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HBIM AND WORKSITE SIMULATION: FIRST EXPERIMENTS

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Abstract:

Numerous HBIM (Historic Building Information Modelling) projects are being developed globally at an incremental pace. As results of steady improvements in the scan-to-BIM processes, as well as of the digital survey technologies available, increasingly accurate representations of heritage assets (and their attached information) are being obtained. Less often, and because of the efforts and resources necessary to explore such phases of the process, a further temporal evolution analysis is carried on, despite having tools that come from the commercial world which could be suitable to that use. This article narrates the attempt of an analysis alike on the case study of the Duomo of Mantova HBIM, where digital instruments were bent to construct the simulation of a refurbishment worksite as a separated actor in the federated model. Accordingly, the possibility of adding a temporal dimension (regarding the sequence of refurbishments) tasks was explored: some seminal 4D simulations were the results. What began as a mean of checking the dimensions and the footprint of a refurbishment worksite and its equipment, became more: the HBIM acted as a decision-making helper, a project management tool and a risk management device.

Keywords: HBIM, cultural heritage, 4D scheduling, worksite simulation

1. Introduction

In 2018 the Diocese of Mantova required the realization of an experimental BIM model of one of its most valuable and articulated assets, the Duomo of San Pietro; the final product (already available to the stakeholders) represents the as-built situation of the building recorded through an extensive and integrated survey combining laser scanning, photogrammetry and topographic techniques (Adami et al., 2019). The model effectively constitutes an example of Historic Building Information Model, or 'HBIM' (Murphy, McGovern, & Pavia, 2009); it was commissioned for assisting planned conservation of the asset. The complexity and the scale of the Duomo determined the breakdown of its model into smaller portions, which refer to different disciplines. The different portions exist together in the 'federated' version of the model (Fig. 1) a solution commonly adopted with large projects (Solihin, Eastman, & Lee, 2016); in the federated model the different parts, originally drafted with Autodesk Revit© software, interact through their shared 'spatial co-location'. Additionally, the possibility of adding a temporal dimension (Castellano-Román & Pinto-Puerto, 2019), conventionally called '4D' regarding time sequencing of the refurbishments tasks was settled; the reason is manifold: the knowledge obtained when including the fourth dimension in BIM environments can be of great assistance in planned conservation projects. Moreover, a thorough understanding of the past temporal evolution of architecture can help predict its future developments and avoid further damages, thus becoming a recommendable procedure for those who work in heritage conservation. In the immediate term, it also helped manage the settlement of a worksite in a difficult context.

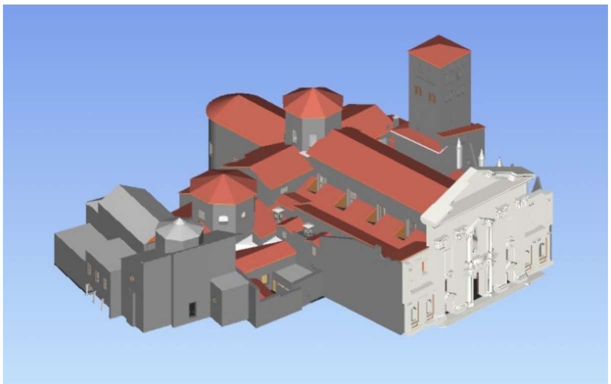

Figure 1: The HBIM original federated model (i)

2. The roof refurbishment project

For evident reasons, it is particularly important to register the 'maintenance and restoration works made over time, keep track of past actions and plan the future ones' in heritage assets. (Bruno & Roncella, 2019). HBIM environments can contain information about historic phases in an integrated way (Jordan-Palomar, Tzortzopoulos, García-Valldecabres, & Pellicer, 2018) or in external stand-alone databases that complement them (Bruno & Roncella, 2019). For the case object of the study, understanding the succession of past restoration worksites during model drafting helped determine the overall historic phases and assign them to the objects within the model. The refurbishment of the roofing above some of the naves of the Duomo in the second half of 2020 was included in the wake of this temporal insight and enriched the historical record that is being produced thus.

2.1. The worksite model

As already stated, the HBIM models referring to the architecture and other disciplines, had already been produced at the time of these experiments. With the refurbishment of the roofing, arose the opportunity to exploit furtherly what already created: a separate virtual model of the worksite was plotted according to the as-built one, to obtain a 'design of the intervention' (Nieto, Moyano, Rico Delgado, & Antón García, 2016). A series of objects composing the worksite were drafted, including a crane (to transport material onto the roofs), several scaffoldings, means of transport and equipment.

Risk management was the objective firstly: as usual for these contexts (historic city centres), space was crammed and with limited manoeuvre options (Lucarelli, Laurini, & De Berardinis, 2019). Important measurements for decisions regarding the equipment (height and type of the crane, length of scaffoldings, loading zones, to name some) were derived from the original HBIM model elements and were double-checked with the point-cloud upon which the model had been plotted.

Planning of the construction site operations was developed by the commission in a traditional way, with a Gantt chart. The limited scale of the intervention meant that all operations required reduced personnel and were dedicated to a specific area, therefore no overlapping between them was predicted by the chart.

2.2. Clash detection and simulation

After having acquired information by the mandatory 'Piano di Sicurezza', the Italian security management plan (Italian Government, 2008), and by observing the development of the construction site, an environment on where all this information could be combined had to be selected: along with the example of some other similar experiences recorded in literature, Autodesk Navisworks© was chosen (Fai, Graham, Duckworth, Wood, & Attar, 2011; Bruno, Musicco, Fatiguso, & Dell'Osso, 2019).

