3D DATA MODEL FOR PURPOSES OF CULTURAL HERITAGE CUSTODY – CASE STUDY AT THE CASTLE KOZEL

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Abstract:

The paper describes a comprehensive data model suitable for database management of Cultural Heritage, which has been developed on the basis of a Case Study in the State Castle Kozel.

Currently there exists a national level geographic data model for the custody of Cultural Heritage (called paGIS) in the Czech Republic. This model has been developed by the Institute of National Heritage and is a part of Integrated Information System of Cultural Heritage Custody (https://iispp.npu.cz/). PaGIS, as a national level data model, deals with a level of detail appropriate to real estate cadastre and objects such as parcels and buildings. This level of detail is sufficient for the current possibilities of nationwide data collecting. But especially curators of castles and chateaux are looking for more detailed data model, which would be able to deal with more detailed objects.

Hence there has been set up research cooperation between Institute of National Heritage and University of West Bohemia in 2005. A data model for either two or three dimension data storage has been designed and developed. Although the model has coherent data structure, it consists of three main data substructures. First substructure is designated for real estate at the level of detail of storeys and rooms. The second part describes movables (furniture, paintings, books, pottery, etc.) of a castle, chateau or other type of cultural heritage object or area. The third part covers exteriors (all objects outside of building footprints of both natural and anthropomorphic origin, including complete topography of the area of interest). During the model design and development phase a strong accent to its compatibility to paGIS has been given. The developed data model has been filled with pilot data and tested in the area of Castle Kozel.

The custody of Cultural Heritage can be of course seen from much wider aspects, e.g. modeling of data models for architectural historical survey, archaeological discoveries or libraries. The article does not describe such data models, but the project team was aware of mentioned consequences and took them into account during the data model design process.

1. PROJECT GOALS

The goal of the project is to create a comprehensive geographic data model suitable for database management of Cultural Heritage, focused on the areal of a castle or chateau. This data model has to allow access to data in all three usual ways:

- 1D – tabular access,
- 2D – map,
- 3D – perspective or real three dimensional views.

The other important aspect of the model is its compatibility to national 1D/2D data model used by Institute of National Heritage – paGIS.

2. ANALYSIS OF THE CURRENT STATE OF CULTURAL HERITAGE CUSTODY IN THE CZECH REPUBLIC

Digitalization of information about cultural heritage is a task which has appeared in a consequence to development of information science and technologies. It was mostly possible to digitalize tabular records and 2D images in standalone databases in 20th century. The fast evolvement of information and communication technologies in the first decade of 21th century has allowed interconnecting standalone databases using internet protocols. The hardware evolvement in storage capacity has allowed storing large volume data and evolvement in video cards (thanks to computer games) has allowed realistic real-time 3D visualization.

From the global point of view, there can be seen digital libraries focused on cultural heritage (e.g. Europeana: www.europeana.eu or World Digital Library: www.wdl.org, or even Google Books: books.google.com). These libraries are based upon digital databases of information about culturally valuable paintings, texts or even videos and sounds. These databases mostly aggregate data from national and regional sources, such as museums or agencies whose take care of cultural heritage.

The Institute of National Heritage is the official institution maintaining cultural heritage data in the Czech Republic. The institute has created a strategic document (NPÚ (2007)) which describes fundamental tasks to fulfill the vision Europe's Information Society and Single European Information Space[1]. According to the document, the Information System of Cultural Heritage Custody (IISPP: https://iispp.npu.cz/) is being developed. IISPP already has 4 key parts:

- Meta information system (MIS).
- Geographic Information System of Institute of National Heritage (GIS NPÚ).
- Information system of archeological data (ISAD).
- Information system of immovable property (MonumNet).

And two next parts are prepared for integration as uniform data base for:

- Information about movables (based on system CASTIS).
- Central repository of Documentation Funds (Tritius).

Those parts has been evolved from standalone databases and they can be, or some of them already are, connected to each other using database concepts (unique identifiers) and internet protocols (tcp/ip, http and odbc).

