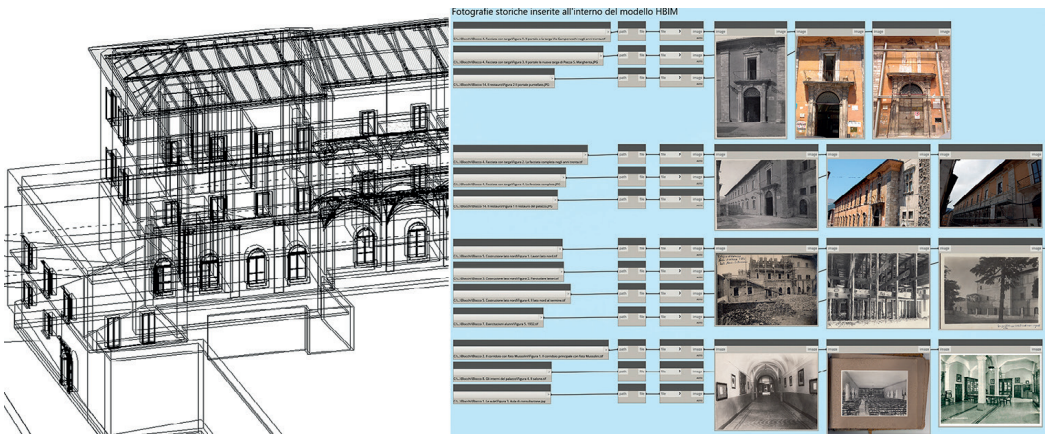
The "LoH - Level of History" for an Aware HBIM Process

Stefano Brusaporci
Alessandra Tata
Pamela Maiezza

Abstract

The HBIM procedure is different from the traditional BIM one, because the HBIM moves from an historical-critical knowledge process, on which then the project dedicated to architectural heritage roots. Consequently, the H-model is characterized by objects with different LoDs. A useful reference is the one offered by LoINs –Level of Information Need– that introduce the idea that LoDs can be critically defined. The paper highlights the differences between BIM and HBIM and consequently it proposes the definition of a new Level of Developmet, called LoH "Level of History". In particular, the representation of the architectural heritage requires the management of information that are not considered in the well-established BIM procedures for new buildings. LoH is made by historical information not computable and related to those aspects that have contributed to the formation of current configuration of the building. Since this historical information can be more or less exhaustive, three levels of LoH can be assumed: high, medium and low. In order to enter this additional information within the HBIM environment, the HBIM database has been expanded using Visual Programming Language.

Keywords
HBIM, LoH Level of History, LoD, LoIN, VPL.



Palazzo Camponeschi in L'Aquila (IT). HBIM Model and VLP for the database expansion.

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Introduction: the HBIM process

BIM is a process born for the design of new buildings. The BIM model consists of parametric three-dimensional objects, semantically related to building components, enriched with a whole series of both qualitative and quantitative informative attributes, concerning architectural, structural, and plant engineering aspects. The BIM process is a deductive procedure based on an analytical approach of *ex-ante* semantized objects that leads to the development of a predictive model with ever more defined LoD.
BIM presents many elements of interest also in the field of the built heritage because of many reasons: national and international legislation provides for the progressive introduction of BIM in the public procurement sector; BIM encourages the control of the building process and procurement, allowing for more objective and administratively transparent procedures; BIM, as a whole, is a database specifically dedicated to buildings and can therefore facilitate the collection and management of information and its use for study and design purposes.
The HBIM procedure deals with built heritage and starts from a path of critical *knowledge* based on architectural survey and historical analysis [Apollonio, Gaiani, Zheng 2012; Dore, Murphy 2015; Di Luggo, Scandurra 2016]. Therefore, the HBIM procedure for historical buildings is based on a different theoretical-methodological approach compared to the well-proven BIM one. In fact, the HBIM process rises from the knowledge (usually not encompassing) of historical artefacts, and after it focuses on restoration and design, because the project roots on the complex informative model of the existing architectural heritage. Therefore, the H-model presents elements with different levels of development and/or information, according to the available knowledge. In particular the HBIM process is an inductive procedure based on a synthesis approach of ex-post semantized objects that lead to the development of a interpretative model with irregular LODs.
Therefore, for an effective use of BIM applied to heritage, the development of a dedicated procedure and LoDs are necessary.
Developing the outcomes of a line of research on BIM's database extension [Brusaporci, Tata, Maiezza 2020], the paper highlights the different characteristics of the HBIM process as a critical process that is fundamental for an interpretive knowledge of the built heritage and necessary in order to be able to develop projects of conservation, restoration, maintenance, management, enhancement [Monaco, Siconolfi, Di Luggo 2019]. Follows the proposal of a new HBIM's level focused on the history of the building and on its documents: the LoH "Level of History". LoH is realized by using the Visual Programming Language for the expansion of the BIM database [1].

