DIGITAL RECORDING, DOCUMENTATION AND CONSERVATION FOR BYZANTINE MONUMENTS USING A PC-BASED SIS

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ABSTRACT

A SIS (Spatial Information System) application is developed for the purpose of recording, documentation and conservation of Byzantine monuments and particular for Byzantine churches, while the open structure of the application can easily be adjusted for applications regarding other kind of monuments. Extensive care is exercised on topology and terminology regarding the kind of monuments used in this application. The monuments are grouped in a number of categories and feature-levels and this classification is used in SIS tabling.

1. INTRODUCTION

In the current paper a SIS system is proposed that is based on data related to monuments and particular to Byzantine churches. Intergraph's MGE-PC GIS s/w on MicroStation PC CAD environment is used as the implementation platform of the application. Mapping and SIS data are organized into a project (ByzMN.mge) that contains three basic parts: maps and drawing files, database information and multimedia data. The MGE-PC uses a relational database management system which requires that all non-graphic data (i.e. database information and multimedia data) be contained in database files known as tables. The ByzMN.mge project consists of system tables related to categories and feature-levels of the monuments and of attribute tables related to particular structural elements used in Byzantine monuments.

Despite the fact that the SIS application is organized - for documentation and conservation purposes - having in mind Byzantine monuments-churches, any kinds of monuments are supported by its open environment. In this case the user has to adjust the categories and extend the feature-levels and attribute tables.

Documentation of rescue archaeological excavations regarding Byzantine monuments could also be supported. Combination of terrestrial photogrammetry and SIS systems speeds up recording and documentation of archaeological excavations, reduces their cost, introduces new quality in this process and conserves data recording for future study as meta-data.

The state-of-the-art information technology (like SIS, GIS, digital photogrammetry and multimedia systems) facilitates the recording and documentation of more than the material monument data. The social influence and significance of the monuments can now also be recorded and demonstrated (Ogleby C., 1995).

2. GIS ANALYSIS - DATA ORGANIZATION AND CLASSIFICATION

The geographic information for Byzantine churches is divided in three main parts. The graphic information (maps, drawings, etc), the text information (documents, texts, reports, etc) and the multimedia information (photos, sounds, videos, animation, walkthroughs). In GIS environments, like Intergraph's MGE-PC, graphic information in digital form is stored in graphical files known as Digital Maps, whilst text information in ASCII or binary form is stored in databases using Tables and multimedia information in digital form is stored in Media Files (wav, avi, fl).

2.1 Digital Maps

The Digital Maps for the Greek Byzantine monuments are grouped geographically in six categories according to Anthrano Alpago Novello & George Dimitrokallis (Novello A., et al., 1995) (i.e Northern Greece (mainly: City of Thessaloniki), western continental Greece (mainly: city of Kastoria), south Greece and islands, the island of Chios, St Mount Athos, and St Meteora) and thematically in ten categories (cemeteries, crypts, sketes, churches, baths, monasteries, graves, chapels, towers and tombs). The relationship between the members of these two groups is N-to-N, for instance for the category Chios there are digital maps for Byzantine churches, baths, monasteries and graves, whilst for the category Byzantine churches there are digital maps in all these six geographic areas.

On the maps and for each thematically oriented category there is a number of monuments (features) enrolled in the project as GIS-features or geographic elements which are related to particular objects-Byzantine monuments of the current category. These monuments-features are grouped in feature-levels according an approved typology (Vociotiopoulos P., 1987).
This layering system operates well and the maximum number of the feature-levels depends on the GIS platform used. For instance for MGE-PC on MicroStation PC CAD platform this number is 63, i.e. the number of layers (levels) supported by this CAD s/w. In the current project (ByzMN.mge) and for the category Byzantine churches there are thirty three (33) feature-levels according to Bouras Ch., 1994 and Giosis N., 1992 (see: Table 1).

Geographic Index Files
The following six Geographic Index Files are used for feature-level grouping as far as the Byzantine monuments category is concerned:
- Early-Christian Monuments (First-Christian period: up to 312)
- Old-Christian Monuments (312-527)
- Justinian Age Monuments (527-600)
- After Justinian Age Monuments (600-850)
- Middle-Byzantine Monuments (850-1204)
- Late-Byzantine Monuments (from 1204 on)

Using the indexing technique the retrieval process is speed up and a semi-spacio temporal SIS is introduced (for chronology related subjects see: Megaw A., 1931-1932 and Krautheimer R., 1965).

