An integrated 3D geodatabase for Palladio's work

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Abstract

The paper presents a novel digital 3D GIS web-based system entirely founded on Google Earth, built to offer a deep insight into Palladio's opera for restitution of its architectural surveys, reconstruction for historical reasons, analysis for structural and other options, and assembly and presentation of all certified Palladian documentation. The development of the application follows the philosophy of visual computing and it is based on an architectural knowledge representation. The information system is conceived as a typical Rich Internet Application and it is based on the digitalization of the complete Palladian corpus documentation implemented by the Centro Internazionale di Studi di Architettura Andrea Palladio (CISAAP). The 3D geodatabase system is, actually, in use at the Centro as the Palladian information system for researchers and in two expositions at Barbaran da Porto Palace in Vicenza, and at Villa Poiana at Poiana Maggiore, where is widely used by tourists for virtual visits to Palladian buildings.

1. INTRODUCTION

In the panorama of sixteenth-century architecture, Palladio is an exceptional and impressive figure, whose opera had a tremendous impact and influence in the following centuries all over the world. In the last years, CISAAP focused part of its institutional mission in the application of information technology (IT) for database management that facilitates research and public accessibility across numerous materials related to Palladio, as well as quantitative and comparative researches. A first attempt to introduce IT to advance the study of Palladian architectural history was the project "Digital Palladio" [1]. These CD-ROMs were the first ones gathering in a systematic way all textual and graphical documentation of about 40 Palladian villas

and more than 30 palaces, churches and other civil buildings, making available spatial and temporal navigation between the data via SQL queries.

Nowadays, the availability of digital 3D models rendered in real-time makes possible a new significant step towards higher levels of knowledge: to have available all information in a visual and integrated way limiting errors due to granularity [2]. Apart from the possibilities offered by the visualization of virtual worlds, a powerful tool available in this field is the concept of 3D database. The architects are accustomed to think primarily in spatial terms, so this might be a great improvement. For this reasons 3D modeling in architecture helps not only to display and storage information, but it is useful to define a more precise, organized and usable information.

Following the concept of 3D database and as part of the celebrations for the five hundred years from Andrea Palladio's birth and the opening of Villa Poiana to the public with a permanent exhibition, the application "Palladio 3D Geodatabase" has been developed. This application allows a complete representation of architecture whose complexity can hardly be approached and understood through textual or iconographic documentation. From this point of view it is an updated evolution of the CISAAP CD-ROMs, no longer usable due to technological obsolescence. Hopefully, "Palladio 3D Geodatabase" will become the preferred interface for accessing this database, managed with ease and immediacy to give access to the recordings relating to individual buildings by Palladio.

The added value of the new system is given by the inclusion of the buildings in the territory, allowing to discover unknown relationships between the villas and the environment, to evaluate their architectural occupancy and to quickly access a complex system of information collected by several extensive studies along the years. The application has been designed for different types of users: tourists, architecture historians, architects, curators charged of restoration, conservation and maintenance, and moreover managers and their staff; these are the reasons why a largely scalable interface, able to support different output devices and to work at different levels of iconicity, has been developed.

Overall, this 3D digital archive represents a complex cognitive system for Palladio's opera finalized through:

- 3D digital models representing the reality and, as metaphor of the observed objects, allowing a direct and semantic knowledge of the data;

- 2D textual and iconographic materials approved and critically analyzed by the most qualified researchers of Palladio's opera;

- development of a new web-based architecture allowing a multi-user access from different platforms, using standards.

The application is completely based on Google Earth (GE). The approach for the development of the application comes from visual computing, has a strong architectural knowledge representation and is deeply rooted in the philosophy of GE that inverts the role of Web browser as application and map as content, resulting in an experience where the planet itself is the browser [3]. GE also features many layers as a source of information on businesses and points of interest, as well as showcasing the contents of many communities, such as Wikipedia and YouTube. In this way touristic information about Palladio villas or logistic information will be added with no cost directly from the different actors that play a specific role in the Palladio work management.

The paper has been organized as in the following: section 2 illustrates the related works and the used technologies; section 3 describes methods and workflows applied to achieve 3D semantic modeling and visualization; section 4 explains the development of the 3D Geographic Information System (GIS) and in section 5 the geodatabase implementation is presented. Throughout the paper, examples and results coming from the case studies, villa Badoer at Fratta Polesine, villa Emo, villa Pisani in Montagnana, villa Rotonda and Valmarana palace in Vicenza are shown; concluding remarks are reported in section 6.

2. RELATED WORKS AND USED TECHNOLOGIES

2.1. 3D model semantic organization

Models are an excellent means of understanding architecture, describable as a collection of structural objects, and identified through a precise architectural vocabulary. The availability of 3D semantic models organized as cognitive systems allows to have geo-object items in a 3D GIS and an improved topological control that allows a semantic approach to the classical problem of model levels of detail generation.