Fig. 1. Palazzo Camponeschi in L'Aquila (IT). Historical image of the façade, lower floor and main elevation.

Fig. 2. 3D surveying: The courtyard facades, and the monumental staircase.

State of the art

The UNI 11337:2017 standard defines the Level of Development (LoD) as a measure of the "nature, quantity, quality and stability of the data and information" associated with each digital element that composes the model. The transition from one LoD to another involves an increase in both the quantity of attributes held by a BIM object and their quality, understood in the sense of granularity, reliability and data consolidation [Pavan, Mirarchi, Giani 2017].
According to the English system (PAS 1192-2 of 2013) and American one (BIM Forum), Italian LoDs are defined on the basis of the Levels of Development of both the graphic attributes (Level of Development of the objects – geometric attributes (LoG)) and the non-graphical ones (Level of Development of the objects – information attributes (LoI)).
For historical buildings, the standard UNI 11337: 2017 recommends the highest level of development –both LoG and LoI–. It is right from an ideal point of view, but it proposes a simplistic transfer of the BIM procedure to historical buildings, because the HBIM model ris-

Fig. 3. Point clouds of interior spaces.

es from a punctual knowledge of old buildings, more or less in-depth and in most cases not exhaustive [Brusaporci, Maiezza, Tata 2018a; Scandurra, Pulcrano, Tarantino, Di Luggo 2017]. Thus, there is a difficulty in establishing an appropriate LoD to be achieved within the model elements, since with historical buildings not all information is available and, while some (physical) can be investigated through diagnostics and surveys, others (e.g. historical ones) may simply be absent. Therefore, LoDs are not uniform, they are spotty with different levels according to the available information.
In this context the introduction of LOINs –Level of Information Need–, whose proposal will be within the new international standard ISO 19650, offers useful suggestions: in fact, the LOINs are be strictly dependent on the type of use and the needs [De Gregorio 2018], i.e. the characteristics of the heritage and the aim of the HBIM model.
Moreover, BIM software and platforms does not fully support the HBIM procedure. In particular, the study of a historical building for a proper understanding includes a large amount of heterogeneous data which, to be included in an HBIM model, requires an expansion of the database [Brusaporci, Maiezza, Tata 2019b].
There are many approaches to study and experiment with new ways of expanding the BIM database and managing information for the documentation of architectural heritage. [Acierno et al. 2017; Quattrini, Pierdicca, Morbidoni 2017; Bruno, Roncella 2019; Messaoudi et al. 2018; Palomara et al. 2020].
The use of parametric tools such as computational design is particularly interesting because it allows you to organize and manage a large amount of data in a structured way. The connection of this data to the BIM model actually allows a real expansion of the BIM database [Khaja, Seo, Mcarthur 2016; Brusaporci, Maiezza, Tata 2018b].
In the built heritage modelling and visualization, the themes of transparency and reliability are very important. In fact, the knowledge of existing buildings is often an incomplete knowledge arising from direct and indirect non-homogeneous sources, for which, it is appropriate to declare the level of interpretation of information for each element, in addition to the type of source used for the information [Brusaporci 2017; Brusaporci, Maiezza, & Tata, 2019a; Maiezza, 2019].

Fig. 4. Historical photo of the construction site of the north part of the building.

