ACCESS AND USAGE OF ARCHAEOLOGICAL-ARCHITECTURAL ON-SITE FINDINGS WITH CARTOGRAPHIC PRESENTATION METHODS

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ABSTRACT:

Present metrological procedures enable detailed recording and documentation of archaeological sites, architecture or cultural heritage (CH). These recorded and archived data, most of them with spatial relation, are aimed to represent the basis for rebuilding in case of destruction, digital data exchange for the support of scientific discussions or common understandable presentations for the shaping of cultural awareness in the public. These objectives and visions presume an effective data administration, systematic data access and most notably the integration of on-site documentation and findings.

One possibility for systematic data access and information presentation in case of CH, due to an existing spatial relation, could be cartographic processing methods, which would combine visual data and information extraction, generalisation and simplification of data according to used presentation-media and support with multimedia components in digital presentations for an effective and common understandable information transfer.

The focus of this work is on a comparison and evaluation of digital processing/presenting methods of spatial related models used in interactive cartographic applications in context with the influence on sustainable documentation and appreciation of on-site findings.

1. INTRODUCTION

On-site findings are fundamental for archaeological work and interpretation. They present indications of the historic state and provide the main link of past and present. A complete review of the site-situation is the basis for further reconstructions of buildings, environments, situations or processes. Therefore its comprehensive documentation is a main step for intensive work off the site afterwards and for future interpretation completions.

Actually the recording and documentation of the findings is only one aspect of an overall process of scientific communication, discussion and interpretation. Other parts include the difficulty of archival storage, especially of digitally processed media, and an objective communication of on-site findings.

The archival storage of digital recordings does not seem to have a powerful solution at the moment. The best working solution on account of rapid changes of media and their devices seems to be a transfer to the latest storage standards, which means that all meaningful recordings have to be copied whenever a new standard establishes. It becomes obvious that this procedure gets out of hand with the increasing number of data coming from precise recording methods, like automated photogrammetry or laser-scanning. In particular this is the case for long-term documentation, where data are collected and preserved for decades, or even centuries. In addition to the resulting enormous copying volume, it becomes more difficult to find specific data without system assistance, which calls for systematic and multilingual data accessing methods. Whereas these methods make digital data available in future, there still exists the question, whether these data are accessible. Lots of text documents, not twenty years old yet, are not readable anymore, because the needed software cannot be run on modern computer systems.

An objective communication of on-site findings ensures the extraction of the basic knowledge that may be generated on basis of the finding. Reconstructions and completed visualisations imply interpretations of the person working with the specific object or area. For instance the remaining of a fundament shows an assembly of stones in particular dimension, height and distribution. An expert with historic-architectural knowledge base would try to reconstruct walls, floor pavements or stairs adapted from existing dimensions and heights. A reconstruction and painting from this person possibly would show an exact fundament, delimited from the remaining environment. On the other hand a layman would only identify an irregular assembly of stones, that is not delimited from the rest of environment and has no junction with the meaning as a building. A painting of this person possibly would only show an accumulation of stones. In both cases the on-site finding stays the same. Only the preliminary knowledge and interest filter, extend and let the expert interprete the specific object in context with spatial and temporal relations. In following steps of model- and presentation-refinement, the choice and adoption of textures, colors, lighting or accentuating important values of the model may be influenced by the individual view and knowledge of the designer and consequentially influence the knowledge transmission to- and extraction of third parties.

A potential presentation technique of on-site findings in combination with spatial and temporal relations will have the need to accentuate specific facts in order to overcome information overload – thus to concentrate on selected information – and to make these important parts perceivable on the chosen computer-human interface. Both needs presuppose some processing and modeling of the originating data without changing, but possibly accentuating the semantic importance of the object. In many cases cartographic processing steps may be appropriate due to the spatial relation of data and the use of specific scale range with associated detailing.

The hypothesis that digital postprocessing- and presentation techniques in 3d cartographic applications, in particular a various usage of light and texture within the rendering process, may take influence on objective evaluation of- and access to findings in their environment should be supported and determined by a comparison of rendering and texturing possibilities of spatial related models. The considerations are also done in context with influence on sustainable documentation and evaluation of on-site findings, which affects applications in their implementation of data formats coming from a primary model and the produced execution format in the presentation model.