[1] http://ec.europa.eu/information_society/eeurope/i2010/single_infor_space/index_en.htm

As can be seen from the description above, the Institute of National Heritage is well aware of a need of digital way of the custody about cultural heritage. Nevertheless the digitization task is very complex and time consuming, therefore there were set up levels of detail in the evidence and each particular level is filled after its precedent level. Accordingly paGIS (the data model of GIS NPÚ) currently deals with a level of detail appropriate to real estate cadastre and objects such as parcels and buildings. Consequently paGIS interconnects its data to other parts of IISPP in appropriate level of detail.

3. MOTIVATION OF THE PROJECT

The motivation of the project is to design and develop detailed data model for cultural heritage custody. Curators of castles and chateaux are looking a data model which would allow more detailed registers than paGIS. The reason appears clearly during a closer look to in example paGIS structure (because geographical nature of paGIS is being used as a simple interconnection of all parts of IISPP). PaGIS current geographical footprints have three levels (IISPP 2007):

i. PaGIS definition points – for each particular subject of interest.

ii. Ground plans at the real estate map level of detail – for immovables.

iii. Ground plans localized using large scale base maps – for archeological sites.

And the castle (or chateaux) typically consists of many buildings whose all belong to one parcel, because a whole castle has one owner. Therefore there is not an exception to have a whole castle with one paGIS identifier (i). Such a castle is typically also represented in paGIS by outer building footprints (ii) and even can have some registered archeological site (iii). But taking care of a castle means to have registers also about building structural elements, particular rooms and even about movable subjects in the castle, and more on also about the castle exteriors such gardens, parks, etc.

Hence there has been set up research cooperation between Institute of National Heritage and University of West Bohemia in 2005. The cooperation consists of development of a paGIS compatible detailed data model for purposes of cultural heritage custody and its verification in the case study at the castle Kozel.

4. DESIGN AND DEVELOPMENT OF A CASTLE DATA MODEL

The data model has been designed according to commonly used methodology of data modeling (see the theory e.g. in Arctur & Zeiler 2004, Longley et al. 2010 or an application in Jedlička 2010):

- Human oriented *conceptual model* based on analysis of user requirements.
- More abstract and formalized *logical model* which groups particular objects into classes and creates and describes relationships among them.
- Computer oriented *physical model* is represented as the structure of the database and keeps the data.

4.1 User requirements and conceptual data model

User requirements on the data model of a castle were defined in Bobek & Jedlička 2004. According to this document, the fundamental concept of a castle data model is built on following key principles:

1. *Interoperability to national systems* – the data in the model is related to existing databases using unique identifiers of these national level databases as foreign keys (e.g.: register of immovables is related to paGIS and the register of movables is related to CASTIS).
2. *Smooth transition* – the model allows consecutive import of data and hybrid maintaining of data in an old (analogous) and the designed model for transitional period.

3. *Openness and future expandability* – the model allows storing both 2D and 3D data gathered in various ways (e.g. geodetic survey, photogrammetry, laser scanning – see more e.g. in Fiala (2011)). While 2D registers prevails at present (for financial reasons), a massive uptake of 3D technologies can be expected even in cultural custody in the future.
4. *Completeness and sufficient detail* – the model allows registering both exteriors and interiors of a castle, whose are separated by outer walls of buildings. While the structure of exteriors is relatively simple (even if both natural and manmade objects have to be registered in exteriors and thus has to have appropriate classes in the model), castle interiors are more complex (even or because they keep just manmade features). Interiors have to be encapsulated into outer walls of buildings and basically divided into storeys and rooms (and other spaces in the building) and structural elements. But unlike ordinary buildings, interiors of castles are much more irregular.
5. *Awareness of a spatial threshold* – not all the registered data about movables has to have full-valued spatial representation. To keep the database manageable, there had to be set a spatial threshold among different types of movables:
    a. *Full-valued (3D) representation of the object shape (and a 2D footprint for purposes of 2D management – principle 6 bellow)* – for big or culturally valuable subjects, such as e.g. altar (fulfills both size and value criterion); case, book case, table or chair (fulfills size and may fulfill value) or even a small piece of pottery, if it has extremely big cultural value.
    b. *Point representation of object's position* – for small items with usual cultural value or even for bigger objects if there is no possibility or need to create a 3D representation (see principle 2).
    c. *Indirect spatial representation* – for small, culturally invaluable objects (e.g. again pottery) or even for culturally valuable objects of similar type stored in a closed space (e.g. books in bookcase or paintings in repository or safe deposit).