LoH Level of History

Both LoG and LoI levels refer to aspects of the digital object representing the architectural element that, to a certain extent, can be considered quantifiable and evaluable: for example, the dimensions or the material or, again, the cost of the component. This is an information regarding the physical characteristics of the architectural element, or the necessary ones for the management of the project and the construction site.
These aspects also clearly affect the architectural components of historic buildings, but they do not exhaust the field of interest which, in the case of heritage, also includes all the historical information relating to the modifications and transformations undergone by the building and which led it to acquire the current configuration.
The UNI considers the LoD as an attribute of the single element, therefore allowing also LoD diversified within the overall model. However, a substantial difference should be highlighted between the BIM process and the HBIM one: if in the first, the difference between the LoDs is linked to the design phase, at the end of which there will be uniformity, the same cannot be said for the HBIM processes for built heritage, for which, even at the conclusion of the cognitive process, it is very likely to have different LoDs due to the lack of homogeneity of the available information.
The LoI includes all the non-geometric attributes that characterize the representation of an architectural element, with all those aspects relating to the physicality of the component (material, mechanical properties, etc.) or that are necessary for the design and management of the construction site (costs, structural characteristics, etc.).
Since the representation of the architectural heritage requires the management of information that are not considered in the well-established BIM procedures, it is useful to introduce a new Information level, concerning historical knowledge: The Level of History (LoH).
With reference to the definitions offered by the current legislation for the LoD –LoG and LoI– the LoH can be understood as a constituent part of the LoD, together with the LoG and LoI, but referred to historical information attributes. However, the LoH differs from

Fig. 5. Historical photo of the construction yard.

the LoI because it includes the historical information relating to the tangible aspects of the architectural asset that in itself are not computable, namely all those aspects that have contributed to the formation of current configuration of the element, such as historical phases. The LoH is understood to be constituted primarily by archival and bibliographic references, but also by information relating to the physical transformations of the asset ('historical sections'). The information related to the LoH are additional to those currently manageable in a BIM environment, therefore they must be merged into an external database, an expansion of the one consisting of the same BIM model, where it is possible to archive and manage historical photos, archive documents, etc.
To delimit the field of such information, the well-known Spagnesi dissertation on the "autonomy of the history of architecture" is assumed as a methodological reference with respect to the more general "history": i.e. in LoH we consider "the knowledge of the physical space built by man, that is to say of the actual reality. […] we can only analyse the occurrence of the essential reasons that produced it in a temporal succession" [Spagnesi 1984, p. 7].
The historic information of the current state of the building elements can be grouped within fields such as: Date(s); Author(s); Description of the transformations; Notes on the constructive techniques; Notes on the construction yard; Documental references; Bibliographical references; Historical documents.
Also in the case of LoH it is possible to use the concept of "level", because this information can be more or less exhaustive.
For each field there may be more than one piece of information depending on the number of events that led the building to its current state, on how many of these events have been documented and on if these documents are available and existing today. We propose to assume three levels of LoH historical knowledge: High level corresponding to an exhaustive historical knowledge; Intermediate level to a partial knowledge; Low level to an absence of knowledge. Obviously, for each one of these levels have to be declared the related reliability.

