Chapter 10
Historic BIM for Mobile VR/AR Applications

Luigi Barazzetti and Fabrizio Banfi

Abstract This chapter presents the latest advances in historic building information modeling (HBIM) that have been transformed into models for mobile apps based on augmented and virtual reality. The chapter aims to demonstrate that a complex model based on HBIM can be used in portable devices to extract useful information not only for specialists in architecture, engineering, and construction industry and cultural heritage documentation and preservation but also for a wide user community interested in cultural tourism.

Keywords 3D modeling • BIM • Built environment • Mixed reality

10.1 BIM for Cultural Heritage Documentation and Preservation

Since its early days, building information modeling (BIM) has provided new digital instruments for integrated and collaborative projects in the architecture, engineering, and construction (AEC) industry [1]. In recent years, economic challenges have caused a surge in interest in smart technologies for the whole building life cycle: design, construction, operation, maintenance, renovation, and demolition [2, 3]. Here, BIM plays a fundamental role.

The main advantage of an approach based on BIM is that it provides a virtual model of a facility, in which architectural and structural elements (e.g., walls, doors, windows, pillars) and mechanical, electrical, and plumbing services are structured in a database. Elements have relationships (e.g., a door fits into a wall), parametric geometry (i.e., elements are defined by specific parameters such as width or height), and attributes (e.g., energy data, material properties).

BIM technology is not limited to buildings. BIM can be used for many projects related to the built environment, such as civil infrastructures [4], for example, highways, bridges, tunnels, and dams. In addition, BIM can also be applied to

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restore, adapt, and reuse existing valuable constructions, including historic structures [5].

Historic BIM (HBIM) [6] is intended as the application of BIM technology to historic buildings, which are digitally surveyed with images and laser scans [7–17]. Here, the complexity of historic constructions, with their irregular geometry, inhomogeneous materials, variable morphology, alterations, damages, and various construction stages, makes the creation of an accurate and detailed model using HBIM a challenging task.

The aim of this chapter is to investigate the possibility of using an accurate model based on HBIM in mobile devices, starting from a detailed survey of a building. Different specialists interested in preservation policies and sustainable management, cultural heritage documentation, disaster prevention, improved risk management, conservation, cost-effective maintenance, and restoration techniques (e.g., architects, archaeologists, restorers, historians, conservators, and engineers) can exploit the benefits of improved team collaboration using HBIM.

On the other hand, the practical applications of HBIM are not limited to professionals. Particular attention is also paid to a wider user community and applications in various fields, including built environment education, interactive learning, cultural tourism, and gamification, among others (Fig. 10.1).

Currently, wider use of HBIM is expected thanks to its close relationship with the latest developments in the technology industry. Cloud computing allows optimized collaboration with multiple devices, including advanced tools for modeling and simulation [18, 19]. Game engines can be exploited for real-time rendering to generate immersive and interactive BIM environments based on virtual reality (VR) and augmented reality (AR).

Mobile devices play an essential role in stimulating interactions between people (including specialists and so-called casual users) and digital cultural heritage. This is useful in the creation of knowledge and preservation of cultural heritage. Handheld mobile devices (mainly smartphones and tablets) can be used for productive work or for personal and recreational purposes (Fig. 10.2). Today, mobile devices are used in various scientific disciplines (e.g., medicine, education, simulated training) because of their highly flexible nature and the real-time access to information they provide: it is normal to digitize notes, send and receive invoices, scan barcodes, or make payments. At the same time, they allow for simple exploitation of digital models coupled with additional information (the "I" in HBIM).

The use of advanced visualization techniques for three-dimensional (3D) models transferred to mobile devices is not new in the AEC industry. For instance, efficient techniques for photorealistic visualization are required to present projects to clients. This is usually carried out in 3D rendered environments or 360° panoramic images, which allow users to navigate virtual scenes with varying levels of immersion and interactivity.

Because HBIM is available in 3D, there is a direct connection between digital models and advanced visualization techniques based on AR and VR. Starting from laser scanning and photogrammetric point clouds, the manual generation of

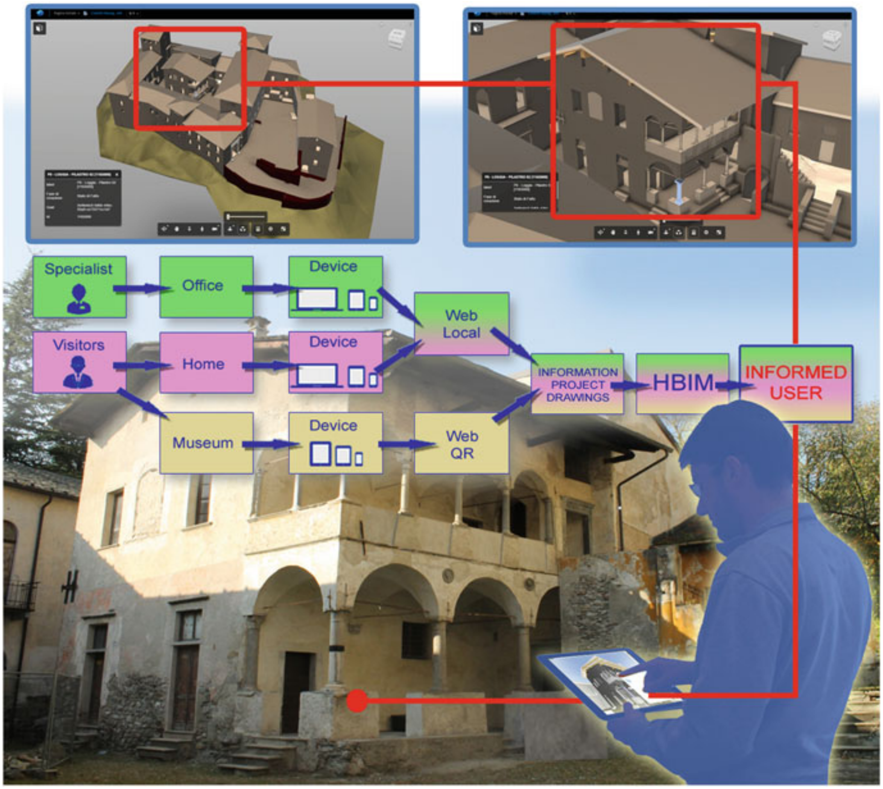


Fig. 10.1 Possible flowcharts for different operators interested in products generated from a model based on HBIM

two-dimensional (2D) project boards can be avoided (or at least reduced) using BIM.

