

How to build a cathedral: Historical and architectural model creation for cultural heritage

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Introduction

This paper will focus on the need of design and method in creating a project of Cultural heritage. The example given is the San Carlos Cathedral (AKA Royal Presidio Chapel) standing in Monterey, CA, and serving as a place of worship for the local community since 1795.

The Wikipedia definition of Cultural heritage:

- Cultural heritage is the legacy of physical artifacts (cultural property) and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations.
- Cultural heritage includes tangible culture (such as buildings, monuments, landscapes, books, works of art, and artifacts), intangible culture (such as folklore, traditions, language, and knowledge), and natural heritage (including culturally-significant landscapes, and biodiversity).

Cultural heritage needs the newest technologies to preserve, learn, visualize, spread, and make available to everyone, for us and future generations. Since the use of technologies such as virtual reality and 3D Graphics for Cultural Heritage is young, designing and creating historical and architectural models is actually important in order to show use cases and find best practices.

Related issues are:

- Finding and Building Resource Archives
- Capture, Display Model Variations over Time
- Visualization, Interaction, End-User Experience
- Site Links to Corresponding HTML5 Web Pages

- CAD Models and X3D Export
- Evaluation, Feedback and Improvement

Semiotics science explains us that a successful design is made up of three operations or levels of analysis (NOTE: For this information I would like to thank Prof. V.Roberto, University of Udine and his lessons).

1) Motivation: What is the inner message I want to communicate with my work?

2) Storyboard: What is the planned sequence of items that make up my work?

3) Final layout: What will the user see or read in my work?

Each of the following paragraphs will focus on one of the layers presented above: 1) We will start with abstract concepts regarding motivations and methods of history. In the second paragraph we will show how a story or storyboard and navigating into an architectural model can create a learning experience for the user, thanks to interesting features designed by the author. In the third part we will focus on the “highest level” and more practical aspects of the design (like the final layout) and common problems and tricks related to the modeling.

Furthermore, we will show in this paper how the language X3D can be used to create a cultural heritage project and how we used it to build the San Carlos Cathedral.

1: The Motivation and the importance of the historical modeling

"Those who cannot learn from history are doomed to repeat it" (George Santayana) . The first people that attended masses in the San Carlos Church were Spanish soldiers and missionaries that forced Indians to work, settle and pray. We know now that different cultures deserve respect and that cultures can only grow learning from other one. This is only an example and one of the inner messages that can be a thread of our historical project and reconstruction. Another one could be: The San Carlos Church was the only church in Monterey until 1876 and it served as a house of worship for people of all religious persuasion. This is a sign of great tolerance that should be an example for the present day society.

Modeling a historical reconstruction requires the traditional methods of history (research, study, archival resources, etc.) and new methods that support the subject at the present time (Databases, programming and web languages, virtual reality, multimedia resources etc.). The San Carlos project, which used the most advanced web technologies and x3d features, started from books and what is known about the church. In books we can find issues linked to the church like the two shown above and its contribution to history (from the local history to the great issues of the secular Spanish colonial adventure), depending on our initial motivation and on the people we are addressing.

A team interested in cultural heritage project must carefully define design goals before to start and ask themselves "Why are we interested in modeling a historic site?" ("begin with the end in mind"). Answers will vary depending on different users (students of cultural heritage, general public interested in learning more, archival history, documenting architectural restoration), in order to identify them and their respective goals. Answers also vary depending on how they use the model, since that affects construction, cross-linking and deployment of the results.

A historical model can be useful for maintaining official records. It must be linked to and cite the sources (archival documents, books, plans etc.) in order to give the user the possibility of verifying what you modeled.

The success of a project relies on how we capture information before we arrange them in a planned sequence (See paragraph 2). Capturing sources means to be methodical, thorough and to keep track of it all.

A historical model can be useful for exploring evolution over time. Every object (tangible or intangible) is the result of an historical evolution. Showing the history of an object is the best way to understand it in the present. Showing the history of an object means to have a look at different forms of it in more than one stages of the past at the same time, like from an higher position.