    As can be seen from the above pottery example, a movable item can potentially fit in any of the three mentioned categories. The key for decision lies in the cultural value of such item.
6. *Hybrid 2D / 3D access* – all present software clients use tabular or 2D access to database records and such an access is sufficient enough for purposes of registration. But the custody of cultural heritage is not only about its registration but also about its protection and presentation. And there can be useful to have a 3D visualization of a object, e.g.:
    a. For a time critical situation such a fire, flood or natural disaster endangering the object (protection issue).
    b. For remote on-line propagation or even in site virtual presentation of a castle or some of its parts (whose can be e.g. inaccessible to public for various reasons).

    Therefore the model allows the hybrid access and also storage of the data (it is possible to store just 2D footprint to fulfill principle 2, which is realized by observing the principle 5.a).

4.2 Structure of the logical model

The logical model structure is based on above mentioned key conceptual principles and is depicted in figure 1.

There can be seen in the figure 1, that there is class **area** which geographically bounds all other classes. Other classes are divided into following groups (note that just classes written in bold are real classes, others are abstract classes; features mentioned in parentheses are subtypes of classes):

- Exterior group:
    - Relief group: **surface**, **contour line**, **elevation spot** and **terrain skeleton lines** (thalweg, ridgeline, slope line, break line).
    - Hydrology group: **water area** and **line**.
    - Vegetation feature: **tree**, **wood**, **grass**, **garden**, etc.
    - **Communication** (line, area).

Names of classes in the exterior groups are common in geographic databases. They are self explanatory; hence they are not described in detail.