An architectural knowledge system is able to describe a series of structured objects using a specific architectural lexicon. One of the most famous examples is the Andrea Palladio's *I quattro libri dell'architettura* (Venice, 1570) (Figure 1).
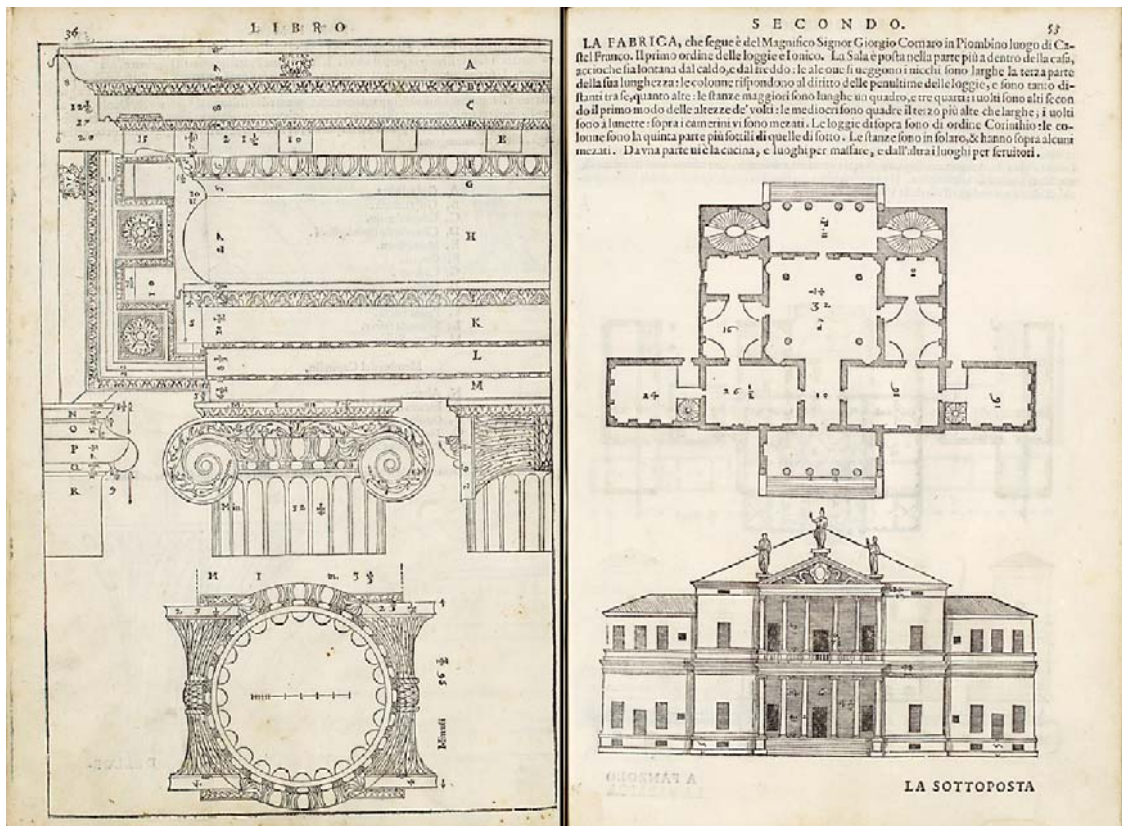

Figure 1: A. Palladio, *I Quattro libri dell'architettura* (1570). Left: first book, p. 36. Right: second book, p. 53.

A first major example of semantic methods for 3D models construction is the 'shape grammars' [4-5]. Quintrand [6] stated that the association of semantics and architectural shape is possible only considering the building as a system of knowledge: the model is extracted from its description while its representation is defined according to the objectives of the analysis.

De Luca [7] presented a methodological approach to the semantic description of architectural elements based on theoretical reflections and on research experiences. Attene [8] developed the ShapeAnnotator, a modular system to load a 3D triangular surface mesh (and its domain ontology), and to define the

meaningful shape parts, annotate them properly and save the result in a database. Semantic modeling and classification has been also used in city modeling applications [9] and, as pre-step, for a successive procedural modeling of architectures [10]. Similarly, Ullrich [11] defined a method, able to describe the shape of 3D objects, that can be classified into two groups: methods following the approach of composition of primitives and descriptions based on procedural shape representations. Schmittwilken [12] showed how attribute grammar formalism can be used as a 3D modeling language.

Larry Sass [13] illustrated a method in which the rules for a shape grammar demonstrate the need for additional information and illustration for rule building. Indeed the shape grammar generates information for a physical construction using rapid prototyping or CMM techniques. The approach we adopted deals with Sass procedure; the main difference relies on the fact that we refer to the real built object whereas his method refers to its project. Therefore, in our proposal not only the schema but also the constructive rules can be identified, highlighted and discussed (Figure 2).
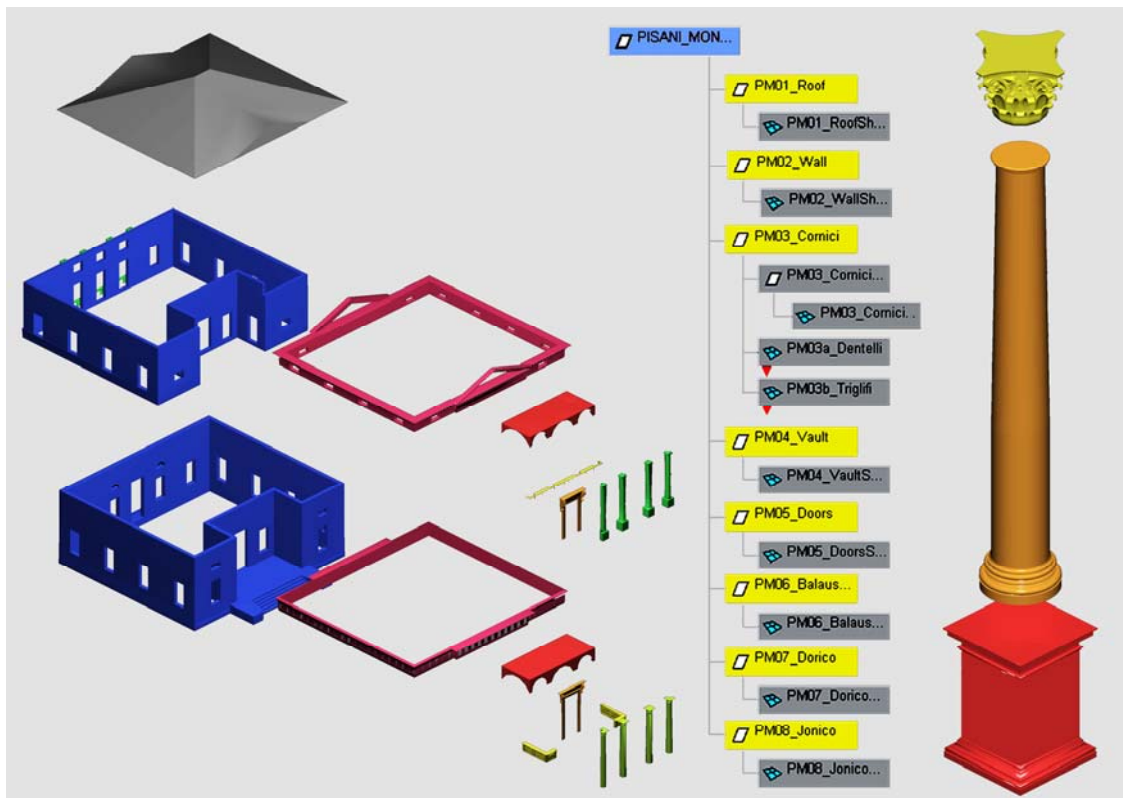

Figure 2: 3D Model Semantic Structure. Left: Villa Pisani, at Montagnana. Right: Corinthian order

2.2. Ambient occlusion methods

The creation of realistic lighting or an accurate shadowing in real-time web-based applications is a tricky and complicated problem. Indeed the most typical visualization standard for real-time rendering web-based applications is the conventional texture-mapped Gouraud shaded, a very limited illumination method since it misses fine details such as light spots on large polygons. Currently it is practically impossible to employ any photorealistic quality methods such as ray-tracing or radiosity to calculate lighting in real time on a web-based application. One of the approaches to improve the lighting quality is based on the pre-calculation of static diffuse lighting of the scene using some advanced high-quality methods. The results are then stored in a so-called light map textures [14]; even if a light map texture has much lower resolution than the ordinary textures of the scene, it allows to store multiple light samples per polygon.