A historical model can be useful for exploring alternatives when actual facts are unclear or unknown and then the interpretation of the source is necessary. Most of the times is impossible even to approach the reality of facts or objects because the source available are only microscopic traces of facts and artifacts of the past. For example, we don't know the color of the walls of a building no more existing. It may be all colored of red because we found traces of red plaster, but only in one room. Instead, It may be all colored of white, because

similar building of the same age were white, and only one room were red. With the new technologies we can advise the user that one of the two hypothesis is more likely and give him the possibility 1) to read and view sources that explain these alternatives and 2) to visualize both in the main model, changing from one to another with a click. Anyway, when sources lack we will never know the truth and what it really important is the inner message we want to give to the visitor. The historian must not give up when faced with lack of source, but he should use the source available in order to be useful and interesting for the group and society in which the historian lives. 3D reconstructions should be an instrument that teaches something and not a mirror on the past that shows how thing were exactly, because it is impossible. We believe that a 3D model (if really made with historical criteria and with the newest interactive features) can teach as a book of history. Even better they can be placed side by side . History should abandon the belief that the high culture (and academic publications) is confined to books and traditional texts. History and culture must have an important post in the most recent technological media and devices in order to be available by the new generations. "The history has a history".

The language X3D is a perfect tool to implement all the aspects we talked about in this paragraph. It can easily create links from the model to the sources and vice-versa. It gives the possibility to show graphical reconstructions, interpretations, hypothesis, evolution over time. It can provide 3D physical context to real-world events. It offers methods to communicate an inner message giving the user sensorial experiences (visual or acoustic), augmented by the possibility of interaction. We will talk more about these experience and interaction in the following paragraph.

2: The Storyboard and the importance of the architectural modeling

Telling a story or creating a storyboard means designing your project as a sequence of objects, facts, instruments and features which make up the user-experience. A typical example to better explain this concept is the use of flashbacks or metaphors in literature. They are instruments used to understand something better, a particular fact or the whole story. The user of a web site or a 3D model is not forced to follow a line in the story but can freely navigate along the document. The user can choose to start a tour of building features, outside and inside. Visitors would like to look at the model from a top point of view or zoom to a detail. They would like to have the ability to explore, jump from one place to another, from one time to another, read a text, watch a video, when they want. An architectural model can be considered as a container of other cultural

heritage items like books and pictures and even a music piece of art. Imagine the historical dwelling of a composer. Entering in his studio and touching on his Piano music can start. Touching the portrait of the artist will enlarge the image and other textual references about his life can be shown. Clicking on a book of his library or one of his music sheets, other information and pictures would appear.

Some samples taken from the San Carlos Project. A guided tour from different viewpoints is provided for the exterior and the interior (thanks to particular features or prototypes like Wiewpoint Sequencer and Wayinterolator) . Another guided tour permits the user interested on pictures hung on the church to focus on them in sequence. Textual information about these and other items, like the crucifix, are provided. We created lighting alternatives for better rendering the church and the user can turn the chandeliers on clicking on them or have an idea of a sun morning light entering from windows. Ten alternatives have been designed until now and a multiple switch is provided for the user. During the navigation it is possible to glance at the church in the mid 19th century a system of references to sources has been created. Animation and sound of the bells has been added to the model, and they are available by the user interested in this feature.

We think that videogames can be used as a model for creating cultural heritage. From the author's point of view they need a story or a storyboard as we defined before. From the user point of view they are interesting and they need a lot of attention from him. How to find a better way to make a child or an adult learn something? Why not create a videogame set in a historic place or in a building? Even obstacles, penalties, questions, points, riddles to solve (all regarding historic topics) could be instruments to aide in learning. The best known games (besides sport games) consist in 1) exploring new worlds or buildings and 2) building a city or an empire. Architecture, history and videogames are often linked tightly. X3D can be used to create videogames. For example this language permits the user to rotate knobs and drag and drop objects.

X3D permits various kind of animation and the possibility to add java and javascript code. These features open almost endless possibility to implement learning experiences. Authors are required to design them carefully. For example it would be possible to watch a movie of the architectural history of a building. We could create a time line made up of buttons. Clicking on the 19th century button only the structures existing in the 19th century would be highlighted or shown. And so on.