Advanced modeling techniques allow for the generation of parametric 3D models, from which traditional project boards (plans, sections, elevations) can be automatically generated [20]. On the other hand, the level of detail that is achievable with laser scanning and photogrammetric point clouds could provide reconstructions with a huge number of polygons [21], too many to be simultaneously visualized on mobile devices. Scalable procedures able to display only specific parts of a model become mandatory. Integration with realistic visualization techniques able to provide a high level of visual fidelity is another important issue in which visibility and occlusion problems, lighting conditions, visual effects, and photorealistic textures play essential roles.

The graphic quality of a 3D model has great importance for the transmission of visual information. Several parameters determine the quality of the final visualization, which is strictly dependent on project requirements. The main aspects relate to, for example, the features of mobile devices, the resolution and image format

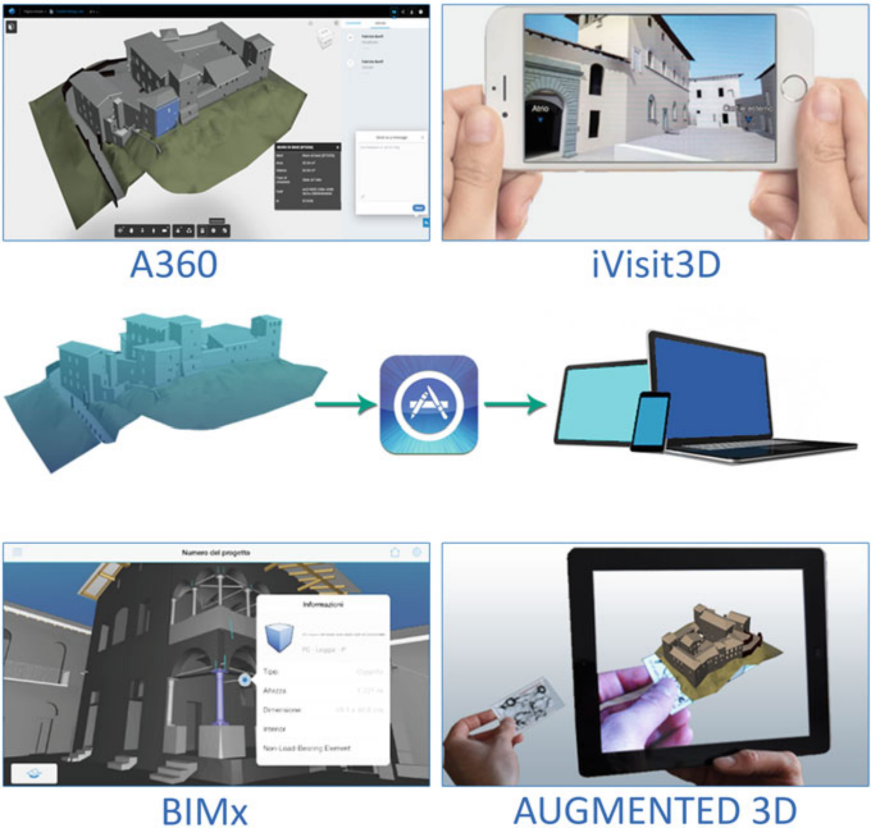


Fig. 10.2 Apps allow the use of HBIM in mobile devices

associated with geometry (e.g., size and number of pixels, radiometric and geometric resolution, depth, texture), rendering engines, and the limits of the mapping system in which the 3D model will be displayed.

BIM technology is based on software for parametric modeling, which replaces the traditional production of “pure geometry” models (direct modeling) with sets of predefined libraries, including building fabric systems and mechanical and electrical objects [22]. Architectural, structural, and mechanical, electrical, and plumbing (MEP) elements chosen from existing databases also contain information for material characterization. Materials for visual mapping can therefore be chosen from native object databases (such as local databases of BIM software and online repositories) or generated as new elements to customize the different visual properties.

This work describes some VR and AR applications designed to run on mobile devices. An accurate and detailed model based on HBIM was turned into several application-specific formats for smartphones and tablets. Results are illustrated and discussed using the case study of Castel Masegra, a castle located in the city of

Sondrio (Lombardy region, Italy). A detailed and accurate HBIM model (500 MB in Autodesk Revit file format) was generated from laser scanning and photogrammetry, which provided a huge point cloud comprised of 7.5 billion points. The various structural elements of the castle were modeled following their logic of construction (how the construction was assembled) as well as chronological, material, and stratigraphic aspects. The model was then simplified and exported into different file formats to try out different mobile applications for both professional workers and casual users interested in digital tourism.

10.2 Conversion of a Survey into Parametric Geometry: Beyond Direct Modeling

HBIM requires a detailed digital reconstruction from point clouds acquired by laser scanning and photogrammetric techniques. The modeling can be carried out by manual, semiautomated, or automated procedures [23–25]. Because dense point clouds reveal the geometric complexity and diversity of historic constructions, parametric modeling is not a trivial task (Fig. 10.3).

Most commercial BIM software packages available on the commercial market were developed for modern and regular buildings. Objects have prefixed shapes, parameters, and attributes that do not reflect the real characteristics of historic constructions along with their anomalies (e.g., tilted walls, variable thickness, and unique decorative and structural elements). Although some BIM software packages have specific tools (family editors) for the generation of ad hoc objects, predefined functions for parametric 3D modeling are not always sufficient for detailed projects, especially if the virtual model must be an accurate digital representation for documentation, conservation, and restoration (not just a visual model).