In 1998, Zhukov et al. [15] introduced obscurances, an efficient technique that achieved in a much more inexpensive way some of the features available only in global illumination techniques [16]. Those features included the realistic look of objects diffusely illuminated, presenting a darker appearance in those zones that are more occluded. At the beginning the obscurances technique, was used in videogame environments as a pre-computed texture map attached to the objects; then it was developed by Landis [17] and Bredow [18], and named *ambient occlusion* (AO), in order to be used in production rendering for movies and implemented in a photorealistic rendering environment as RenderMan.

Ambient occlusion is a lighting technique used to get a global illumination-like effect, as if it was lit from an entire hemisphere. A set of visibility samples are collected from the hemisphere above a point, and a scalar AO value is computed based on the percentage of unoccluded samples. Therefore AO measures how much a point on a surface is obscured from light that might otherwise arrive from the outside. This average occlusion factor is recorded at each surface element and used to simulate self-shadowing. Surface elements located inside cast ambient occlusion, and surface elements outside are ignored.

From 2003 many different techniques that compute AO appeared, and consequently integrated in commercial software. In the real-time rendering scenario, many approximations to AO exist. Object-based

methods calculate the AO at the object level [19, 20]. Depth maps are used by Whitehurst [21] in an 'outside-in' method consisting on a hemispherical array of spotlights to generate several depth maps.

Vertex-based methods are algorithms that compute the AO at the level of vertices. Martin Knecht in [22] presents a good overview of some of these methods. Most of them require a very little pre-computation effort, being able to perform AO calculation on the fly. Image-based methods are algorithms able to calculate ambient occlusion with a viewing plane driven approach [23-25]. Therefore, compared to other AO algorithms such as ray tracing, *Screen Space Ambient Occlusion* (SSAO) has the advantage of handling dynamic geometry with significantly lower overhead. Unfortunately SSAO algorithms are not usable in this study because the GE rendering engine does not support these algorithms neither external feature programming.

Figure 3: "Palladio 3D Geodatabase", Valmarana Palace, in Vicenza.

2.3. 3D Web GIS system

The difficulties to realize a 3D Web GIS can be summarized in five points [26]:

1. Conceptual model: existing 2D and 3D objects data structures usually present lacks in spatial representation of objects.

2. Data collection: a key point in the development of 3D GIS is the definition of techniques to store, manipulate and display high quality and reality-based 3D data. Despite some interesting attempts to implement automatic acquisition and 3D reconstruction of objects, manual work remains dominant [27].

3. Visualization, navigation and user interface development: 3D visualization requires a number of specific issues to be investigated, e.g. appropriate means to visualize 3D spatial analysis result, tools to effortlessly explore and navigate through large models in real time, tools for walking through the model, exploring particular phenomena and improving the cognitive perception.

4. Internet access: the World Wide Web has a remarkable ability to improve the accessibility of spatial information.

5. Spatial analysis: similar to 2D variants, 3D GIS should be capable to perform metric (distance, length, area, volume, etc), logic (intersection, union, difference), generalization, buffering, network (shortest way) and merging operations.

The key point is the topological organization of spatial data. Ellul and Haklay [28] identified and reviewed a list of requirements for topology in 3D applications. Three key areas were studied for the purposes of identification requirements, supplies for visualization in 3D and for 3D analysis supported by topology. This is a particularly demanding set of requirements; for this reason GIS software that handles reality-based 3D data are very rare. The problem is even more amplified for data defined by a large number of polygons. Over the last few years we have seen an increasing amount of work in the fields of modeling and managing geospatial 3D objects. Earlier projects were focusing on the modeling and management of complex 3D objects – in a primarily relational DBMS environment [29, 30]. Some more recent projects employ object-relational concepts to address these issues [31, 32]. In a geospatial model a 3D geospatial object can be defined by its geometric or topological representation, or by using both representations [33]. Today geospatial models represent large number of objects, mostly in 2D/2,5D, with simple geometric representations. Recently 3D Information models were developed for representing the real world objects. A

notable example is CityGML [34], developed since 2002 by the members of the Special Interest Group 3D (SIG 3D) in Germany with the aim to reach a common definition of the basic entities, attributes, and relations that can be shared over different applications. The technology appears like a great improvement over previous applications and a comprehensive framework. However CityGML does not seem to be enough robust for high resolution architectural models, and the geometry is still limited to simple representations. The DILAS (Digital Landscape Server) project [31] partially addressed this issue focusing on object semantics, complex object geometries and photo-realistic textures, integration of existing (geospatial) databases and temporal aspects. The DILAS 3D GIS technology combines an object-oriented topological 3D data model with an XML-based 3D object storage in an object-relational DBMS. However, these projects revealed a number of unsolved problems associated with the process of creating high-resolution 3D models of typical cultural heritage objects [35].

2.4.   Rich Internet applications

Rich Internet applications (RIA) are web applications that have the features and functionalities of traditional desktop applications. RIAs typically allow to transfer the necessary processes for the user interface to the web client and keep the bulk of the data (i.e., maintaining the state of the program, the data etc) back on the application server. RIAs offer a greater functionality within a browser and are less dependent on the server, compared to traditional web pages. The delivery and maintenance costs of RIAs are low compared to standalone applications, since they require no installation, updates or patches, even offering bigger advantages [36]. Even if some RIA platforms require a browser plug-in, RIAs have a high degree of availability and flexibility, since they are accessible worldwide where networked computers are available. In addition, RIAs are platform independent. For all these reasons they have been chosen as the framework for this new edition.