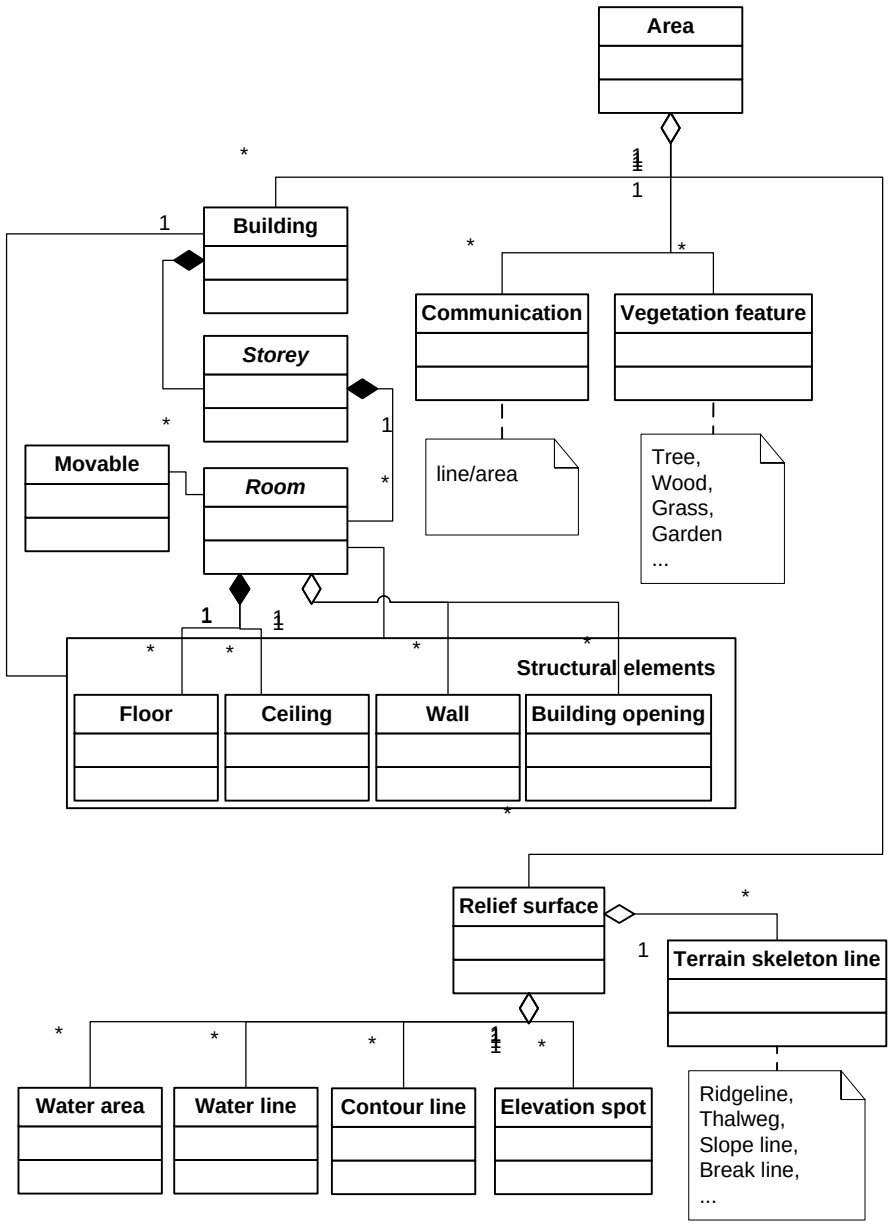

Figure 1: Logical structure of the model of a castle using Unified Modeling Language (UML).

- Interior group:
    - **Building** – composed of outer walls and footprint of a building. Separates interiors from exteriors.
    - Storey – abstract class composed of rooms.
    - Room – abstract class composed of its floor, walls, ceiling and belonging building openings.
    - **Floor** (of the room) – represents the simplest expression of a room. Each room is primarily represented by its floor because most of the movables belonging to the room can be spatially identified as lying on its floor or lying in between its floor and its ceiling or higher floor.
    - The class **wall** represents all inner walls of a room.
    - **Ceiling** holds the information of ceiling of a room.
    - **Building opening** stores all wall openings (such as doors, windows or even empty spaces - passages).
    - The class **movable** holds the information about geometric shape or position (see principle 5) of movable subjects and also their unique identifier which interconnect them to the CASTIS.

4.3 Physical model and realization of a pilot project at the Castle Kozel

As it was mentioned above, the main part of verification of the castle model has been done as a case study at the Castle Kozel, but some parts were also verified on the Castle Švihov (Kopejtková 2009) and Castle Nečtiny (Strejcová 2010).

