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BIM BANG: WHY BIM AND 3D MOCKUPS ARE KEY FACTORS FOR AEC

BUILDING INFORMATION MODELS FOR THE MANAGEMENT OF HISTORIC BUILDINGS

In recent years there has been an increasing need to have structured and semantically enriched 3D digital models of historical buildings in order to handle, more efficiently, projects of maintenance, restoration, conservation or modification. In effect, in order to acquire accurate data on existing buildings, various survey techniques are adopted such as laser scanner, which allows obtaining raw 3D points clouds of buildings.

The concept of Building Information Modeling (BIM), its expansion and democratization among professionals in the field of AED (Architecture, Engineering and Design), make it essential in this quest of semantization of digital mock-ups.

Thus, Art Graphique & Patrimoine, as a leader in the use of the 2D-3D technologies for cultural heritage, adopted and developed this new paradigm.

What is the BIM?

For the beginning, BIM which is the acronym of "Building Information Modelling", is not a new technology but the evolution and the structure of existing techniques and building practices. It is a process providing a set of structured information around the building.

According to the definition of buildingSmart , the BIM is *"a business process for generating and leveraging building data to design, construct and operate the building during its life cycle. BIM allows all stakeholders to have access to the same information at the same time through interoperability between technology platforms".*

It can also be both defined as a technology and as a methodology. It is a technology because it is a digital representation of physical and functional characteristics of a building, and it is a methodology because it enables the collaboration between the various actors in the different phases of the building life cycle. In addition it is based on a set of structured architectural information on buildings, concerning components, characteristics and relations between them, and allows both to complete and to enrich the purely geometric description of a digital mock-up by associating semantic features.

Unlike a traditional CAD model, a BIM is a semantically rich model because it allows representing objects features and properties (material, cost, etc.) and also relationships between them. For example, in a BIM a wall is described using a set of parameters including its geometrical properties, its material characteristics and adjacency relationships between it and other components in the scene, while in a CAD model, it is only described as a volumetric object.

BIM is essentially used for the design and the management of new buildings, but there is a growing interest for its application in the field of cultural heritage. For modern buildings, BIM is usually constructed on the basis of a CAD model. The final model cannot truly describe the real state of the building as it is actually built. Indeed, a building may not be constructed exactly as it was designed, or may undergo some renovation works. In addition, when it comes