Most 3D documentation projects from dense point clouds are carried out with direct modeling techniques, in which static 3D models are generated without advanced parametric representation. This is not sufficient in BIM projects where parametric objects allow the user to modify shapes by setting specific parameters stored in a database [26]. The parametric 3D model is intended as an advanced computer technology able to manage information for the automatic generation of drawings (e.g., sections, plans), reports, design analysis, schedule simulation, thermal and structural analysis, facilities management, and much more. Semantics cannot be neglected in BIM. Objects know where they belong, how they relate to other objects, and what they consist of [27].

A synthesis of the basic requirements for parametric objects is provided in [28]. More specifically, parametric objects:

- Contain geometric information and associated data and rules
- Have nonredundant geometry, which allows for no inconsistencies

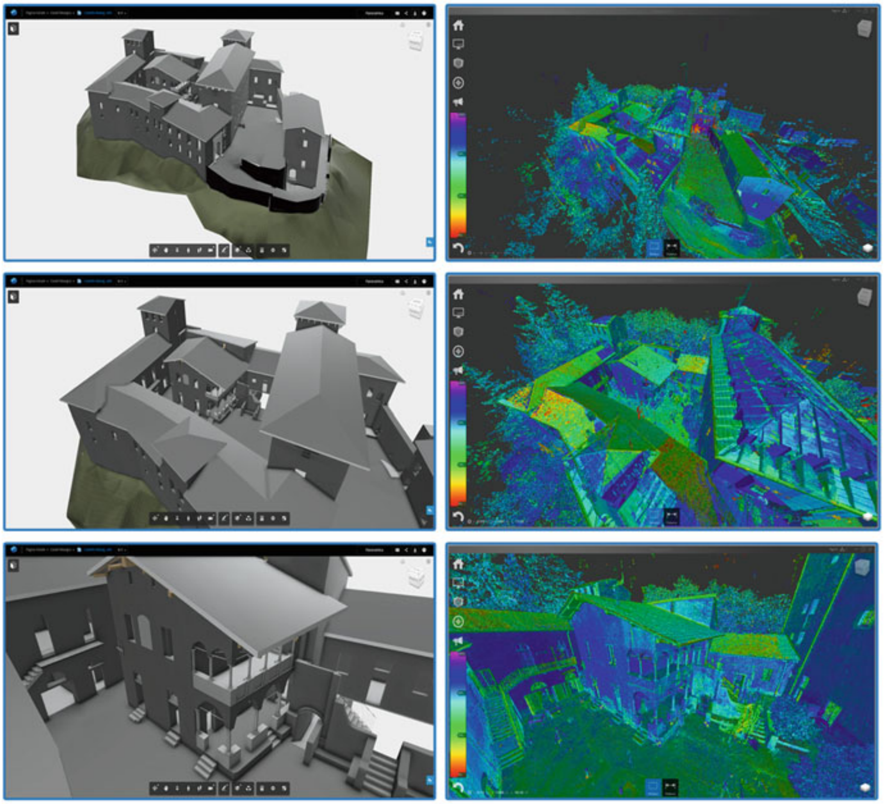


Fig. 10.3 Point clouds (*right*) are converted into a detailed HBIM model (*left*)

- Have parametric rules that automatically modify associated geometries when inserted into a building model or when changes are made to associated objects
- Can be defined at different levels of aggregation
- Have the ability to link to or receive, broadcast, or export sets of attributes, for example, structural materials, acoustic data, energy data, or cost, to other applications and models

The choice of structural elements that require parameterization and the kind of parameterization required represent a new paradigm for HBIM. As mentioned earlier, historic buildings are often characterized by geometric anomalies, including walls with variable thicknesses, tilted columns, and voids and floor deflections, for example. Here, predefined structural elements with a consistent logic of construction and unique shape are not available in existing data repositories.

The creation of new object libraries (for each specific case study) might be a solution. However, producing a new library is a very time-consuming work. Some authors have developed new methods for capturing the geometric complexity in a

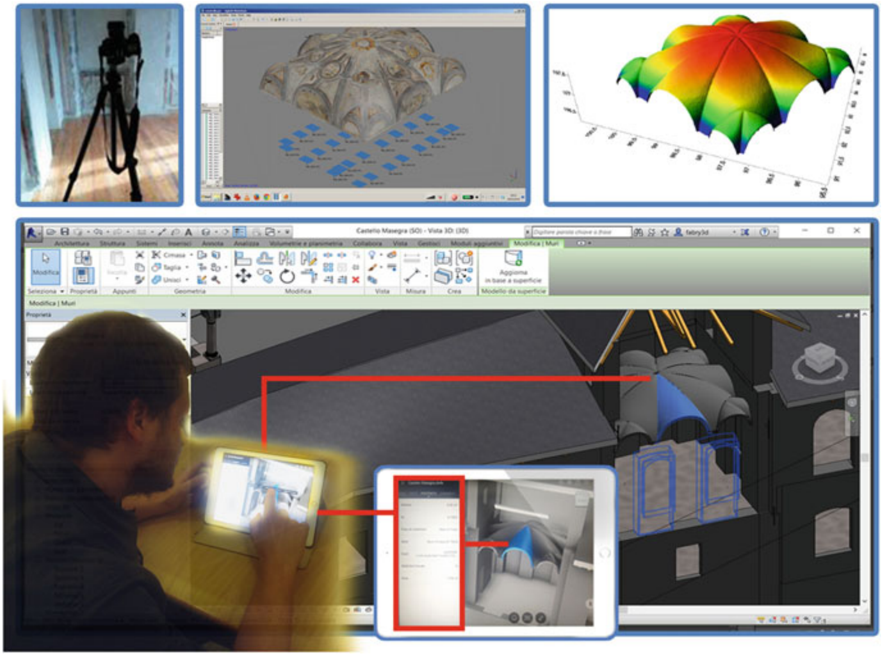


Fig. 10.4 Example of irregular vault with additional parameterization of the thickness following survey of intrados with point clouds

parametric way [29], facilitating the use of BIM technology in cultural heritage documentation.