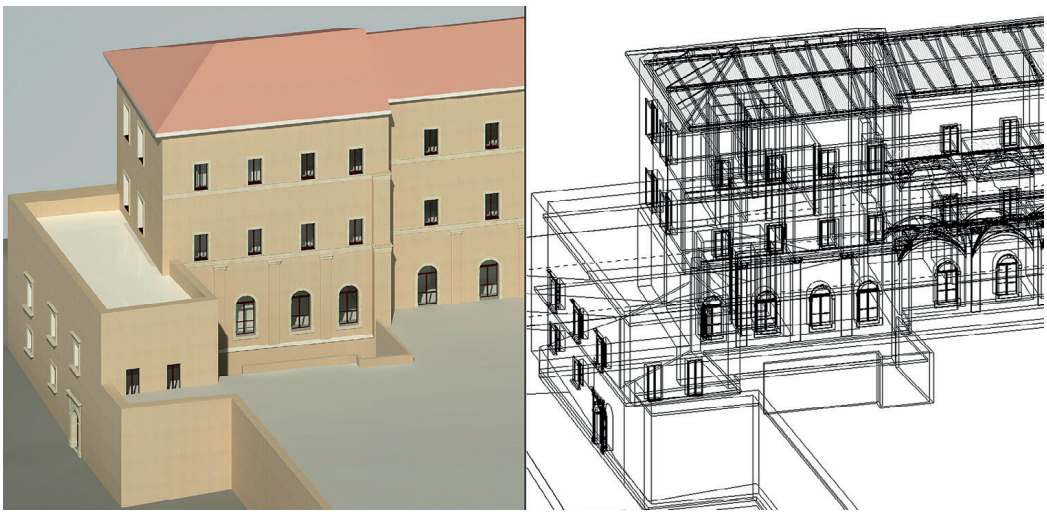

Fig. 6. Views of the HBIM model.

VPL for LoH

The BIM platforms, structured for the management of construction processes of new buildings, are insufficient to manage the large amount of heterogeneous data necessary to document the built heritage. Therefore, it is necessary to make an expansion of the database, connected to the BIM elements, which allows the insertion and organization of all the historical information deriving from the surveys and documentary archival research.
For this experimentation, the expansion of the database was achieved through the use of Autodesk Dynamo software, which is a visual programming tool for Autodesk Revit, and it

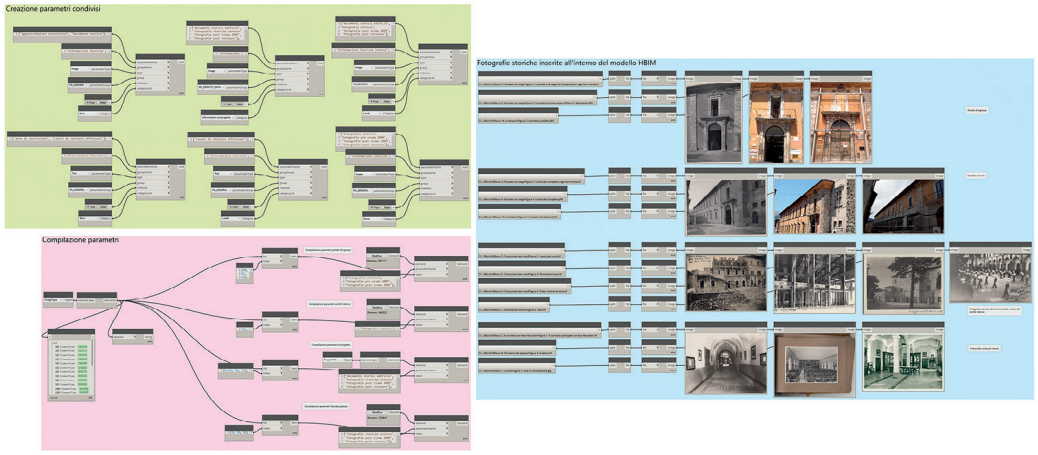

Fig. 7. Visual Language Programming to design the new Level of History (LoH).

allows you to extend its potential by providing access to the API (Application Programming Interface) of Revit in a smoother way. With the VPL, in fact, the programming is not realized through the writing of a code, but through the manipulation of graphic elements called "nodes", each with a specific function.
To achieve the expansion of the BIM database, we created a new file of shared parameters in txt format, external to the project and therefore reusable in the future, within which all the parameters necessary to enter the historical information available on the object of study that have no place in the BIM databases can be uploaded (such as historical maps, historical photographs, archival documents, information relating to the construction equipment, etc.). Information is divided into: a) general information on the asset; b) specific information of some elements that constitute it. In order to enter the former, there were shared parameters belonging to the "Project information" category, i.e. global information that is not linked to the elements of the three-dimensional model. For the latter, however, the parameters created were assigned to the families to which the information to be entered corresponded (for example, the historical construction sections of vertical or horizontal closures have been assigned to the category "walls" or "floors").
The creation of the parameters was carried out within Dynamo using the 'Parameter.CreateSharedParameter' node which was given as input the names of the parameters to be created, the name of the group in which to insert them necessary to organize them in the txt file, the type of parameter (image, text…) and the category (information on the project, rooms, walls, etc.).
Then, these parameters were compiled through the use of the 'Element.SetParameterByName' node. In the case of data relating to specific elements, the parameters were compiled by selecting the objects to be assigned the information directly from the BIM model, using the 'Select Model Element' node. In case of repeated data for more elements of the model, however, it is possible to compile them in a semi-automatic way through the realization of specific programs according to the needs [Brusaporci, Maiezza, Tata 2019].
The direct connection with the model also allows you to simultaneously update the latter and view what is programmed directly in the BIM environment. Furthermore, according to the needs, it is possible to manipulate and query the data directly, within the computational design environment.