3. MODEL CONSTRUCTION AND VISUALIZATION

3.1.   High resolution model construction pipeline

The classic approach to create a 3D model is to build it from scratch using CAD software, surveying data, and technical drawings. In this way the created models are not photo-realistic and do not include all fine details of the original artifacts. In addition the goal of this study was not to obtain a replica of the original building but a semantic reading of the reality and the design intents throughout the interpretation of the shapes described by the model itself.
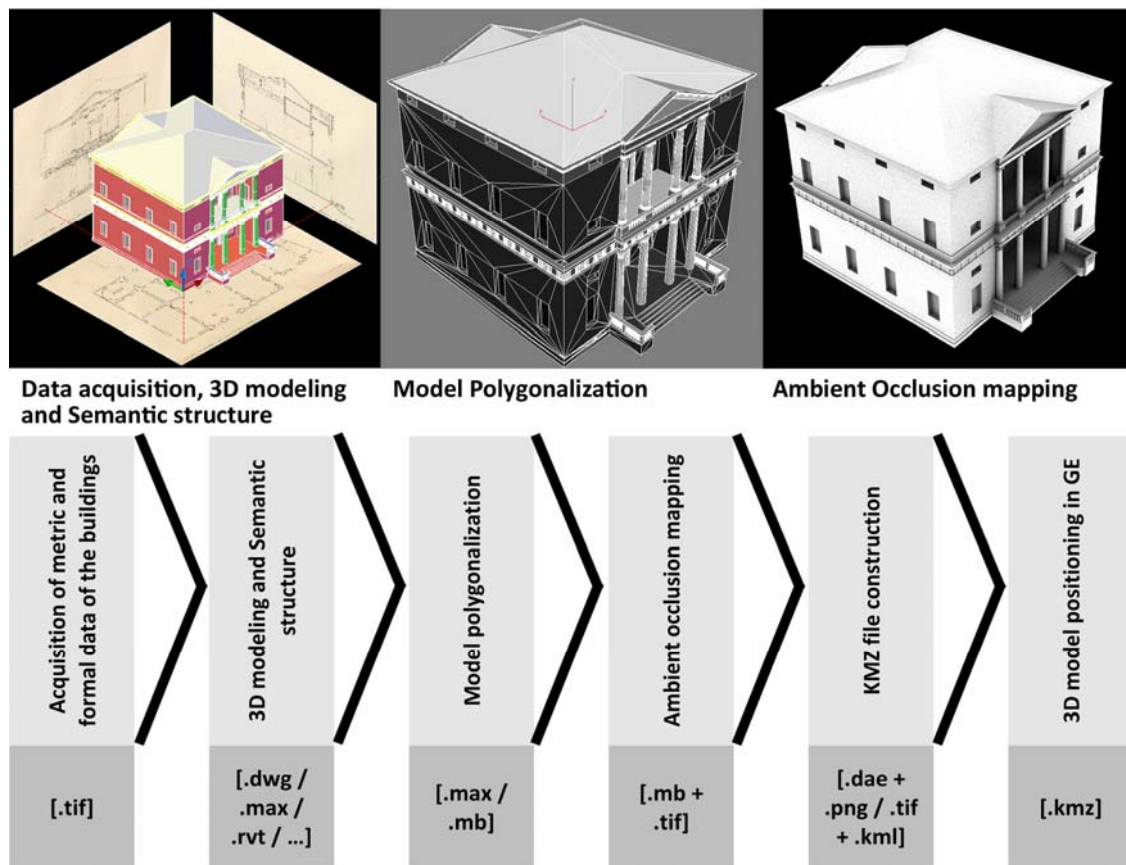

Figure 4: 3D Model Construction Pipeline.

Following this aim, the model construction pipeline consisted of six different steps (Figure 4):

- Acquisition of metric and formal data of the buildings.
- 3D modeling with a Sematic Structure.
- Model polygonalization.
- Ambient occlusion mapping.

- KML file construction

- 3D model positioning in GE.

The pipeline started from digital scans (tiff format and resolution equal to 250 dpi) of the handmade survey of the *Corpus dei rilievi delle fabbriche palladiane* performed by CISAAP with the support of the Italian National Research Council (CNR). Drawings consist of a set of tables at different scales depending on the type of representation (1/100 – 1/10); some drawings are quoted too. Deformations in drawings due to time and suboptimal conservation were corrected thanks to the presence of the graphical scale.

Overall, for 1/100 scale drawings precision was less than 2.5 cm and for 1/50 scale drawings it was less than 1.25 cm. An additional approximation of ±1 cm and ±0.5 cm characterized digital reproductions and scans depending on the original scale (1/100 and 1/50 respectively).

This 3D modeling system was based on the accepted convention of architectural analysis whereby structures were described as a series of structured objects using a specific architectural lexicon. We have adopted the classification method of Tzonis and Oorschot [37] that subdivides various representations of architectural space according to their level of 'abstraction' (clustering, topological and metric). Then, component parts have been reassembled using a 'put-together' method as previously reported by Stiny and Mitchell [5]. To do this we adopted a 'shape grammar' using a pre-established set of tree-shaped formal rules which indicate a clear purpose and an evident structure. We therefore obtained semantic models ready-to-use as a knowledge system. This type of numerical model organization allowed to manage 3D models as multi-resolution models and to subdivide them in consistent and hierarchical subsets of a defined number of triangles/polygons in order to be included and visualized in GE according to the limited amount of triangles that it supports. Besides, this organization allowed highlighting and isolating individual model portions through the consultation interface . Once the loading and parsing of kmz file has been completed by the GE plug-in, the browser can access the various sub-nodes through the classical hierarchical organization of nodes parent/children. The application code written in Javascript is able to extract the structure of nodes and offer it to the users. Through the tree–shaped graph the user can select individual elements and decide what to keep visible and what to hide.

To construct the 3D models we used several operators with different skills. For this reason the pipeline could start using different modeling commercial software like Autodesk AutoCAD or 3DS Max Design or

other, with the only very large condition that the geometries used will be B-Rep or NURBS, or polygons to ensure geometric interoperability. Starting from these raw models we generated the final KMZ file using Autodesk Maya 9.0 as software environment. In Maya we realized the successive pipeline steps: model segmentation; AO mapping; single element export in DAE format (the core file format of the pipeline).