The following two Geographic Index Files are used for Byzantine monuments category grouping:
- Thematical group of categories
- Geographical group of categories

The Monuments Categories:
A. Roman
B. Venetians (included Veneto-Byzantine)
C. Gothic
D. Ottoman (Islamic, Muhammedan)
E. Greek
F. Egyptian
G. Buddhistic
H. Romanesque (8th-12th century)
I. Slavic

The Greek Monuments Categories:
E1. Archaic Greek
E2. Early Greek
E3. Greek Byzantine
E4. Modern Greek

The Geographically related Categories for Greek Byzantine Monuments:
Northern Greece (mainly: City of Thessaloniki)
Western Continental Greece (mainly: City of Kastoria)
South Greece and Islands
The island of Chios
St Mount Athos
St Meteora

The Thematical related Categories for Greek Byzantine Monuments:
1. Byzantine Cemeteries
2. Byzantine Crypts
3. Byzantine Sketes
4. Byzantine Churches
5. Byzantine Baths
6. Byzantine Monasteries
7. Byzantine Graves
8. Byzantine Chapels
9. Byzantine Towers
10. Byzantine Tombs

1. Early-Christian Cemeteries
2. Early-Christian Crypts
3. Simple Dromedary Basilicas
4. Cross-Aisle Basilicas (type A,B,C,D)
5. Cruciform Basilicas
6. Centralized Churches (circular, octagonal)
7. Domed Basilicas
8. Octagonal Churches
9. Basilica Order Churches
10. Basilicas with Dome Churches
11. Single-Space Domed Churches
12. Cruciform domed Churches
13. Greek Cruciform inscribed domed eight-pillared Churches
14. Greek Cruciform inscribed domed transitive Churches
15. Mid-Byzantine Basilicas
16. Single-space dromedary Churches
17. Free-cross shaped domed Churches
18. Single-space triconch domed Churches
19. Tetrachoric domed Churches
20. Cruciform semi-inscribed domed Churches
21. Circular domed Churches
22. Churches with dome and loggia
23. Transitive Cruciform Inscribed domed Churches
24. Cruciform inscribed domed (complex)
25. Cruciform inscribed domed (semi-complex)
26. Inscribed Cross-like with dome (with 4 Pillars)
27. Inscribed Cruciform domed (with 2 Pillars)
28. Inscribed Cruciform domed (with 2 Columns)
29. Inscribed Cruciform domed (a special case)
30. Inscribed Cruciform domed (concise)
31. Cross-shaped sheltered domed Churches
32. Complex Octagonal Churches
33. Simple Octagonal domed Churches

Table 1. The Feature-Levels for Byzantine Churches Category.

2.2 Tables

In SIS project, feature is any monument (church) that is represented graphically on a map. An unlimited number of features can be placed in the project, but only 63 kinds-of-features in each category. Each kind-of-feature in a category should be stored on a different drawing level, which in MGE-PC is called a feature-level. This layering supports the display of any given combination of features on a map.
Feature information is stored in Feature Tables (see: Table 2). The feature tables can be created and populated using appropriate MGE-PC GUI commands. The following table is a representation of the relevant columns of the feature table used in ByzMN.mge SIS project. For instance the records for a 13th century byzantine church and for the four most important Greek and Orthodox old-christian Byzantine churches in Thessaloniki have as follows: The St. Panteleimon church (built in 1250) is characterized as cruciform inscribed domed (Flevel=25), the St. Dimitrius church (built in 413 (324)) is characterized as a five-aisled basilica of the so called helenistic type (Flevel=4), the church of Aheropetitos (built in 431) is characterized as a three-aisled basilica (Flevel=4), the St. Sophia church (built in 780 (550)) is characterized as a domed basilica (feature-level = 7), and the church Panagia Halkon (built in 1028) is characterized as complex cruciform inscribed domed (Flevel=24).
<table>
<thead>
<tr>
<th>mslink</th>
<th>Fcode</th>
<th>Fname</th>
<th>Category of table</th>
<th>Ftype</th>
<th>Flevel</th>
<th>Fstyle</th>
<th>Fweight</th>
<th>Fcolor</th>
<th>digcmd</th>
<th>place</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>1098</td>
<td>StPanteleimon</td>
<td>E-3-4</td>
<td>CCcntr</td>
<td>Raster</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>place</td>
</tr>
<tr>
<td>79</td>
<td>2107</td>
<td>StDimitrius</td>
<td>E-3-4</td>
<td>CityCntr</td>
<td>Vector</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>2108</td>
<td>Aheropeitos</td>
<td>E-3-4</td>
<td>CityCntr</td>
<td>Vector</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td>place</td>
</tr>
<tr>
<td>108</td>
<td>2109</td>
<td>StSophia</td>
<td>E-3-4</td>
<td>CityCntr</td>
<td>Vector</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td>place</td>
</tr>
<tr>
<td>166</td>
<td>2110</td>
<td>PanagiaHalkone</td>
<td>E-3-4</td>
<td>CityCntr</td>
<td>Vector</td>
<td>24</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td>place</td>
</tr>
</tbody>
</table>

**Table 2. The Feature Table used in ByzMN.mge Project.**

Vector files related to features (churches) are stored in Maps Tables (see Table 3), whilst raster files are stored in Media Files (see Table 6). The maps tables can be created and populated using appropriate MGE-PC GUI commands (like: Set Up MGE Tables).