How to better introduce and suggest the inner message we previously talked about (See paragraph 1)? An architectural model should be put in a contest. Modes of usage are: the Web (online interactive site),

applications (download, CD/DVD or installed media), electronic book. We may consider the cross-reference with multimedia information:

- HTML pages with descriptive text
- Photographic closeups and special events
- Audio descriptions
- Naming, indexing and metadata are important

Textual introduction to the history and the location of the building are usually necessary, like maps of the area (also consider the GIS technologies), pictures, videos and other primary sources. A database can be a way to store and maintain official records. They can be linked to and from the model.

Web 2.0 technologies can be part of the context of the model. The user which is reading something or is navigating the model could (once received privileges) send comments or even new precious sources like old photographs or everything else.

A 3D model and its context have not a final version like a book of history and can be at any time updated if new sources come to light. Types of sources that we would like to have in order to realize an architectural model are: Historical descriptions and records, photographs, illustrations, architectural drawings and floor plans, measurements (ultrasonic scanner, laser level), laser and point-cloud techniques. We need to keep track of it all and various instruments, like a version control and draft website, can help their management (everything has a place to go and information architecture evolves in tandem). We have to consider that perfect modeling is difficult. The real world is not perfect or perpendicular and pictures can be taken to emphasize aspects of interest and hide flaws or imperfections. 3D models have both good parts and difficult parts to capture. Authors must decide on tradeoffs and design goals and use cases help (See paragraph 3). This matches historical analysis: how to make sense of partial information, contradiction, alternatives, evolution, etc (see paragraph 1)?

3: The Final layout and the model creation

At this level the design of a cultural heritage project concerns questions like: How long should a particular text of my work be? What kind of vocabulary should I use? Specialized or available to everybody? Questions about the final layout are quite important and the use of a font instead of another for the texts can

improve legibility. We think that legibility of a long or medium long text on a screen is still a problem to solve in order to make a cultural digital work a success and for a wider public. Other examples about the layout are: What color should I use as background of my 3d model? A light or a dark color? Clicking on a button during the navigation of the model, in what part of the screen should an explanation text or the picture of a detail appear? It is clear that what the user will find on the screen is very important for his learning experience and it should not be underestimate.

Buttons with different colors or shapes can indicate different kinds of links (for example one to an archival source and one to a repository of photographs of an existing area of the model). A legend would explain their meanings and a switch could hide or show these references in order to not bother the users that are not interested in learning more during his navigation. Structural parts that don't exist more, are uncertain and fruit of an interpretation by the author can be presented to the user with a semi-transparent appearance.

Model creation is a matter of design, because for every shape you are going to model there is more than one way to create it, using for example different X3D nodes. Before to start the entire model and before to start every single part of it (for example a wall, a window or a bench) you have to study the single object, think carefully about all the possibilities and nodes that the language offers and decide the strategy and the node to use. Of course, if after a while the root you chose was wrong, you can always delete it (but is better anyway to save everything) and start again from the beginning with another root or node. Model creation is a matter of patience. This is rule number one if you want to create a big and detailed model like a cathedral.

A general problem of modeling is how to render an irregular object (like a chandelier) or with curved shapes (like an arc above a door). Historical buildings like the San Carlos Cathedral are full of irregular shapes. In practical, for the majority of curved shapes we decided to use the X3D Indexedfaceset node, but usually the extrusion node is another way to model irregular shapes. We used the extrusion node for the bells and for the facade window. The extrusion node is perfect in addition with its scale attribute. Almost all of the other curves and arcs in the San Carlos project are the modification of only one arc created with the Indexedfaceset node. This arc was simply put into a transform node and stretched or shorten in one or all of his dimensions (x, y, z) thanks to attribute scale of the node transform. As you can see from the image n°x it was a very helpful to use a section or a photograph in order to recreate a curved shape, as the top part of the facade. We put the section on a box as a texture. Then we put the original arc above the section and we started to stretch and shorten it (with scale) until it is superimposed with the curved line you want to render. The way to do that is the trial and error method and a bit of patience. Only the design before to start each one of these operations can save you

time.

