This paper presents the overall information system architecture and the approaches used for creating the Palladio Virtual Museum - a heterogeneous database of history and architecture. Creating a virtual museum is treated as an information system engineering task [Martin90]. The World Wide Web (the Web) is used as the open access platform for both presentation and input. Client-server database transaction technology [Date95] is used to provide a concurrent real-time system for consumers (visitors) and producers of information. The system is a test bed for structuring, searching, and presenting historical, architectural, spatial information.

1. Introduction

The Palladio Museum is a virtual museum dedicated to the works and life of Andrea Palladio (1508-1580). This museum of history and architecture is by necessity, virtual. The artifacts - buildings - are not physically transportable or containable. Furthermore, collections of physical fragments are decontextualizing. Electronic media is uniquely suited for creating flexible, dynamic, interactive, context-sensitive representations of historical, architectural space and time.

Although a virtual exploration does not replace the corporeal experience of traveling to Italy in person to visit Palladio's villas and palaces, it does provide a wide audience with an information-rich alternative. In particular, many works are not in existence. Some were designed but never built. Others were only partially executed. Still others are in existence but differ from the documented designs, as Palladio laid out in the Quattro Libri dell'Architettura [Palladio]. A virtual museum of architecture can facilitate the piecing together of both artifacts and information to form a coherent view. Analytical reconstructions of unbuilt, destroyed or incomplete works can act as surrogate representations where none would otherwise exist [Mitchell93]. The historian's efforts of piecing together facts, and making sense of drawings and physical fragments can be made manifest in 3-dimensional computer models. Although they are analytical and interpretative works, such virtual representations of (lost) architecture can serve vital educational ends.
There are a few areas in which virtual museums in general, and the Palladio museum specifically, can extend and redefine what a museum is. First, a virtual museum can present a more complete experience of times and places past, things destroyed or never built. Second, a virtual museum can be an online center of activity and information on its area(s) of specialty. The Palladio Museum project is a venture by its sponsoring academic institutions [1] to create a resource suitable for both public and research use. The public face will appear as the Palladio Museum on the World Wide Web, and as dedicated interactive sites. The research face will also appear on the web but as an optional and possibly regulated resource. Both will draw from a common collection of material. The museum will strive to present an experience of architecture and history in virtual medium - Palladio's built and unbuilt works, 16th century Veneto, the people, events and things that influenced his unique influential designs. The research center will strive to provide an electronic locus of information on the study of Palladio and a virtual community where information can be shared. Instead of crafted presentations, the ability to pose specific questions and find novel inter-relations between people, places, and events will be sought.

In between these two reference points - the research center and the public museum, lie many possibilities. The resource can become a virtual community of scholars and students studying Palladio's architecture. Exhibit-making can become a distributed enterprise in which shared and private materials and tools are used to craft a view of Palladio's works. The electronic carnation of the museum can be an ever changing, evolving, electronic focal point on Palladio. Electronic artifacts do not have to be precious items kept inside glass cases, but instead be resources to be reformed and used anew. Serious 'visitors' to the virtual museum can go beyond passive spectatorship, to engage the material experimentally.

The creation of a virtual museum of architecture and history can be approached in many ways. The major areas this project has addressed include:

2. Web based retrieval

In order to provide access to the widest possible audience, all information within the system is retrievable via the Web. This presents particular challenges when dealing with visually intensive material. Browsing material from the Web not only involves being able to display the multimedia content in a browser, but also organizing the material in a logical manner, providing access paths and tools to explore relationships. The Palladio Museum's approach has been to present information without a high degree of crafted narrative. Places should be explored via interactive maps that allow the user to select regions to explore. Buildings should be explored in terms of places, images, models, written materials, and so on. The internal information 'web' is spun around an underlying relational and object oriented database. This database holds facts about people, places, events, buildings and other things [Booch94] [Ross87] and digital representations [Mitchell95] such as searchable texts, images, HTML pages, and VRML models [Ames96].