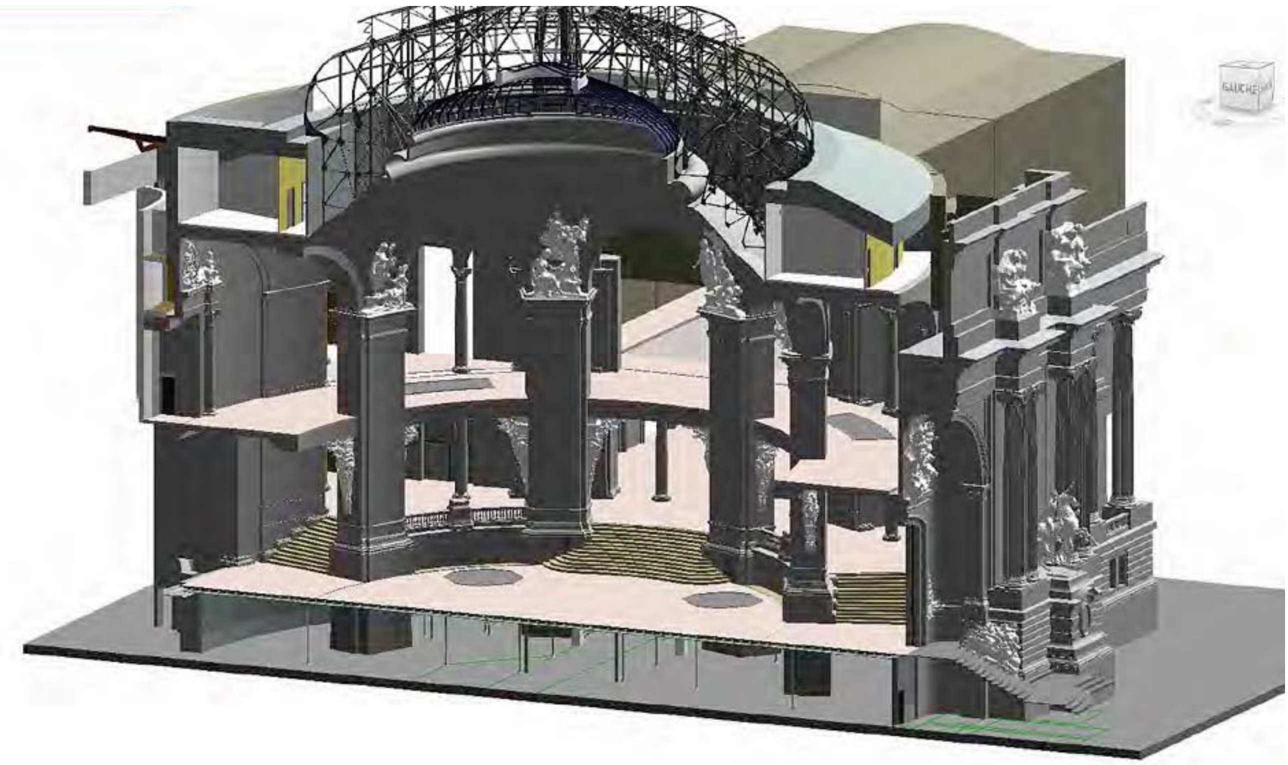


Figure 1 BIM Palais d'Antin ©Art Graphique & Patrimoine

to historical buildings, CAD model does not exist. For these reasons, and especially in the field of cultural heritage, there is a real need to represent buildings following the as-built conditions. The term of "as-built" BIM is used in that cases.

What is "as-built" BIM and what is AGP' process ?

"As-built" BIM is a term used to describe the BIM representation of a building describing its state at the moment of survey. This would help informing about the state of conservation of historical buildings. It is usually a manual concept that involves three aspects: firstly, the geometrical modeling of the component, then the attribution of categories and material properties to the components and, finally the establishing of relations between them.

"As-built" BIM is also a process that follows the traditional steps for modeling existing buildings: 1) a first step of data collection, in which dense point measurements of the building are collected using various techniques of data acquisition such as laser scans; 2) a second step of data segmentation, in which the sets of the point cloud from the collected scans are filtered to remove artifacts and combined into single parts of the point cloud applying an accurate segmentation algorithm; and 3) a final step for the BIM, in which the segmented point cloud is transformed into a model enriched with semantic features.

Data acquisition

Main data acquisition techniques are topometry, photogrammetry and lasergrammetry.

Topometry includes all traditional ways of survey such as the use of optical telescopic sight and measuring system for angular direction of sight. These techniques allows obtaining results with high precision but it requires important work of interpretation in order to find significant object structures to facilitate its post-treatment. It is a time consuming technique and becomes even more tedious when objects become more complex.

Photogrammetric techniques are adopted for the 3D restitution of scenes using images taken from different points of view. Even if this technique is not the easiest neither the speediest, the resulting point cloud is enriched with color information that could help informing about the conservation material state in the case of historical building for example. Moreover in some hybrid approach, photos can be manipulated in a second phase and allow completing missing parts of the point cloud.

Lasergrammetry is the most efficient technique in term of time and speed. It is a real-time and direct acquisition process based on the projection of a laser beam onto the surface to be measured. There are different kinds of scanner: long-range scanners that measure angles (horizontal and vertical) and distances by calculating the time of flight or by comparing the phase shift of the transmitted and received wave of a modulated signal; triangulation scanners include a base and calculate the impact point of the laser beam using one or two CCD camera. Today laser scanning technologies are in constant evolution and allow obtaining a better point clouds quality with highest density of points and a reduced error margin.

After a laser scanning survey it is essential to follow some rules in order to obtain an exploitable and structured point cloud, especially when different scanning stations are performed for various reasons that may be related to the volume of the building, the complexity of the objects, the ►

limit of the vision field of the scanner or the presence of obstacles that prevent the direct sight of the scanner.

The first step in the treatment of this unstructured point cloud is the consolidation. The aim of this treatment is to merge the different point clouds by identifying homologous points in every scanning station. These homologous points can be specific targets or characteristic points in the scene.

