A New Approach to Cultural Heritage Information Systems

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Abstract

Work on archaeological sites or cultural heritage artefacts usually generates a huge amount of heterogeneous information. The strong spatial structure of data suggests that this information should be linked to a three-dimensional model of the artefact. This paper presents a new approach to the representation and management of information in the Cultural Heritage field. We propose a method for associating attributes with a 3D model using information layers, following an approach similar to that used in Geographical Information Systems.

Categories and Subject Descriptors (according to ACM CCS): I.3.4 [Computer Graphics]: Graphics Utilities—Graphics packages

1. Introduction

A key problem in Cultural Heritage is the management of information. Dealing with heritage sites and artefacts involves a large volume of data: text documents, images, measurements, and so forth. The data collected usually comprises information about the spatial location or distribution of the object's features, so it therefore seems natural to bind the data to the object's surface [MGP*07]. However, the problem of how to connect non-graphical information elements to a three-dimensional surface is still unclear. Many approaches have been proposed to address this problem. Most of these require building a segmented version of the model, to which a set of labels and annotations are added [DCPS08, GPV10].

In this work, we present a cultural heritage information system in which non-graphical information is organized by means of a set of attribute layers that are defined on the object's surface. This structure allows layer information to be managed in a similar way to GIS maps. Only information of large archaeological sites can be managed using traditional GIS. 3DGIS could be an alternative to manage data although they have some disadvantages on this field:

- Raster layers are 3D grids that store much more than just the information about the object's surface.
- Vectorial layer resolution depends on the resolution of the 3D elements (such as triangles) used in the represention of the 3D model. Therefore, binding information to smaller elements requires a modification of the 3D model.
- Topological relationships are defined using a 3D neighbourhood, while we are interested in 2D neighbourhood on the 3D model surface.

2. System Overview

Organizing information as a set of layers is one of the key ideas that our system has adopted from GIS technology. Essentially, an information layer represents the distribution of a particular attribute on the 3D model surface. The proposed system allows users to deal with these layers in the same way as GIS users manage maps. For example, users are free to create layers at any time and decide what information will be stored on them. It is also possible to choose which database information fields will be included, as well as add or edit the label fields. The key features of the system functionality are summarized below.

Model Creation. The geometric representation of the object is created automatically using a triangle mesh that can be obtained from a laser scanner as input.

Rendering. Layers can be rendered on the surface of the 3D model using different colours for each property/attribute value. By using colours to visually code property values,

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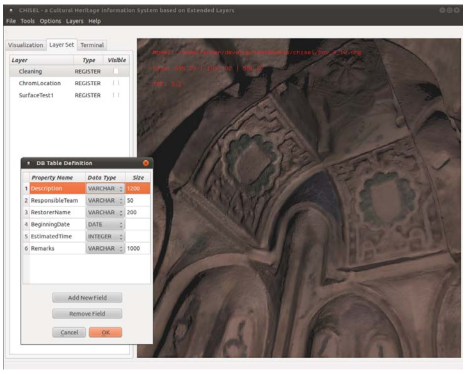

Figure 1: *Layer definition on a 3D model from the Honeycomb Ceiling of the Alhambra's Hall of the Kings.*

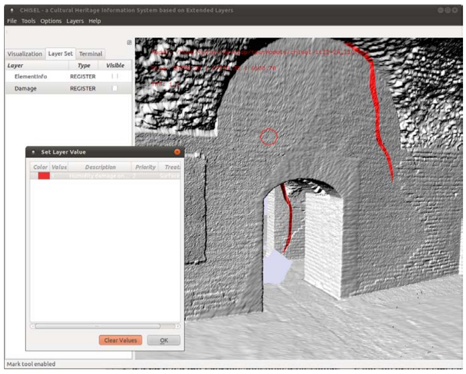

Figure 2: *Editing of a Damage information layer of a 3D model from the Roman City of Italica.*

the user can establish a personalized colour map for the information supported by each layer.

Editing. Layers can be easily edited in an interactive way by simply drawing on the 3D surface. To bind an attribute value to a particular part of the model, the user first selects that value and then marks the corresponding part of the surface using a tool similar to a paintbrush.

Operations. Combining layer data is another way to automatically process and generate information about the model. Data can be combined using an algebraic operation involving one or several layers. A clear example of an algebraic operation on raster layers is that of the r.mapcalc operation on GRASS GIS.

Queries. Users can search for areas of the surface model which hold a particular attribute value by specifying that value. This can be a single value, a range of values, or a complex query for label layers using SQL commands. Conversely, it is also possible to query for attribute values in an interactive way, by just clicking on the 3D model surface. When this is done, the system determines which part of the surface must be queried and which values of the currently active layers are associated with that part of the surface. The set of values bound to the designated area is then displayed.

Topology. Topological relationships are computed on the mesh surface, which allows neighbourhood information to be obtained.

Multiresolution. Attribute values can be bound to different sized portions of the model surface, according to the level of detail required by the user. In this regard, our system allows users to define information layers with different resolutions as attribute values can be bound to different sized portions of the model surface, depending on the level of detail required by the user. Independently of the layer resolution, users can also decide the resolution for performing a particular task, such as visualization, value binding, and so forth, at any time.

3. Implementation

In order to define a mapping from the artefact surface to the space on which the layers are defined, we use an octree data structure. The octree includes only those voxels that are intersected by the object surface at a predefined resolution, ignoring non-intersected nodes. Each of these cells are stored in a linear array, comprising:

- An *octcode* representing the spatial location of the voxel.
- A reference to the triangles set which intersect the voxel.

This spatial structure forms the basis of our raster representation. Each information layer comprises a sequence of data values related to the octree cells. Since cells intersected by the artefact surface are stored using a linear array, we can also represent layers as linear arrays including a specific value for each octree cell. Thus, the value position in the layer array determines which part of the object surface is bound to that value. This layout makes it possible to attach any kind of information to a particular part of the artefact surface as well as to perform spatial queries.

In this research a prototype application has been developed using C++, OpenGL (http://www.opengl.org) as a renderer and SQLite (http://www.sqlite.org) as a backend database system.

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