The following is an example of a populated map table with the name CityCntr having 50 entries.

<table>
<thead>
<tr>
<th>mslink</th>
<th>MapName</th>
<th>Category</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AllSaints.dgn</td>
<td>E-3-4</td>
<td>39</td>
</tr>
<tr>
<td>11</td>
<td>StDimitrius.dgn</td>
<td>E-3-4</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>Aheropeitos.dgn</td>
<td>E-3-4</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>StSophia.dgn</td>
<td>E-3-4</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>PanHalkn.dgn</td>
<td>E-3-4</td>
<td>2</td>
</tr>
<tr>
<td>50</td>
<td>CuleCafe.dgn</td>
<td>E-3-5</td>
<td>29</td>
</tr>
</tbody>
</table>

**Table 3. The CityCntr Maps Table.**

A special kind of non-graphic Attributes of monument-features, as names of materials, construction details, decoration details, descriptions, type or kind of primitives used and technical specifications, are stored in Attribute Tables (Wallis M., 1973). For instance the name, description and the technical specifications of cylindrical arcades or the origin of marble doorposts are examples of this kind of information stored in Attribute Tables.

An attribute table contains at least two required columns: mslink and mapid. Other columns could be defined using a suitable editor (e.g. in MGE-PC: the Column Builder editor). The column mapid holds the number of the map containing the linked monument, while the column mslink holds the occurrence number in attribute linkages, i.e. links the record to a monument. The user-defined columns hold the user-defined attributes associated with the monuments, like type of Arcades, type of Domes, kind of Drainpipes, etc.

The following tables 4.1 and 4.2 are examples of attribute tables used in ByzMN.mge SIS project.

<table>
<thead>
<tr>
<th>MapID</th>
<th>mslink</th>
<th>Class</th>
<th>Description</th>
<th>Type</th>
<th>Kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>223</td>
<td>A</td>
<td>Arcade</td>
<td>Cylindrical</td>
<td>Brick</td>
</tr>
<tr>
<td>4</td>
<td>332</td>
<td>C</td>
<td>Cornices</td>
<td>Stone</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>980</td>
<td>P</td>
<td>Dies</td>
<td>Spherical</td>
<td>Stone</td>
</tr>
</tbody>
</table>

**Table 4.1. Attributes Table used in ByzMN.mge Project.**

<table>
<thead>
<tr>
<th>MapID</th>
<th>mslink</th>
<th>Class</th>
<th>Description</th>
<th>Type</th>
<th>Kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>223</td>
<td>A</td>
<td>Arcade</td>
<td>Cylindrical</td>
<td>Brick</td>
</tr>
<tr>
<td>4</td>
<td>332</td>
<td>C</td>
<td>Cornices</td>
<td>Stone</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>980</td>
<td>P</td>
<td>Dies</td>
<td>Spherical</td>
<td>Stone</td>
</tr>
</tbody>
</table>

**Table 4.2. Attributes Table used in ByzMN.mge Project.**

<table>
<thead>
<tr>
<th>MapID</th>
<th>mslink</th>
<th>Church-Name</th>
<th>Characteristics</th>
<th>Wall Painting</th>
<th>Erection</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>St. Panteleimon</td>
<td>“School of Macedonia”. YES</td>
<td>1380</td>
<td>Stone and Bricks. Open aisle (peristoon).</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>St. Dimitrius</td>
<td>Five-aisled basilica without dome. YES</td>
<td>413 (324)</td>
<td>Timber roofed. Stone and Bricks. Peristyle (atrium).</td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>St. Sophia</td>
<td>Cruciform Domed Basilica YES</td>
<td>780 (550)</td>
<td>Church High drum-domed NO 1028</td>
<td>Apse (with Prothesis and Diakonikon) Bricks only. Tomb of Krisiotores (founder).</td>
</tr>
</tbody>
</table>

**Table 5. The Characteristics Table used in ByzMN.mge project.**

| 2.3 Media Files - Multimedia Data |

Multimedia technology helps SIS and GIS systems become more productive. An integrated Multimedia-SIS strategy that includes the common multimedia presentation (raster images, audio descriptions, video clips, etc) has been added to ByzmN.mge project through pointers pointing to suitable MDL event-handlers (drivers) (Syladias A., 1995). The following tables are related to CCcntr media file used raster image connections for Thessaloniki’s City Center churches.

