the various aspects embedded in its social, economic and space organization, the buildings composing the historical center present several levels of information. Their public facades, along the roads and the squares, are the backdrop of the city life, filter between public and private spaces. The advanced survey of the facades can support several aspects concerning the buildings characteristics, its material composition and the interpretation of its construction logic. The knowledges developed by geometrical survey, historical analysis and other investigations can be grouped in dynamic databases, allowing a general improvement in sharing the information concerning buildings, the open spaces, the functions and the changes occurred to the built heritage characterizing the city centers. Information concerning historical documents related to common buildings, like cadaster maps, ancient representations or pictures of the city center showing changes and transformation of the urban settings, detailed analysis on peculiar decorations (like frescoes, graffito, etc.) and more detailed indications about building structures (like masonry texture organization and other building techniques), can be collected in modern platform services linking geographical data with architectural objects. These data sets can be shared and associated with other digital tools for increasing the knowledge about the city center characteristics and give effort to an active involvement of local people in valorization polices set for the built heritage (Della Torre et al., 2019).
Advanced surveys techniques, combining digital representation obtained from laser scanning and digital pictures rectifications, provide a fundamental effort in promoting detailed analysis on the historic centers, allowing considerations on persistence elements, representing long lasting elements for the urban system, and turning points in its relational system balance.
Architectural Geographic Information System based software can support management processes for recovering town quarters belonging to historical centers, classifying the level of problems (from distribution of the functions to misused building units) and providing a map of the state of conservation of each building. Several examples describing this new methodological approach, based on digital georeferenced tools, are available in literature (Achig Balarezo et al., 2016 and Heras et al., 2016). These solutions are useful for assessing the buildings and their characteristics at urban scale. Further analysis can integrate this first step by adding information at different scales, recording the information connected to the risk assessment observed at the level of the built units. The aim of this procedure is the setting of a proper administrative action addressed to a interventions proposals fallowed by serious policies for guaranteeing a constant risk assessment.
Moreover, the impact of the detailed representation scale of historical building plays an important role for mechanical analysis, allowing observing peculiar aspects of the surveyed structures. The relationship between diffused crack pattern and deformations of the architectural elements can find important support by the geometrical analysis provided through the three-dimensional model of the building. On the contrary, the common analysis of the surfaces of the historical buildings, divided into material and decay identification, is mainly based on two-dimensional representations, where the accurate reproduction of external and internal prospects is not fully used. The recent trend of substituting rectified pictures to drawings of the architecture, for assessing the surfaces conditions of historical buildings, limited the interoperability offered by BIM technology.

6. CONCLUSIONS

The paper presents arguments supporting a new direction for research on historic BEAM, underlying the concept that each phase of the conservation process requires an adequate level of accuracy and complexity. This means that instead of heading towards models, which should comply with very different requirements, research should invest on the capability to generate specific interoperable parametric models carrying the correct levels of accuracy, complexity and information, always referring to a common data environment.

The reported experiences show how it is possible to transfer into a parametric model the highest level of accuracy as well to downgrade geometries to the levels required for specific tasks.

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