The content of a KMZ file defined for the Palladio 3D-Geodatabase is a single root KML document (notionally "doc.kml") and a series of referenced files (DAE, TIF or PNG) in the sub-directory "models" referenced in the KML including network-linked KML files. DAE files describe geometry; while TIF or PNG files include mapping information of the corresponding DAE files. Each model was placed using the 3D geographic longitude, latitude and altitude, used by KML for its reference system, according to the internal coordinate system of GE based on the World Geodetic System of 1984 (WGS84) datum.

3.2. Model visualization - real-time rendering and ambient occlusion

The typical way of drawings by Palladio is a flat representation characterized by no depth, as can be seen in *I Quattro Libri dell'Architettura*: a collection of two-dimensional drawings of plan and elevation representing the relationship between them. Unfortunately this technical system, surely clear for its author, resulted cryptic not only for occasional users, but also for architects and researchers that made many errors in the interpretation of Palladio's work, along the years. Therefore we looked for a form of representation that could bring out volumes from flat drawings of Palladio, resolving, at the same time, another typical problem of displaying 3D models in GE. The shading provided by the viewer is the simple Gouraud shading, which causes a shimmering view and returns a 3D visualization of drawings by Palladio unable to grasp the true volume of objects. Even the image obtained applying the feature "Displaying the Sun" involves only flat shading from directional light without casting shadows or ambient diffuse shading. Therefore, to show the true Palladian schemes in 3D, we applied AO techniques (Figure 5), using render-to-texture (also called texture baking) techniques.
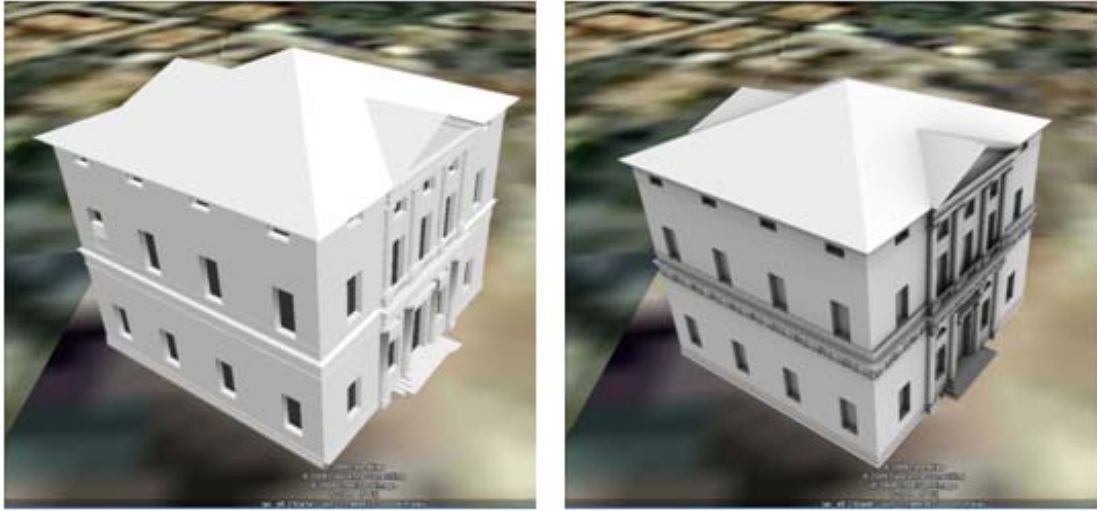
Figure 5: Villa Pisani, Montagnana. Left: Gourard Shading in GE. Right: Ambient Occlusion Mapping in GE.

The process is standard for texture generation but requires a model pre-processing to export textured wire-frame correctly in GE. The *base* shader library from Mental Images starting from Mental Ray version 3.4.3 provides a set of utility shaders helpful to gather and control occlusion information. Our implementation follow *Occlusion tutorial* with Mental Ray [50] and is accomplished at the shading level through the *mib amb occlusion* shader. Examples of AO results on Valmarana Palace and Villa Badoer are shown in Figure 6.

Figure 6: "Palladio 3D Geodatabase", Villa Badoer, at Badia Polesine.

Problems in this pipeline are typical visual artifacts caused by:

1. 3D model tessellation: the 3D modeling software inverted surface normals randomly, and generated a poorly formed mesh.

2. Lightmap texture mapping: lightmaps are essentially a rectangular grid of polygons overlaid onto whatever surface texture is already present on a polygon. Therefore, extra thought is required to devise a means to reduce aliasing errors.

3. Sampling error: samples may be obscured or 'contained' inside the 'solid' of the geometry. Any part of the rectangle represented by the 'inside' sample lying 'outside' of the geometry, will be visible and most likely will have an incorrect intensity. This results in lighting that 'creeps' underneath walls and corners.

4. Sampling rate: Mental Ray uses the same resolution for every lightmap, and assign an unique lightmap to every polygon. Instead of increasing the resolution of the lightmap for larger polygons, it scales it to fit the polygon dimensions.

The segmentation process was an excellent method to give solutions to the problems of point 2 and 4 just using a single atlas texture map for each group of semantically similar elements and using the appropriate dimensions for each group from 512x512 to 4096x4096 (Figure 7). Point 1 requires the control of the normal direction and point 3 the control to avoid intersection or overlapping of surfaces or solids, but this is a hypothesis of the modeling pipeline we applied.
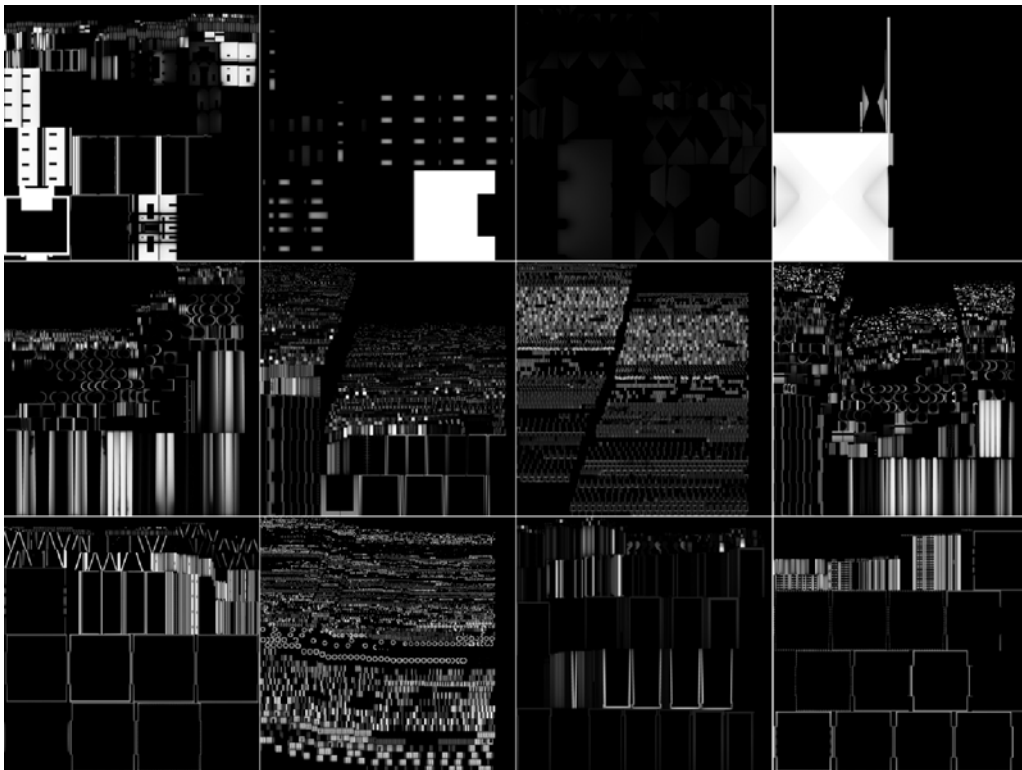