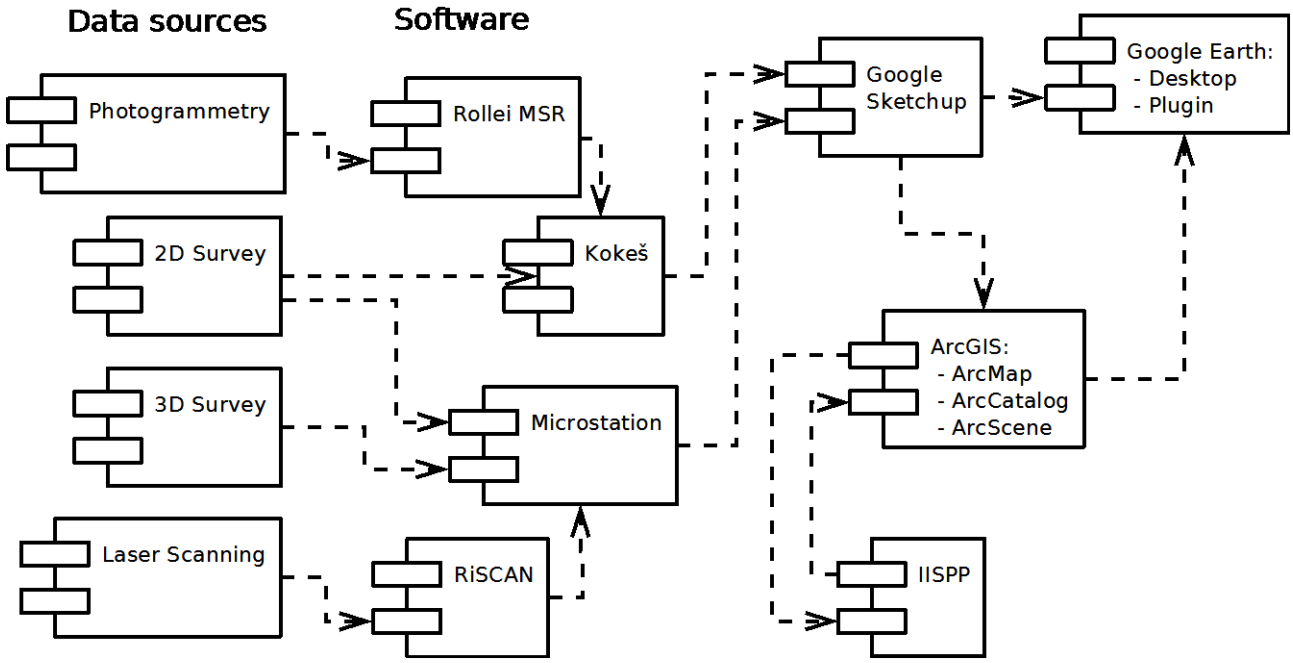

Figure 2: Dependencies among data sources and processing technologies.

The selection of technologies looked as an easy part from the first point of view. The logical model was turned into an empty physical structure stored in Esri Geodatabase file format to maintain compatibility to GIS NPÚ, which is based on Esri technologies. But during the population of the model with data from various sources (according to principle 3), the technological solution became more complex (see figure 2). According to the data primary source (photogrammetry, 2D or 3D

survey or laser scanning) different preprocessing software had to be used (Rollei MSR, Kokeš, Microstation or RiSCAN) for preparing:

- Interior data for the 3D construction in Google SketchUp, from which they are imported into ArcGIS.
- Exterior data for the direct import to ArcGIS (these links are not visualized in the figure 2, for readability reasons).

Also the connection of the model stored in ArcGIS to the IISPP and connection to Google Earth can be seen in the figure 2.

The whole data model for purposes of cultural heritage custody has been verified in three consequent diploma theses leaded by second author of the article:

- Rauch (2006) – classifying of existing data and gathering new,
- Luňák (2009) – data models of interiors,
- Šuba (2010) – data model of exteriors.

An example of the resultant 3D data model filled with data of the Castle Kozel can be seen in the figure 3. There are clearly visible the exterior classes, simple volume representation of particular buildings and detailed exterior geometry of the castle chapel. There are also depicted the interior classes of the chapel in the viewport in top right corner of the figure.

Figure 3: Example of perspective view at the 3D data model of the Castle Kozel.

The custody of Cultural Heritage can be of course seen from much wider aspects, e.g. modeling of data models for architectural historical survey, archaeological discoveries or libraries. The article does not describe such data models, but the project team was aware of mentioned consequences and took them into account during the data model design process. The further development of the model in cooperation with architects (Hladík (2011)) can serve as an example of such taking care of consequences.

5. SUMMARY

The paper describes a project focused on design and development of a comprehensive geographic data model suitable for database management of Cultural Heritage, focused on the areal of a castle or chateau.

The paper firstly describes the current situation at national level and the need of detailed data model for purposes of castles custodians. Then the article describes key conceptual principles, whose were used during the process of design and development of the detailed data model. Afterwards the paper describes the class level structure of logical model. Finally the paper focuses on technologies used for implementation the physical model and also to the population the resultant structure with data.

The project is still running and the data model is under development, but ongoing results from the Case Study at the castle Kozel have already being used for research purposes in the Institute of National Heritage and are a regular part of internal research reports of the institute.

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