The trial and error method maybe is the key to line up one shape to another and it is one of the more time consuming problems of modeling with X3D. Because it doesn't have a Snap feature like the CAD softwares that lines up objects automatically. A way to skip the problem would be to use very big Indexedfaceset node (in theory you can create only one node for the whole model). But 1) the bigger the Indexedfaceset is, the more you lose the control of it when you are going to transform and texture it; 2) in front of thousand of coordinates you can easily make errors and the search of a single number could be like "looking for a needle in a haystack". We often used quite big Indexedfaceset, like for the walls and for the roof of the church, but we decided to use boxes or small Indexedfaceset shapes lined up to each other in order to create other shapes, (Divide et impera). It is an example of that the profile of the windows shown in the image number x. As you can see in the same image a trick that can help you during the trial and error method (when you want to line up two shapes) is to change the color of one and keep going with the try and error until the "aliasing" or also called "tearing"? will inform you that they are perfectly lined up.

"The better is enemy of the good enough". If you want to exactly recreate the real world you will never finish a model and in any case it will be useless because a photograph will come closer to the reality much more than the best computer graphics tool. The representation of a real or an unreal object is a matter of design and choices. There is not a rule how much an entire model or parts of it can be different, simpler or less detailed from reality. It depends on what your motivation is, what is the inner message you want communicate to the users (see paragraph 1). A simple example can be: if your motivation is an architectural history of a church it is useless to spend days modeling an altar with hundreds of coordinate point, shapes or irregular lines; if your motivation is the history of the sacred furnishings, you should be more detailed; if your motivation is "art in 18th century altars" your model must be very detailed.

Talking about texture and material for rendering your model we have to repeat what we said previously: design the level of detail of your object, think carefully before to start about what strategy to use , use the trial and error, use a good graphics software, be patient.

We want to communicate two warnings in this paper. 1) Try to keep the level of detail similar for all the items of the same model. 2) Don't cheat the user. Explain what level of detail you used and why. Explain when you are forced to change something from reality and, much more important, when you render something that is no longer existing. In a text the place to explain that is typically the introduction or the foot notes. And this is

what makes a text a scientific text. Maybe there is not yet a standardized way to implement such a simple tools to make a digital resources (like a 3D reconstruction) a scientific digital resource. We will keep going with use cases.

Conclusion

In this paper we talked about the most important issues and problems related to the design and the realization of cultural heritage project using X3D. It is important to say that a 3D model can't replace a real tour of a historical site. It can be put at his side. It can "talk" to the user about its history, its historical documents and related issues. Most of all it can say something about people that used and lived in it. We looked at the example of the San Carlos Cathedral in Monterey. Now we will try to summarize and create a more practical and minimal list of steps to create a big model with x3d that responds to the cultural heritage criteria.

- Choose a building or a historical site. The study or the modeling of it must be useful and interesting for a community
- Before to start you have to know the basic information about the history of the building or historic site you chose. Verify if the building and the topics related have been studied by other researchers, if not, you have to face an archival and bibliographic research.
- Verify if the shape of the building is too much irregular. Maybe a project which uses only pictures will be more useful.
- Verify the existence of floor plans and sections. If not you have to take measurements
- Decide what you want to model of the building and what you want to exclude. For example you want to exclude a garden or a small building in it. How many time can last the all the modeling? It should be a part of the whole project.
- Modeling
- Texturing
- Design and add a navigation system, the user interaction, lighting, points of view etc.

- The user must have the possibility to view pictures, floor plans and other sources of the real building
- Do you want to create a model of the building in the past? If yes, you must study a complete bibliography on the topic and, if necessary, look at primary sources in archives. References to indicate every interpretation is necessary.
- Put your model in a context of historical, architectural and geographic information, photographs, citations from books and other multimedia sources. Other programming languages can help the availability of additional information and the link between the model and his context.

In conclusion, we believe that X3D is an excellent tool for creating a model of cultural heritage interest. Because this language is designed for the web and it provides several tools for animation and user interaction that can be easily designed as a learning tools.