Figure 7: Villa Pisani, Montagnana: AO maps.

4. THE 3D GIS SYSTEM

Andrea Palladio - 3D geodatabase is an application organized as a Rich Internet Application (RIA), a typical client-server architecture with components in both sides. In the developed application we incorporated four key components: an open relational database management system (RDBMS), a web server, a web/virtual reality browser and a web server language side-oriented together with software for dynamically recalling the contents (Figure 8). On the server side, the web server manages the client

requests of static and dynamic contents. It accepts the requests from the web browser and provides these contents on internet using the HTML language. The local client consists of a collection of web pages and allows to control the accesses and to register the events; a static GIS client side application includes the control menu, display and visualization and the dynamic content required by the user, with calls back to register the user state and align the server; it benefits of the application through the web and GE browsers.

The user accesses the data on the server side using a Graphics User Interface (GUI), a combination of HTML forms and KML/KMZ models. HTML documents - through a simple query in SQL - are used to specify queries and visualize text, images and movies as well as additional data supported by the web browser. KMZ documents represent the visualization interface and – through a series of place marks – point to objects for querying and visualization of spatial analysis.
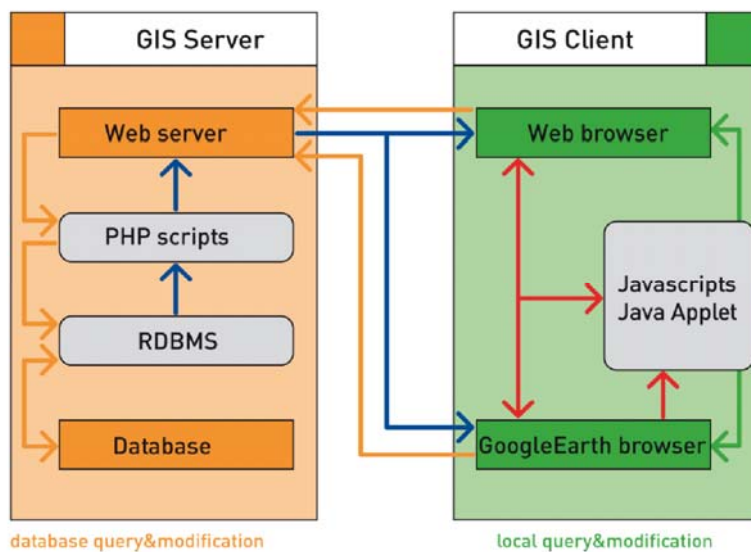

Figure 8: "Palladio 3D Geodatabase", key components.

The user interface is a key point of the project since it is completely different from the usual mode to visualize information on a web browser. The GUI allows the user to control the different operative modes, to select specific inputs, to check the current state and to surf inside the application, through different modules. The main menu and the working area at the top of the screen allow to enter different sections and

at the same time and they offer the opportunity to evaluate the urban system and/or specific sites using the interface as a virtual table.

The developed application (Figure 9) allows two types of query aimed to obtain additional information regarding an object of interest and to search artifacts that meet specific requirements. These queries satisfy two important interaction modes since the user can access environments and objects in the same 3D space and, through GE, can select pages containing other types of information.
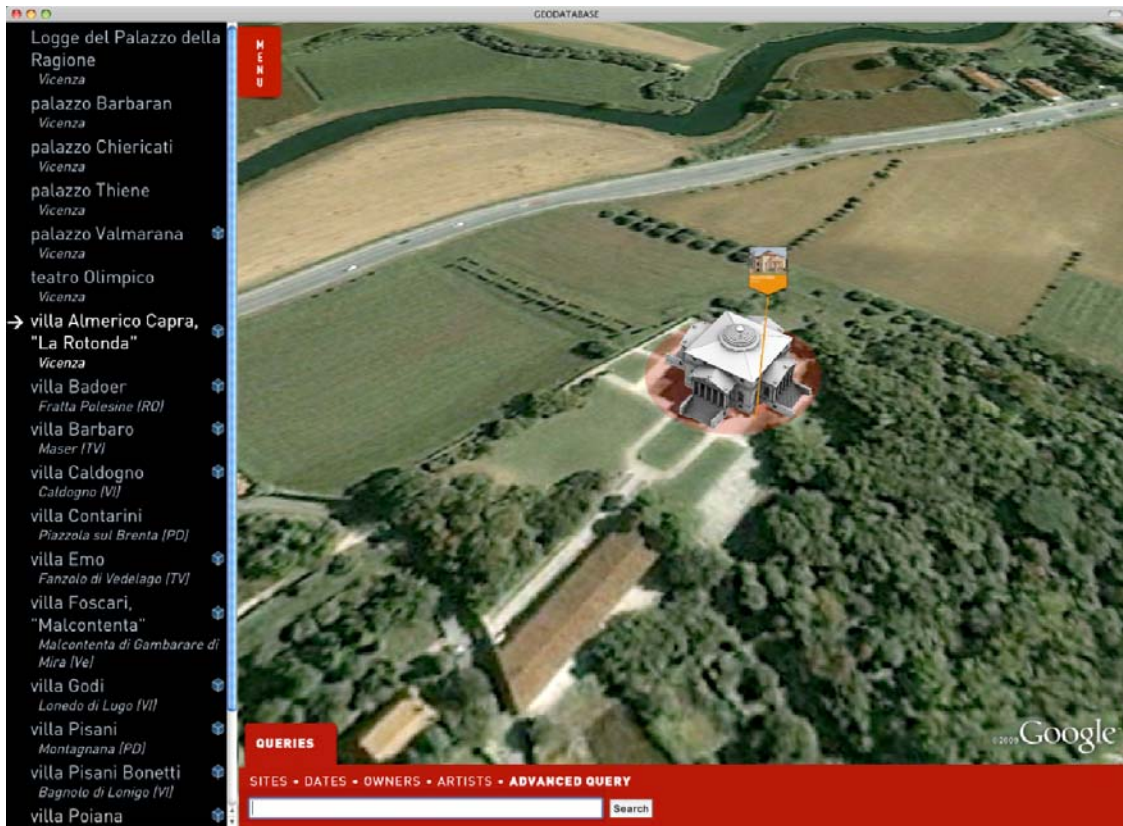