An example of a historic object with additional parameterization is shown in Fig. 10.4. The umbrella vault of Castel Masegra was surveyed with laser scanning point clouds and photogrammetry to create an accurate digital model. Point clouds can capture only the external surface of the vault (intrados), whereas BIM requires a parametric representation with solid objects and their internal structure (layers). Because information about the thickness of the vault was not available, the parameterization of the extrados was generated through a dynamic thickness. The method uses an interactive offset [30, 31] of the different parts of the vault. Obviously, semantics must be added to create an effective vault object consistent with the floor upstairs and the lateral walls.

10.3 The Importance of the "I" in HBIM

Building information modeling is more than a 3D model. It is a rich database of the facility, in which the 3D model provides interactive access to a variety of information, including, for example, materials, thermal properties, and layers. The word

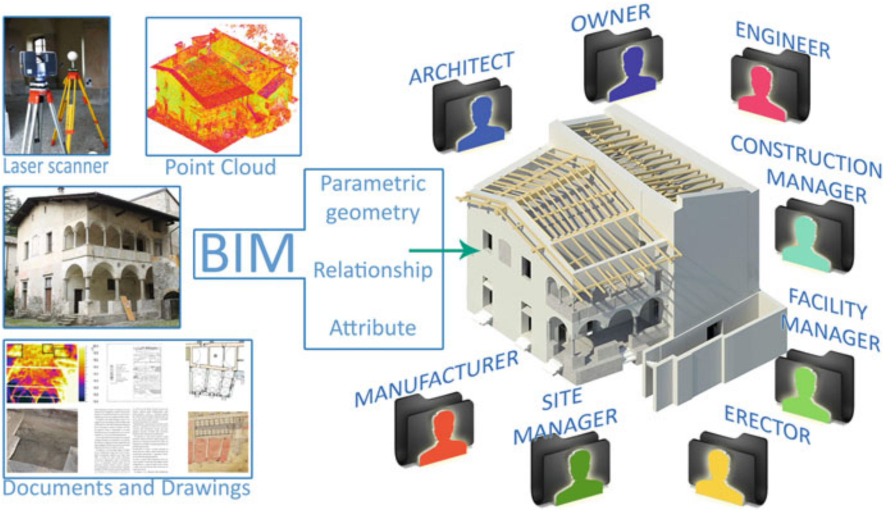


Fig. 10.5 Information from multiple data sources can be integrated into HBIM, which is becoming a common platform for the different professional workers involved in the project

information in the acronym BIM plays a fundamental role. A database that includes semantics and object properties is mandatory to create and manage meaningful information about the building. BIM software packages (e.g., Revit, ArchiCAD, AECOsim Building Designer, Teckla) allow users to electronically collaborate at different levels, from basic configurations based on isolated (independent) processing on different platforms (desktop and mobile) to an integrated data access via cloud services [32], which is fundamental to ensure a consistent exchange of information.

The availability of multiuser information makes BIM a shared platform for all professional operators involved in a project (Fig. 10.5). BIM is designed as a 3D information model of the construction industry, with expected improvements in the overall project workflow for the opportunity to share information and facilitate decision making.

As mentioned earlier, the 3D model is not only a graphic representation of the construction; it is an advanced computer technology that can be used to manage information for the automatic generation of drawings (e.g., sections, plans), reports, design analyses, schedule simulations, thermal and structural analyses, facilities management, and much more. BIM is a so-called seven-dimensional solution able to share information throughout the building life cycle, thereby eliminating data redundancy, data reentry, data loss, miscommunication, and translation errors. If the first three dimensions refer to geometry, 4D simulation adds time (e.g., the sequential phases of a project before the construction phase or the transition from the design phase to the construction phase), 5D provides a direct link to costs (e.g., cost management), 6D relates to building life cycle management, and 7D concerns facility and asset management.

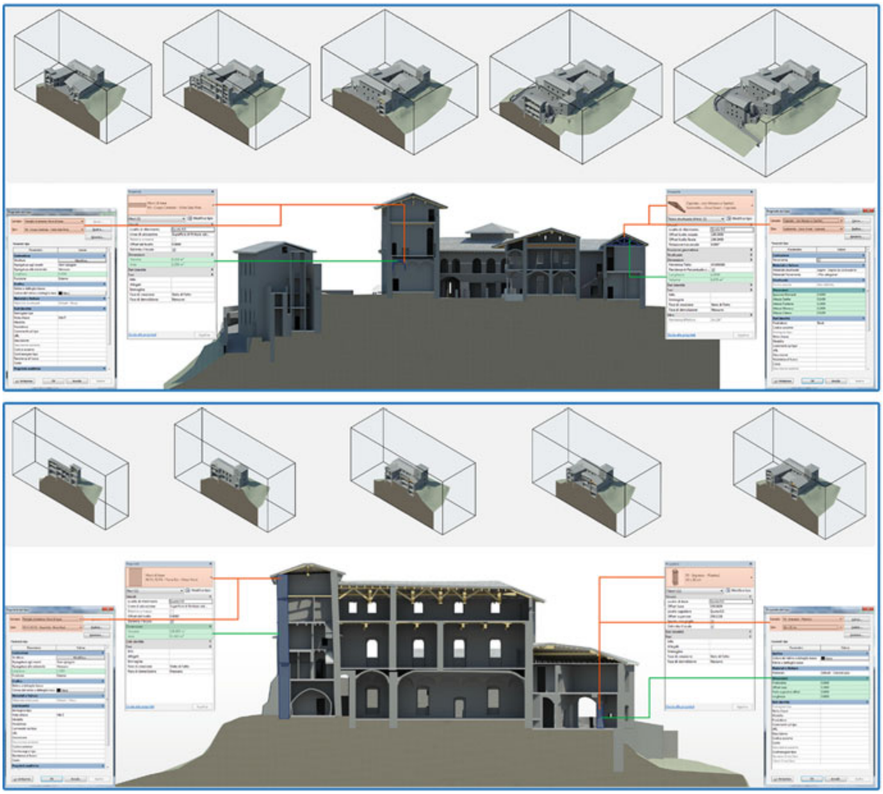


Fig. 10.6 Information incorporated into the database of the building (for the different structural elements) comprises a fundamental part of a complete BIM project

The case of historic buildings surveyed with photogrammetry and laser scanning poses new challenges not only in terms of the complexity of geometry but also the basic information that is usually required to enrich an HBIM database (Fig. 10.6).