The software strengths are two: clash detection and 4D simulation. Its clash detection capability was used to combine and see the interaction between: the generic architectural model (i) and the model of the construction site (ii), which for the first time existed together in the Navisworks environment (Fig. 2). The 4D simulation, although limited, was the tool used to place this intervention along a timeline, and to check the movement of equipment. The results of the clash showed only minor collisions between the worksite objects and the as-built model, of which an example is shown in Figure 3.

3. Discussion

The federated model interoperability solution was explored after noticing that the architectural BIM model on its own could not collect all the information necessary for the worksite operations. Instead of implementing the construction site objects (crane, scaffolding etc.) into the architectural model, it was preferred to plot the objects in another new (equally georeferenced) model (Fig. 4). It appeared more immediate for clash detection purposes and for avoiding the increased weight of an already substantial Revit file. Paradoxically, having an active construction site, which is native for BIM, compared to the exhausted ones of the past, posed a new issue: the presence of several objects not functional for conservation activities schedule, that could be eliminated. On second thought, having drafted the worksite model separately (even though always loadable in the federate environment) resulted convenient: all the objects temporarily necessary for simulating the worksite but not significant for the lifecycle heritage of asset information have not unnecessarily occupied and weighted the model.

Nevertheless, the set-up interoperability allows retrieving this information, which is conveniently stored when not used. Moreover, future interventions and the documentation related, could be, in the same way, drafted and stored accordingly, thus creating a historical record of those objects not strictly necessary for planned conservation.

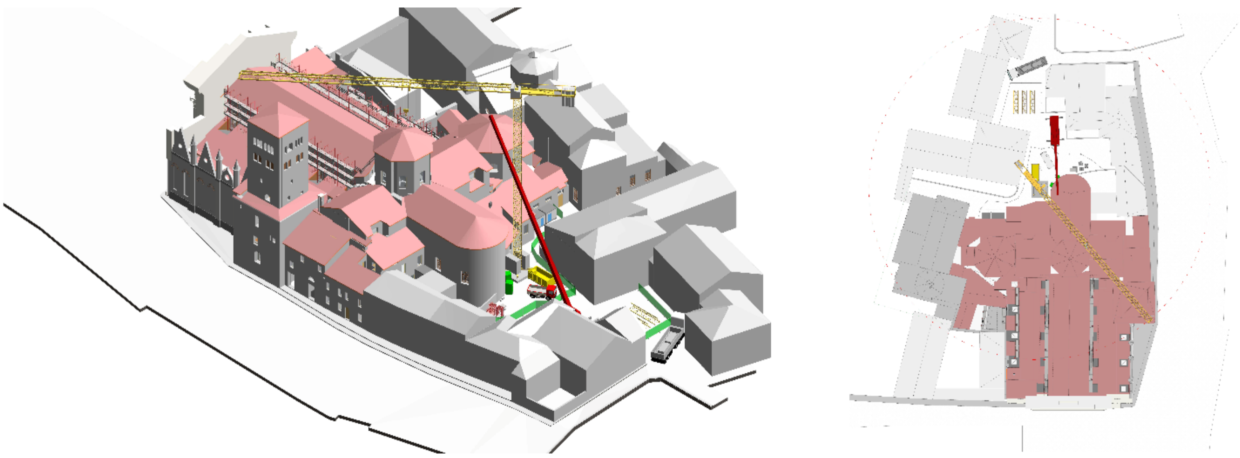

Figure 2: The two models (i,ii) coexisting and interacting in Navisworks: check of the operating range of the crane.

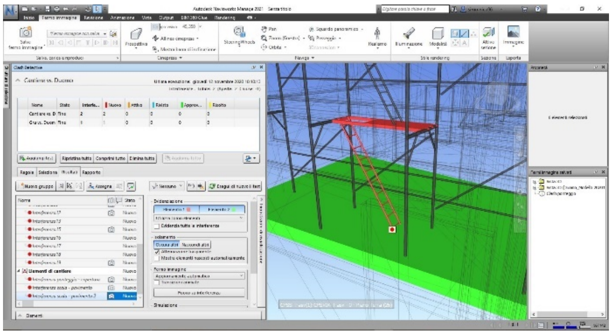

Figure 3: Example of a clash in correspondence of which Navisworks detected an unwanted interaction between the worksite scaffolding and the as-built model.

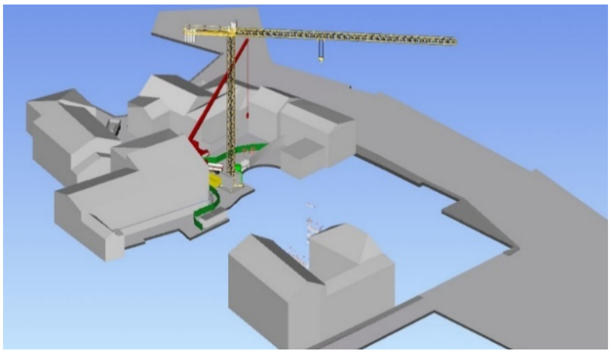

Figure 4: The model of the construction site (ii); parts of the surroundings of the Duomo had to be added because important to define the construction site.

4. Conclusions and future works

The host Autodesk Navisworks project is going to collect the timeline of interventions, the ones already carried out as well as the future ones. It is demonstrated that temporal analyses and reconstructions, when coupled with reality-based models, can enhance decisions related to conservation interventions. Introducing the temporal dimension into three-dimensional geometric objects is beneficial: the several advantages that derive from these representations and their potential use for heritage conservation should be explored; the Duomo HBIM project is an occasion to act on such premises.

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