Data segmentation

Point cloud segmentation is a huge aspect whose research is in constant progress. It can be manual, automated or semi-automated and leads to structure the point cloud in sub parts and removing the unnecessary data from it. Many algorithms can be applied based on the recognition of geometrical shapes (RANSAC, Hough Transform…) or on similar characteristics of neighboring points.

"As-built" 3D modeling

The aim of the 3D modeling is to link the different points acquired in the previous steps of data acquisition and segmentation in order to have a geometric model of the building.

In a BIM context, an "As-built" 3D modeling process involves 3 activities: it begins with the geometrical modeling of the components, then with their attribution of categories and material properties. Finally the relations between them are defined. This process is usually manual. In fact, any software allows integrating all these tasks and even if reverse-engineering software is very efficient in geometric modeling, semantic information is not completely handled. In addition, BIM design systems cannot manage neither manipulate the huge quantities of information issued from laser scanner and are not able to directly convert primitives created from reverse-engineering tools.

1. Shape representation

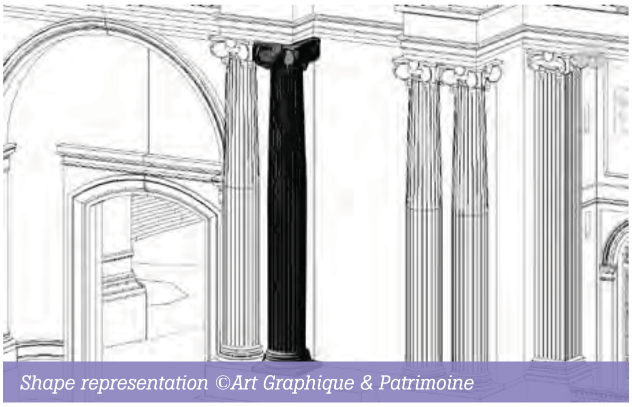
Different methods are used in order to obtain this geometric model:

- A model based on predefined geometric primitives (point, segment, curve, cylinder, …)
- Modelling using an automatic recognition and reconstruction based on differential geometric tools for point clouds segmentation
- A model based on existing parametric libraries specific on certain fields.

Another kind of modeling is the use of a meshing model. This technique is mainly used in the field of cultural heritage because of the difficulty of the mathematical modeling of historical components. A mesh model is a set of vertices, edges and faces defining the shape of the object we would like to model. Faces are mostly triangles, quadrilaterals or simple convex polygons. Then finite element calculation methods are used to discredit the point cloud and divide it into smaller sets of tetrahedrons that only meet by their shared faces.

2. Representing relations between objects

Representing relations between objects is a fundamental requirement in the case of BIM. In effect, relations are necessary to describe positions, and displacements of components (i.e. diagnosis on lacks and failures in tubes and pipelines, navigation inside a building, etc.)



Shape representation ©Art Graphique & Patrimoine

Some proposes detail the different spatial relations in a BIM context: aggregation, topological and directional relationships. Aggregation (i.e. part of, belong to, etc.), could be modeled with a hierarchical-based tree representation that permits to describe the composition in a local-to-global way. For example, nodes could represent objects or primitives and arc could represent the aggregation relations linking them. Topological relationships (i.e. connected to, inside, outside of, over, etc.), and directional relationships (i.e. above, below, etc.), can be represented by a graph-based. However, it is possible to represent all those spatial relationships by using a B-Rep representation.

3. Representing objects attributes

The representation of this feature is essential in the context of BIM. In effect, it allows characterizing objects in order to enrich the final 3D representation. They include information about materials, (texture, age, cost, etc.) and can inform also on the state of conservation and on the documentation of historic building, for instance, whether the object has been replaced or restored.

Attributes or object classes can be: graphical or alphanumerical. The graphical attributes includes properties required for the 3D modeling (Cartesian points, numerical values, limited spaces, etc.). The alphanumerical attributes includes all additional information concerning dimension, composition, economic data, etc.

Attributes are also structured on a set of classes. In effect, every object is characterized by semantic information defining it. Classes can be tangible (i.e. wall, floor, ceiling, etc.) and abstract (cost, manufacturing process, relationships between classes, etc.). ■

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