The survey cannot be limited to the acquisition of geometric data. The survey is intended as an exhaustive analysis of the building, including a historical analysis, because the different construction stages reflect the modifications to the building, the identification of materials, technological aspects, stratigraphic analysis, and information from other inspections such as destructive and nondestructive tests, and infrared thermography. Information from additional analysis with nondestructive (e.g., thermography, sonic tests, geo-radar), minor destructive (e.g., flat jack, coring), or destructive (sampling) tests may be available in conservation and restoration projects. The mechanical characterization of the materials used in historic buildings, along with their internal composition, represents another significant challenge. Buildings are made up of heterogeneous materials (e.g., bricks in combination with mortar, stones), and construction elements have variable morphologies, with alterations, repairs, demolitions, or additions occurring over time.

Material decay, cracks, disconnections, and other damage can have a significant effect on structural performance.

A diagnostic analysis can be extremely useful in combining material properties and geometric data. The deterioration of materials and historical evolution of a building, as well as progressive modifications and repairs (e.g., infills, new openings, restoration or substitution of damaged elements with new objects and different materials), must be considered. Changes in the original conditions affect the structural behavior of buildings.

As mentioned previously, the identification of the different construction stages cannot be neglected in the analysis of historic constructions. The availability of existing drawings (not only modern project boards but also historic plans and sections) can be extremely useful for understanding how a particular building was built. Historic buildings are the result of transformations that occurred in the past, where new parts were added while others were demolished. This information can be stored in the HBIM using an approach based on chronological phases, in which a specific period can be associated to the different elements, along with a description of the different data sources available (e.g., reports, drawings) and information about the expected margin of error (Fig. 10.7).

The availability of an HBIM enriched with information must be taken into consideration for future reuse in mobile devices. As things stand at the present, only mobile applications based on BIM can preserve digital information, whereas information loss is inevitable for most AR and VR apps. These aspects will be described in the next section.

10.4 HBIM in Mobile Devices Through Augmented and Virtual Reality

The use of BIM on mobile devices is becoming increasingly important for collaborative projects involving many different specialists. The ability to work with mobile apps connected to a centralized cloud service allows specialists to pursue a strategy of simultaneous exploitation and exploration of BIM, sharing rich digital information at different levels.

Examples of mobile applications integrating BIM technology were proposed in [33], where a virtual panoramic environment was developed to show the construction progress. A mixed reality tool to support professionals in the AEC industry was developed in [34], whereas AR and BIM were integrated in [35] to detect construction defects.

Recent years have witnessed the realization of mobile BIM applications for training, education, and simulation. Projects aimed at developing learning tools for energy issues (such as heating, ventilation, and air-conditioning) were proposed in [36, 37]. A simulation of evacuation was proposed in [38], including Web-based

MURO DI BASE [661707]

label	Muro di base [661707]
Area	5.10 m²
Lunghezza	8.17
Volume	2.50 m³
Fase di creazione	Stato di Fatto
Guid	a5b0cd12-d692-42b2-9d6c-515f7bee90e0
Id	661707
Utilizzo strutturale	Non portante
Altezza non collegata	1.74
Delimita il locale	Sì
Offset base	102.96
Offset superiore	0.00
Vincolo di base	0 - Base

Fig. 10.7 Information on chronological phases can be integrated in different objects

visualization tools and serious games. Approaches to the sustainable management of buildings were proposed in [39] by means of a serious game.

Nowadays, several applications for so-called mobile BIM are available on the Internet. Most BIM applications can be downloaded from the Apple Store or Google Play. Examples include Autodesk 36, Buzzsaw Mobile, Tekla BIMsight Mobile, Graphisoft BIMx, SketchUp Viewer, BIManywhere, Structural Synchronizer, McNeel iRhino, LCi Sightspace3D, BIM 360 Glue, Navigator Pano Review, Revizto Viewer, InfraWorks 360, and others.

The aim of this chapter is to demonstrate that HBIM technology can be used on mobile devices not only by specialists in AEC industry fields and cultural heritage preservation but also by a wider user community interested in digital reconstructions and virtual tourism. The use of HBIM with mobile applications for VR and AR could represent a new opportunity for modeling and understanding cultural heritage. Mobile AR and VR deliver advanced multimedia contents with high levels of entertainment. The combination of geometry and digital information encapsulated in a model based on HBIM with AR and VR has the potential to become a new way to interpret, understand, reuse, and preserve cultural heritage.

10.4.1 HBIM in Mobile Apps for Specialists

Different mobile applications able to handle models based on BIM technology are available on the Internet. The main idea is to move the use of BIM from the office to the construction site, providing a new collaborative environment for architects, engineers, customers, producers, and builders, among others. Nowadays, growing attention is being paid to apps integrating cloud technology for connecting multiple users, avoiding multiple project versions with possible inconsistencies. A centralized version of the model can be remotely accessed by different professional operators, who can review, inspect, and edit project files without expensive hardware and software. Real-time communication can be carried out between multiple specialists through chat and e-mail notifications.