Conclusions

For a more efficient use of the HBIM methodology an expansion of the database is necessary to insert not computable historical information. For this information, we propose a new level: 'LoH - Level of History' as new Level of Development, which, together with the LoGs and the LoIs, would contribute to a more accurate definition of the LoDs for the historical building.

In LoH, the information non directly related to the physicality of the individual digital element can be inserted. The LoH is not be generically referred to the 'Cultural History', but it is about historical information related to transformations that have led to the current reality, both in terms of spatial and material configuration.
The proposal of LoHs finds support in LoINs: in fact, the concept of LoINS is really interesting because: 1) it highlights how BIM digital objects can have different LoGs and LoIs in relation to the aims of the design and characteristics of the building, therefore the LoDs could be non-uniform in the whole BIM model; 2) it melts the differences between LoGs and LoIs, that are only different kind of knowledge, but respectively related.
In conclusion the VPL Visual Programming Language allows to document the built heritage in a structured way by realizing an effective expansion of the BIM database.

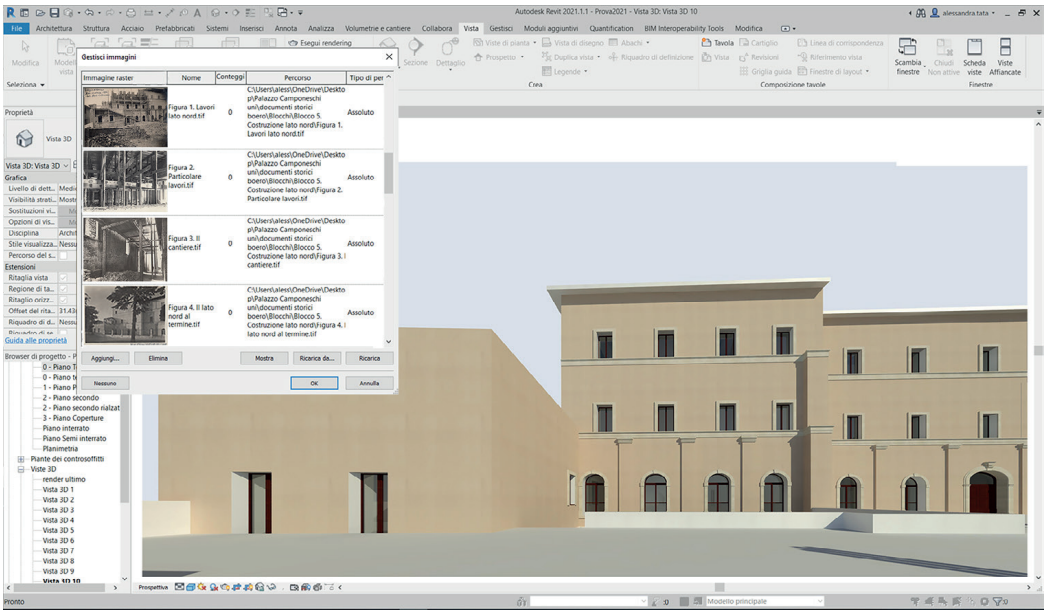

Fig. 8. The HBIM model with the visualization of historical images through the use of LoH.

Notes

[1] Although the contribution was elaborated jointly by the authors, S. Brusaporci wrote he paragraphs 'Introduction' and 'Conclusions'; P. Maiezza 'LoH Level of History'; A. Tata 'State of the Art' and 'VPL for LoH'.
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Authors
Stefano Brusaporci, Università degli Studi dell'Aquila, stefano.brusaporci@univaq.it
Alessandra Tata, Università degli Studi dell'Aquila, alessandra.tata@graduate.univaq.it
Pamela Maiezza, Università degli Studi dell'Aquila, pamela.maiezza@univaq.it

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