Figure 9: "Palladio 3D Geodatabase", Queries interface.

The geodatabase was organized including:

- An architecture database;

- A 3D model repository;

- An iconographic documentation repository;

- A web structure for hosting the plug-in generated by the server, also including the client-side processing logic;

- A local client including a web browser and GE plug-in;

- A client side Adobe Flash interface for showing and describing specific contents;

- An Internet connection for accessing 3D maps of the analyzed area.

3D model files, their textures, and the iconographic documentation database are hosted on a dedicated server. For each villa or palace, the database keeps information about:

- building name;

- geographical location (county, municipality, street, etc.);

- geographic coordinates referring to a hypothetical building mass centroid;

- building type information;

- historical information regarding architecture, construction, decoration, etc. (Figure 10);

- link with the 3D model file (Figure 11);

- link with available iconographic documentation.

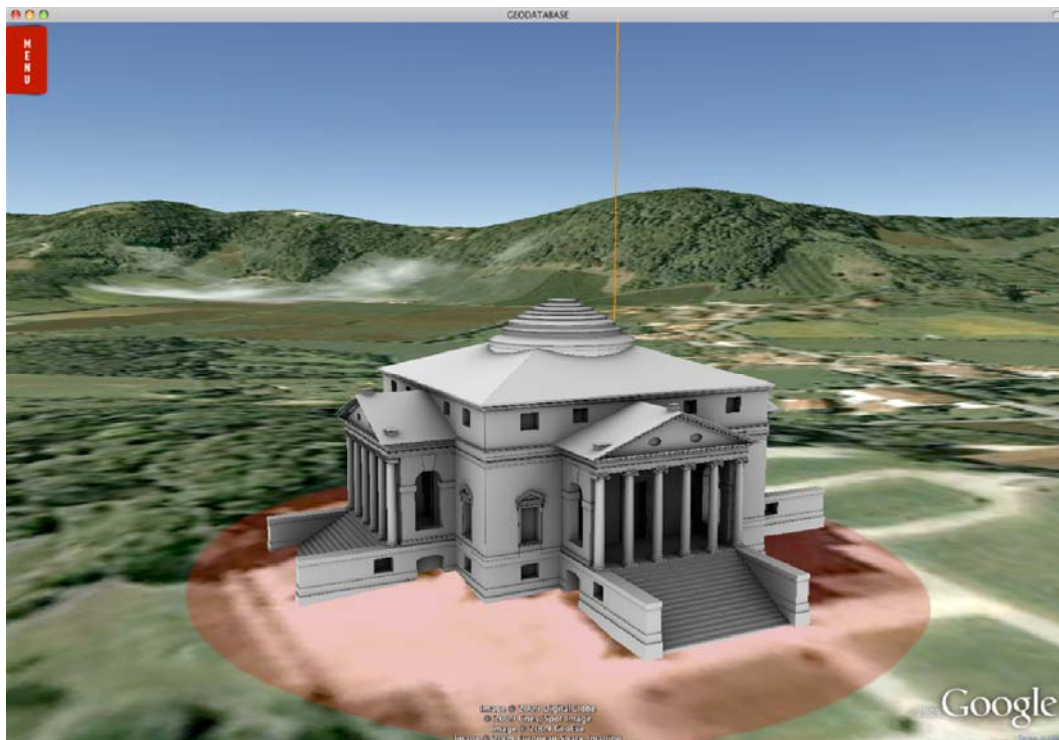Figure 10: "Palladio 3D Geodatabase", Villa La Rotonda: historical information.

Figure 11: "Palladio 3D Geodatabase", Villa La Rotonda.

5. THE GEODATABASE IMPLEMENTATION

The DBMS (database management system) based on MySQL is at the heart of the application. The information regarding each building was included into a table of the database. For each Palladian building, items textual data sheets (both in Italian and English) and the geographic coordinates of reference that were used by the interface of consultation for the location of the various placeholders in the open countryside, were included. The table of buildings is connected with 1-n relationship to the table of iconographic materials; for each building, the different visual sources (photographs, historical engravings, scanning) are then available. The application queries the database with standard SQL-query and it produces a list of buildings; the placeholders referring to each building are placed on the territory and the tags with the building information are ready to be displayed.

As shown in Figure 12, the database could be interrogated in different ways:

- from the side bar menu including the list of buildings and allowing to move into the territory at the location of the selected building;

- selecting the placeholders in the territory and displaying the corresponding information;

- through a conventional system of textual search through which a list of buildings satisfying the criteria is obtained and the geographical browsing is possible.