The first application presented in this work is Autodesk 360 (A360) (Fig. 10.8), a mobile application with an associated cloud-based service that can be used to handle projects generated in Autodesk Revit. A360 is defined as “a cloud-based platform that gives you access to storage, a collaboration workspace, and cloud

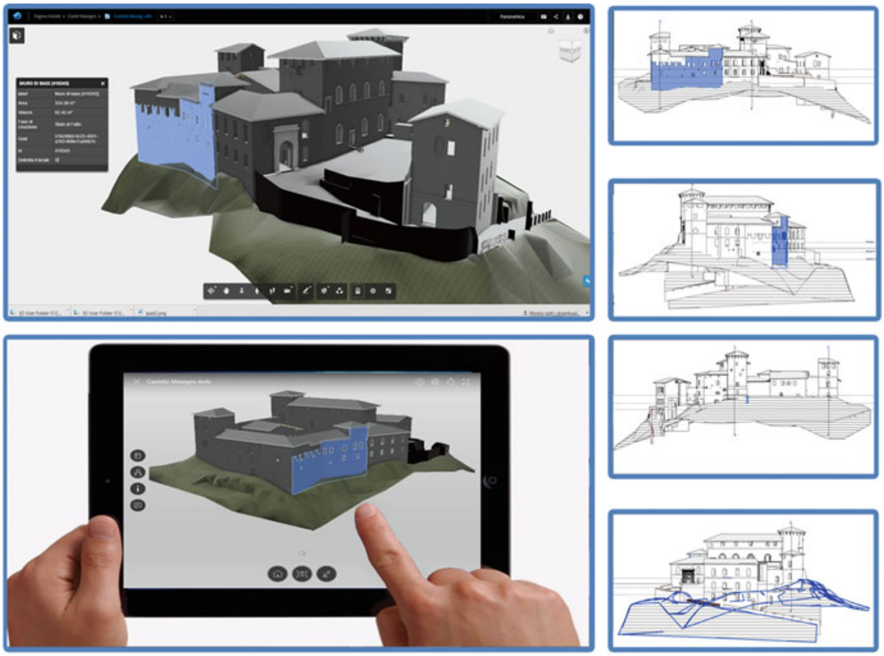


Fig. 10.8 BIM of Castel Masegra in A360

services to help you dramatically improve the way you design, visualize, simulate, and share your work with others anytime, anywhere."

The system provides 3 GB of free storage space; a monthly, quarterly, or annual subscription includes 25 GB and the access to cloud computing services for rendering, optimization, energy analysis, and structural analysis. Files cannot exceed 2 GB in size. A360 provides real-time visualization of 2D and 3D models with different predefined views (e.g., 3D views or planar visualization for plans and sections) to facilitate access to different parts of the model. Object properties can be reviewed, and reports of the different activities in progress can be visualized and modified.

The Web browsers that are supported include Google Chrome, Mozilla Firefox, and Microsoft Internet Explorer for 2D visualization (e.g., plans, sections, elevations), whereas 3D visualization is only supported by Google Chrome and Mozilla Firefox. A mobile application is also available to fill the gap between office and construction site. The mobile app supports more than 100 file formats used in the AEC industry, including 2D and 3D formats (e.g., .dwg, .dwf, .ipt, .iam, .idw, .rvt, . sldprt, .sldasm, .asm, .nwd, .nwc, .catpart, .catproduct, .f3d), and can be used to access e-mail attachments and files from Dropbox, Box, Google Drive, OneDrive, iCloud, or Buzzsaw, for example.

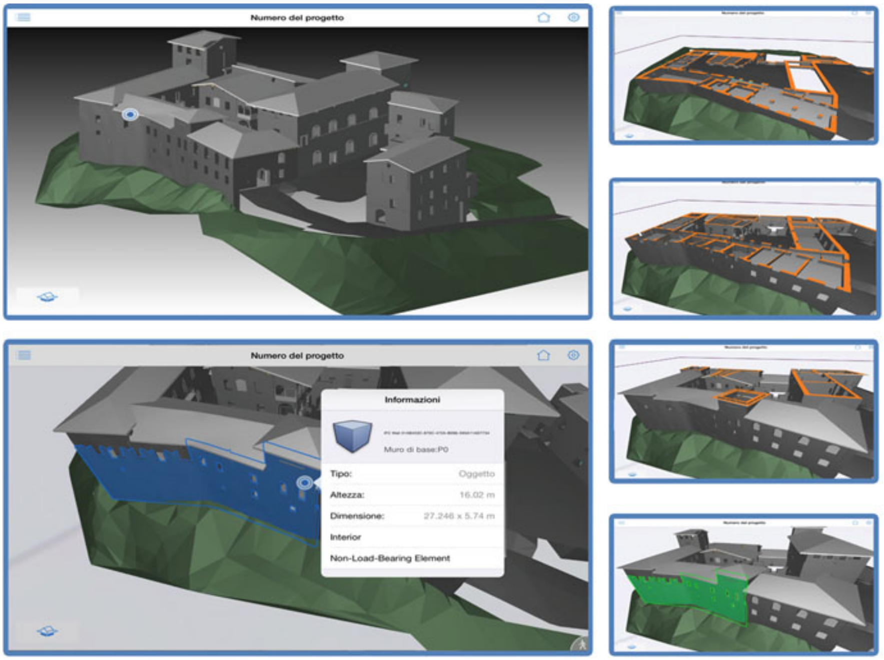
Specific functions are available for reviewing and navigating models through intuitive touch-based functions (zoom, pan, rotate); tools for annotation, markup, and comment are available as well.

The HBIM project of Castel Masegra (Autodesk Revit file format) was saved in the .dwf file format to preserve object information. Object properties (e.g., level, type, category) can be exported during the creation of the mobile version, so that the HBIM database remains available in smartphones and tablets.

Graphisoft BIMx (Fig. 10.9) is another application that can be used to handle BIM files converted into a new format for portable devices. BIMx provides cloud-based data access with free (mainly for clients) and low-cost versions (mainly for specialists). Hyperlinks between specific objects of the model can be generated to connect Web browsers, an Facilities Management (FM) database, or a product catalog application.

BIMx cannot directly use BIM files generated with Autodesk Revit. A preliminary conversion using the interoperable Industry Foundation Class (IFC) format was needed to import the model in ArchiCAD. Although IFC files should be in interoperable file formats for an efficient exchange of information between different BIM packages (from Revit to ArchiCAD in this case), the conversion may cause errors, especially in connection with complex shapes, object textures, and material properties. This results in a loss of information for some parts of the model.