<table>
<thead>
<tr>
<th>mslink</th>
<th>RasterName</th>
<th>Category</th>
<th>The MDL Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AllSaints.tif</td>
<td>E-3-4</td>
<td>dialog display *.tif</td>
</tr>
<tr>
<td>11</td>
<td>StDimitrius.bmp</td>
<td>E-3-4</td>
<td>dialog display *bmp</td>
</tr>
<tr>
<td>13</td>
<td>Aheropeitos.bmp</td>
<td>E-3-4</td>
<td>dialog display *bmp</td>
</tr>
<tr>
<td>14</td>
<td>PanHalkn.bmp</td>
<td>E-3-4</td>
<td>dialog display *bmp</td>
</tr>
<tr>
<td>50</td>
<td>CuleCafe.gif</td>
<td>E-3-5</td>
<td>dialog display *gif</td>
</tr>
</tbody>
</table>

**Table 6. The CCcntrR Media File.**
3. GIS FUNCTIONALITY

Database functionality is based on XBASE (i.e. DBF format) and particular on dBaseIII+. Users are able to create and edit local-disk database structures for every category of thematically or geographically related Byzantine monuments. They are also able to define additional feature-levels for particular categories within the limit of 63 (MicroStation PC environment).

A fully functional link to external database management systems compatible with MGE-PC (like Oracle and RIS) supports relations 1:N.

Multimedia functionality is based on event-handlers implemented in MDL and embedded in GIS tables through pointer-values. In this way raster images of various market formats (BMP, GIF, TIFF, etc) can be attached to geographical elements (Byzantine churches) enhancing the functionality of SIS processing. Alternately the Vista Map extension s/w could be used for multimedia functionality.

Modelling functionality is supported of existing vector files of Byzantine monuments (DGN format) or of input vector data through digitizing existing maps or scanned raster images. Intergraph's I/RAS B and I/RAS C connections enable handling of binary and continuous tone raster images of up to hundreds of MB files.

MGE-PC Functionality

Intergraph's MGE-PC environment provides a friendly GUI for map and feature handling. In this s/w there are: the Map menu to perform all map related tasks (eg. creating, opening and setting up maps) and the Feature menu to perform feature-related tasks (eg. digitizing geographic elements, reviewing properties). The following workflow (Fig. 3) is used for Byzantine churches recording, documentation and conservation.

A) Setting up the Data Base
   set up MGE System Tables
   set up Categories
   set up Features
   set up Attribute Tables
   set up Multimedia Files
   set up co-ordinate system for spatial analysis
   and spatial queries

B) Adding Data to Data Base
   create map files
digitize features (geographic elements) onto maps
define attribute values for these features
   create index files
   create vicinity map

C) Verify and Update Data

Fig. 1. Western Elevation of St. Dimitrius Church (The FRONT - view of St. Dimitri.dgn).

The following Figure (Fig. 2) illustrates the relationship between Feature-Levels and Attributes used in ByzMN.mge project. Once again the displaying of any combination of monuments (i.e. features or geographic elements) that have been placed on any map is helped by this layering.

Fig. 2. Relationship between Feature-Levels and Attributes.

Fig. 3. The workflow used in ByzMN.mge SIS Project.
Figure 5 displays raster images of two Byzantine churches in Thessaloniki. The compression used was based on Run Length Encoding form. The spatial questions to SIS were: "Display raster images (Elevations) for cruciform domed churches built between 1020 and 1030" and "Display raster images (Elevations) for five-aisled basilicas built between 400 and 420". As result the image of the South Elevation of Panagia Halkon Church (cruciform domed - 1028 AC) and the image of the Western Elevation of St. Dimitrius Church (five-aisled basilica - 413 AC) are displayed.

4. CONCLUSIONS AND FUTURE ENHANCEMENTS

SIS software provides a wealth of data documentation and conservation tools as well as tools for data-handling, data-analysis and data-retrieving purposes. SIS documented data can be retrieved faster and maintained so that the most current information is always available (Patias P., et al., 1995), (Paraschakis J., et al., 1992).

In current SIS application a feature is any monuments (geographic element) that is represented graphically on a map. An unlimited number of features can be existed in a SIS project, but only 63 kinds of features (feature-levels) in each category for MGE-PC MicroStation CAD platform. Each monument in a category should be stored on a different drawing level, which in MGE-PC is called a feature-level. In this way any required combination of monuments on a map could be displayed.

Future enhancements will be based on new Object-Oriented SIS Systems using Object-Oriented design techniques and methods regarding monuments as objects with various attributes, e.g. text data, raster and vector files, multimedia data.

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