Figure 1: Map applet searches for places and buildings

Figure 2: Digital text search results. Figure 3: Images and text documents found (e.g. on "The Teatro Olimpico")
The above clips show examples of an interrelated web of information and media. Selecting a region on a map causes a search for places and buildings. Selecting a building shows images and documents on that building. 2-dimensional media (text, photographs, drawings, etc.) can be combined with 3-dimensional representations such as VRML models, to provide a coordinated browsing of both spatial, visual and textual information.

3. Web based data entry

Browsing the museum on the Web is only half of the picture. The system is intended to be contributed to via the Web. A scholar working in a library, with internet access and authorization, should be able to contribute to the information within the system directly. This requires an underlying transaction database system. The displayable content has to be dynamically updated to reflect the current state of the system. Web pages therefore have to combine static content with dynamic content. The combination of Web entry, concurrent transaction based updating, and dynamic content serving over the Web makes for a fully open Web database.
Web sites that are primarily based on static pages require updating documents. The present system trades some degree of custom authorship for custom dynamic on-demand publishing. A common set of facts and media are stored in a database. Changing the underlying data or meta data reconfigures the served pages automatically.

4. Digital media procurement

An information system is only as good as the information it holds. One great impedance to achieving a functional system is the procurement of content in suitable digital format. Images have to be made digital. Texts have to be converted into machine readable form. Facts have to be organized and stored in logical structures. Representations have to identified and made searchable. This process is both a logistical and technological. Some of the pathways from source materials to digital representations are shown below. Increasing the ease of data assimilation into the system is critical. Direct to digs recording - such as with digital still and video cameras - is one step in this direction. Automated / smart cataloging methods are also critical.
5. Architectural and historical information representation
The explicitness of how information is represented has a direct bearing on how it can be manipulated, searched for, and ultimately presented. A page of text may contain facts that are comprehensible by a human, but without the aid of natural language processing, it is only searchable by a computer as word strings. The Palladio Museum stores explicit facts about people, places, buildings, events, etc. and representations of these objects. Information models define what attributes exist and how they relate to each other. Representations are digital media that have meta-information about how they can be displayed.

Current trends in information analysis and modeling are object-centric. However, traditional entity-relationship modeling techniques are still important because of the high cost and complexity of object databases and because relational searching offers advantages. Both methodologies have been utilized in the analysis of the historical
architectural domain at hand. Impedance problems between object and relational models have been approached via hybrid O/R/Relational solutions in which distinct functional layers are realized in one technology.

Figure 8: Object and relational designs (fragments shown).

The creation of an underlying information framework (whether Object oriented or entity relational) codifies a domain of knowledge in a particular (computable) manner. This model becomes an evolving working representation that is tested on 2 fronts - from the contributor who has information to put into the system, and from the viewer who explores and asks questions.
6. Search techniques

A narrative provides an authored perspective on a subject. A research database needs to go beyond prepared narrative to provide content based on logical searches. Different media require different search techniques. Texts such as a fully indexed version of Palladio's Four Books of Architecture can be searched by word phrases. A real world object (such as a building) can be searched for as an object, attribute or relation. For example, a search for the "Barbaro" may find it as a person’s last name, as in Daniele Barbaro and Marcantonio Barbaro; as a building's name, as in the Villa Barbaro, and Tempietto Barbaro.

The current approach to searching is a direct extension of the underlying object/relational framework. A search can be initiated on a word (e.g. "Barbaro"), an object type (e.g. Person ("Barbaro") vs. Building(“Barbaro”)). In all cases, the search hits each underlying database - indexed text base, relational tables, and an object metabase. The system is now using the Relational Navigation Engine [3] that dynamically creates Web pages by searching and extracting information from the underlying relational database based on an object-role schema. This system creates dynamic pages that are self-propagating and implicit. New links are generated on each successive page based on the object schema being traversed and on the available information. Complex form based searching which requires a high degree of upfront information to ask a question is replaced by contextual search-links.

7. Concluding Remarks

In many ways, it would be simpler to construct a system that, as is the norm, is a large collection of crafted multimedia documents/exhibits. This traditional approach does not make the material searchable other than by standard syntactic methods. The making of computable architecture and history, the structuring of information within these domains of knowledge, and the representing and presenting of this information within an open Web based system are fundamental goals of this research.

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