The visualization of the model of the castle imported into BIMx was very fluid, with the opportunity to create dynamic sections with a slider and smooth transitions between two and three dimensions. Indeed, BIMx has powerful visualization functions to walk or fly around naturally on mobile devices and 3D glasses for an immersive environment. The advanced interaction level is surely attractive for the direct use of HBIM outside the office.



Muro di base:P0

Tipo: Oggetto
Altezza: 16.02 m
Dimensione: 27.246 x 5.74 m
Interior
Non-Load-Bearing Element

Fig. 10.9 Mobile version of Castel Masegra in BIMx

10.4.2 Panoramic Virtual Tour from HBIM

Panoramic virtual tours are based on rendered photospheres at an angle of 360°. Single panoramic images or complete tours can be generated from 3D digital models. A static (panoramic) image is usually generated by projecting the world (e.g., a scene visible from a specific point) on a sphere, which is then mapped using specific cartographic projections (e.g., equirectangular, spherical). For this reason, the visualization offered by panoramic images is not carried out in a pure 3D environment, even though the visual effect is remarkable.

The final visualization is based on a predefined set of images placed at different locations, which correspond to different rooms of the original building. Virtual navigation is also quite fluid on mobile devices with limited performances because the output is not a complete 3D model, only a combination of static images.

The tour is created using a set of linked panoramic images, so that users can visit the different rooms available, including indoor and outdoor spaces. Images derived from a 3D model can also be coupled with panoramic images acquired using a rotating camera and stitched with automated software for panoramic photography (e.g., PTGui, Autopano, 360 Panorama, Photosynth, AutoStitch Panorama, DMD Panorama, Sphera, Pano). This combines digital models and real photographs.

The application used for the tour of the castle is iVisit 3D, which is based on the rendering engine Artlantis (Fig. 10.10). Thanks to Artlantis, users can produce

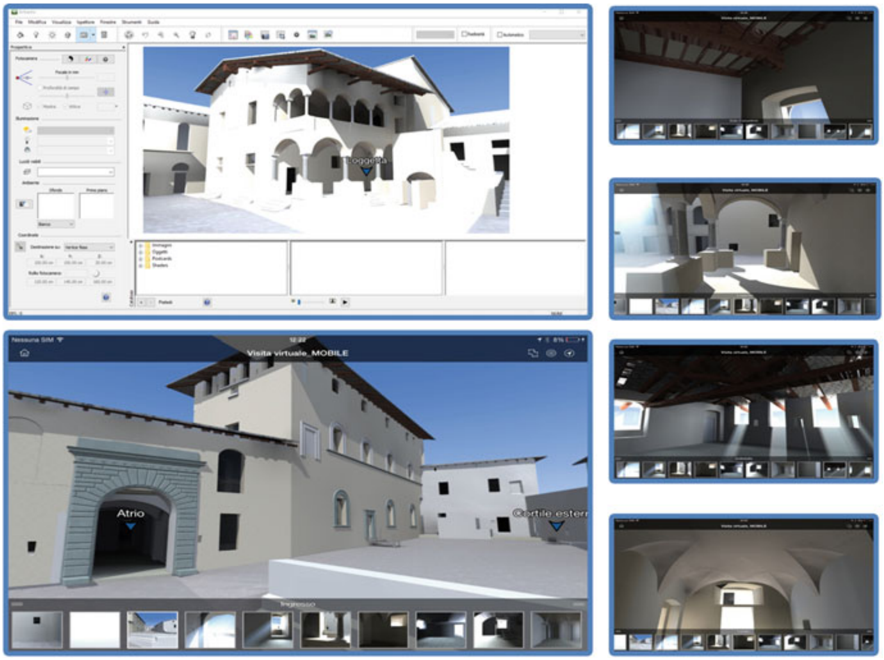


Fig. 10.10 Graphic interface of Artlantis, used to handle model exported from Revit

professional renderings with advanced visual effects available in a large library of shaders, textures, and 3D objects. Each element has several customizable parameters (properties such as adjustable reflection, transparency, representation scale, and brightness, for example), which can be adjusted directly from the graphical interface of the software. A simple so-called drag-and-drop tool allows users to associate a wide range of materials or textures to different objects, enriching the 3D model with synthetic images, photographs, rectified images, and orthophotos generated with photogrammetric or computer vision techniques.

Graphic performance depends on the level of detail of textures associated to the surfaces of models based on HBIM. File formats like .3ds and .obj can be imported in the software without losing the morphological complexity of complex elements. This is a very important aspect, which requires the translation of the HBIM into a format that can be imported in Artlantis. This conversion comes at a cost: the creation of a pure geometry model (in this case the .3ds file format was chosen), which results in an information loss.

The creation of the virtual tour is a simple procedure that includes mapping textures and setting lighting conditions. It is sufficient to set different points of view, which can also be directly linked in an immersive visualization (direct movement from a panoramic image to another) or connected through an overall keyplan visible during navigation.

The final result is delivered as a small .pno file that can be visualized on mobile devices as well as additional files generated from Artlantis for visualization through Web browsers. The use of such panoramic visualization is very simple, attractive, and fluid, so that the method has great potential for presentation and dissemination activities.

10.4.3 HBIM and Augmented Reality

The opportunity to combine BIM and AR (which overlays digital information on the real world) holds remarkable promise for several applications in the AEC industry [40–42]. The main idea is to move the use of 3D models from the office (more generally, from known spaces with predefined conditions) to the construction site, which is intended as a dynamic place where continuous modifications are in progress. This kind of applications must still reach full technological maturity in terms of technical issues related to automated localization, tracking, and alignment in the case of complex scenes that change over time.

Typical applications based on AR are related to the visualization of a 3D model starting from printed drawings (e.g., plans, elevations, and sections). Project boards can be used as markers to exploit different visualizations of objects, such as architectural and structural models with MEP services. Starting from a reference object (e.g., the map of a specific floor), multiple 3D contents can be easily inspected and reviewed. This represents not just a different way to visualize predefined 3D models; AR can be envisioned as a new approach to understanding projects.