GE provides both the basis for geo-location of Palladian villas and palaces and the rendering engine of 3D models thanks to the GE plug-in. The choice of using this plug-in rather than a standalone application is due to the possibility that the first provides for interaction between the 3D content of the territory and the models with the general interface through JavaScript calls. The main structure of the interface is realized through simple HTML standard code that defines the main elements in the page.
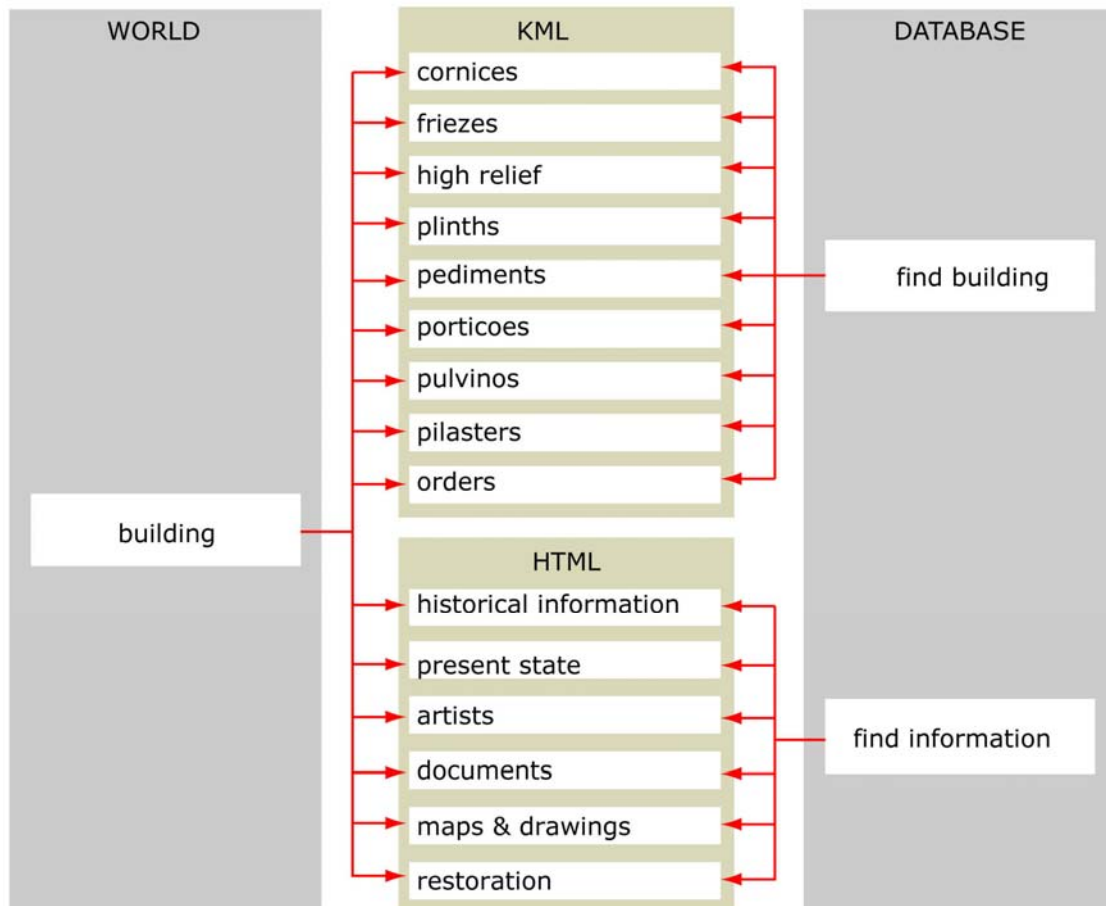
Figure 12: "Palladio 3D Geodatabase", Query interface.

Data are loaded together with the page through AJAX calls to the server and to a web server that, through a PHP script, pre-processes the data before returning it to the client. For each record, the name of the building is extracted to form the list of Palladian works and their geographical coordinates. Then, using JavaScript, the system places the placeholders on the territory and connects a mouse click on them with the opening of an informative balloon.

All navigation actions exploit Google native instructions that allow easy and homogeneous surfing between two points of the world. The information panel, activated by clicking the placeholder of the model, is shown inside balloons directly created from GE. GE plug-in allows to dynamically define the balloon contents through basic HTML code. To provide the geodatabase information inside the balloon, we applied a template developed in Flash. The Flash applet queries the remote database recalling all the information of

the model and its iconographic content. The system includes a main tab introducing the opera and several additional tabs with specific content.

The information is available in the 3D world, inside one box, overlapping the 3D world but never completely hiding it. The initial script records a set of actions related to the user interaction with the 3D world. The system registers the mouse click on the place mark and on the area around the model.

This option allows toggling the view of the complete model or just the territory without the building. Clicking on the territory, the application shows/hides the 3D model; while selecting the placeholder the user accesses the information panel with the information extracted from the database.

For each entry in the list of villas and palaces, the system associates an action that drives Google at the location of the model. In addition the system allows to hide and recall the list to have it visible only when necessary, leaving the maximum space for the 3D world exploration.

The system supports now 15 3D models of Palladian buildings well performing 50 fps at 1920x1200 pixel of resolution using a PC equipped with an Intel Core 2 Duo E6850, 4 Gb RAM, Nvidia Geforce GTX 290 graphic card and it could be used with a minimal customization to manage other visual database of architecture. At the moment, the platform has some limitations due to: (1) the limited number of triangles for each portion of the model; (2) the rendering engine not supporting shading techniques; (3) the limited number of APIs to get the model structure; (4) the navigation system that does not detect collisions with the models, making the exploration difficult; (5) some countryside areas have low resolution textures of the landscape; and (6) 32bit operating software tends to lose stability when several models are loaded simultaneously.

6. CONCLUDING REMARKS

The proposed paper reports a new digital 3D web-based GIS system that will be the basis for several platforms with different purposes: tourist information, scientific researches and projects, management, conservation and maintenance activities of the Palladio's work. This system works as a web-based application and it is capable of using a single database for several user categories (asset managers, researchers, tourists etc.) simply filtering the requirements. The framework is completely geo-referenced

using GE and 3D model based. The 3D models are generated using semantic techniques. The framework is designed in order to be scalable in the visualization and the client PC systems, from large screen displays and high-end workstations to desktop monitor displays and low-end PC. The system is completely based on widely spread and standardized interchange file formats and data entry, and the final application is completely founded on open source software. In this way the application will be opened to subsequent implementation to follow the progress of the Palladian studies; the quality of the actual and future implementation of information will be guaranteed also in case of different users and future changes in software and platforms.

Figure 13: "Palladio 3D Geodatabase", at work in Villa Pojana.

The quality of our system is witnessed by its use in two different expositions prepared by CISAAP at Barbaran da Porto Palace in Vicenza, and at Villa Poiana at Poiana Maggiore (Figure 13), one of the most famous Palladian Villas, in which the system is widely used by tourists visiting the Palladian buildings.

Acknowledgements

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