It is clear that BIM holds great promise for use on mobile devices and applications based on AR. The extraction of 3D information directly from a BIM model and the use of mobile AR can improve the collaboration between contractors and different specialists involved in the project. Although AR applications are mainly carried out in the office (or in so-called controlled conditions), the opportunity to work with automated geolocalization tools at a construction site is attractive not only because it allows one to evaluate construction progress but because it can also reveal hidden objects such as subsurface utilities, clash detection, and assisted work and facilitate operator training and the simulation of future scenarios.

AR is also very attractive for dissemination activities that stimulate better interactions between people (e.g., expert operators, tourists) and a built heritage. A model based on HBIM can be the starting point for specialists who are mainly interested in the preservation and restoration of cultural heritage or a wider user community interested in visual products derived from HBIM.

The example in Fig. 10.11 shows that the model of the castle can be turned into an informative product for tourists. The tested application is AR-media, which consists of different plug-ins for 3D modeling software, such as Autodesk 3ds Max, Sketch Up, Cinema 4D, Vectorworks, Nemetschek Scia Engineer, and Autodesk Maya. The final visualization is carried out with AR-media Player, which is

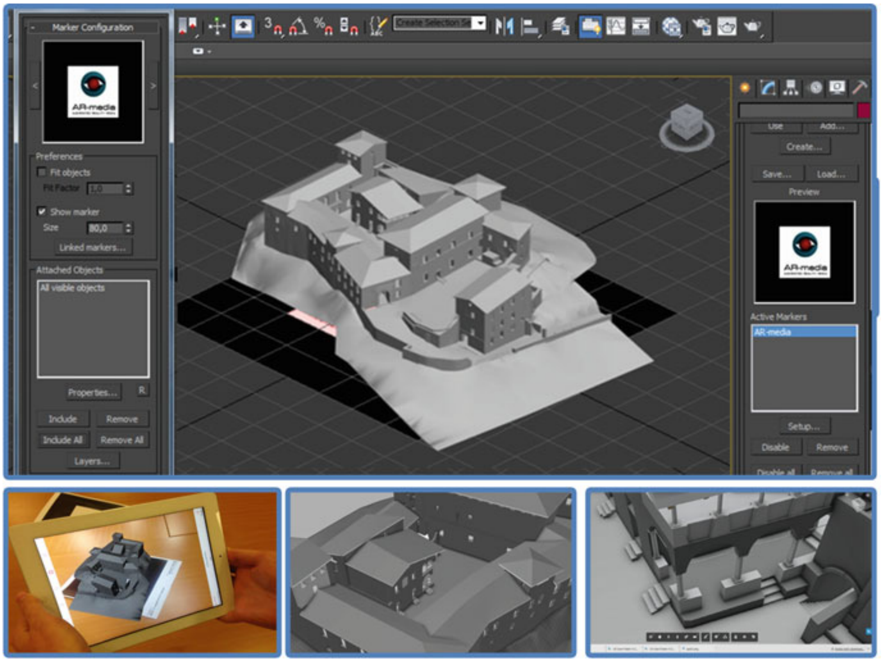


Fig. 10.11 Model of caste coupled with AR. The 3D model in AR-media was generated from the HBIM in Revit

available for Windows and OS X (desktop), including the mobile app downloadable from Google Play and Apple Store. In addition, AR-media Player supports several head-mounted displays, such as eMagin and i-glasses.

AR-media allows for correlations between 3D models and multiple markers (a brochure on the castle in this case), so that its elements can be visualized from different points of view. Objects can be structured in multiple layers and visualized independently, including a visualization with synchronized slides for a sort of presentation with specific functions for advanced animations and transitions, such as rigging and morphing.

In the Revit model, the castle was converted from the original BIM format to .fbx format, which was then imported in Autodesk 3ds Max. This led to an information loss regarding object properties. After importing the 3D model in 3ds Max, it is possible to link the model with specific markers. The procedure is very simple and intuitive. The model can be saved in the .armedia format, resulting in a model of limited size that can be transferred to mobile devices. After running the mobile application, the model will be automatically displayed when the camera captures the marker.

10.5 Conclusion

Mobile devices play a fundamental role in promoting interactions between people and digital cultural heritage in different ways: connecting people and heritage, creating knowledge, and preserving cultural heritage.

Historic building information modeling holds great promise for use on mobile applications based on AR and VR, leading to new opportunities and alternative approaches to data representation, organization, and interaction for the operators in the field of cultural heritage documentation and preservation. On the other hand, practical applications are not only limited to specialists in digital documentation, restoration, and conservation or experts in the AEC industry. New applications can be developed for a wider user community interested in cultural tourism. Here, AR and VR, coupled with HBIM, can promote interactions between users and cultural heritage.

Particular attention must be paid to interoperability requirements, standards, and protocols for the efficient use of digital reconstructions in both BIM packages and VR/AR applications. Standardized procedures and formats are needed for the reliable exchange of digital information, starting at the first phases of work (data acquisition) to the delivery of outputs in various formats, which can be used with multiple devices through cloud-based services.

This chapter started with a simple consideration: the use of BIM technology is becoming increasingly important in the field of construction. This means that the availability of 3D models in mobile devices, along with functions and tools for authoring, editing, documenting, sharing, searching, and navigating, is expected to eventually serve as a bridge between office and construction site. As things presently stand, only personal computer systems with large enough monitors can be used for concrete work (say, productive work) in which the model and its associated database are handled. On the other hand, new mobile applications will play a primary role in onsite (productive) work, where project documentation is currently carried out with printed project boards. Advances in algorithm development, along with the availability of new portable devices for VR and AR (such as the Samsung Gear VR, Microsoft HoloLens, and emerging technologies such as Magic Leap), will hold great promise when it comes to the complete integration of HBIM on mobile devices.

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