2. MAIN PRINCIPLES OF CARTOGRAPHIC PRESENTATION METHODS

The main task of cartographic communication, to support the transfer of spatial related information and knowledge from one person/group to another, includes considerations of human and technical perceptional bandwidth, applicable information depth, highlighting of specific data and transformation of presented data to individual knowledge. Due to this challenge cartographic presentation methods concern expressiveness and effectiveness based on perception and cognitive processes, as well as knowledge acquisition supported by information accentuation which helps data structuring in mental maps.

Expressiveness refers to visualisation capacity of the interface, which concerns the semiotic question of representing all important and necessary details of recorded objects in order to preserve semantic. Is it possible to present all the detailed information with the "low" resolution and "few" communication parameters the interface offers? For instance, if the resolution of the interface (e.g. screen) is lower than the number of desired detail values, the expressiveness criterion will not be met. Some detail values will then not be perceivable. Only if the number of resolution-pixels of the interface matches or is higher than the detail values, the desired univocal relationship becomes established [MAC86] and all details of the object will be presentable on the interface. Mapping more detail values onto one single resolution-pixel makes determination impossible.

Effectiveness regards aesthetic concerns as well as perceptional information acquisition, immersive interface use, optimisation processes for data simplification and visual rendering improvements. The quality of presentation and thus success of communication process is mainly depending on the understanding and acceptance of the user. The simulation or rebuilding of an interactive environment, which is similar to the surrounding of everyday´s life by means of perception, multi-modality and interaction, seems to make the presentation more effective.

In order to meet expressiveness and effectiveness criteria, the cartographic communication process accounts for the transformation of originating data, which are stored in form of a "primary" data model for the management and analysis, to a secondary data model, the presentation model, which focuses on the technical and perceptional capability of the interface and thus the depth of information [KEL02]. Usable semiotic, bandwidth of modality and accentuating mechanisms for information are main important parameters for a successful information transfer. Various processing steps and a distinct intensive application of these are needed for the wide range of usable interfaces for the spatial related communication. Mostly the intensity of this generalisation depends on the resolution and size of the interface. A display for digital-use (screen) may offer a size of about 30 x 40 cm and a resolution of 72 or 96 dots per inch (depending on PC or Mac). All information coded to graphics on this screen underlie these parameters. Thus a minimum size for points, lines and areas may be fixed to ensure perceptional availability of information, which means that the information can be read and recognised.

The consequences of these communication criteria on visual access and communication of recorded on-site findings with human-computer interfaces lie in resampling of detail and often loss of precision. It is not only the recorded finding, but the overall environment and representation of spatial relations that underlies these scale- and interface-dependent criteria. The provision for this demand of detail-resampling results in a decision-making of creating communicative and perceptive content or keeping high detail that may not be transmittable.

3. VISUALISATION METHODS AND RENDERING PROCESSES

An interactive cartographic application deals with the presentation and communication of spatial related information. Archaeological findings, moveable as well as location fixed objects, always have some spatial relation. Depending on the definition this relation names the place of finding, -of use, -of trading or similar. The spatial relation of objects in context with topography, topology and semantic is an essential part of cartographic applications. On the other hand, when an object is separated from its spatial relation, specific cartographic aspects and problems (like scale dependent information depth or geometric/positional accuracy) may not appear. Remaining tasks for computer-based realtime visualisation are confronted with bottle-necks of rendering pipelines, computation bandwidth or memory allocation (not restricted to these examples), which form one research focus of computer-graphics. The following reflections should concentrate on the presentation of archaeological-architectural on-site findings, thus holding a specific spatial relation, in context with computer-graphic techniques.

The creation of the presentation model, according to the communication process, additionally conforms with possible visualisation methods, rendering processes, hardware configurations and at least the content and its complexity. All these factors may take influence on the evaluation of presented information and the impression the content invokes at the user-side. Thus the various implementation of all these factors may be target-oriented, in order to support and highlight a specific interpretation or dataset, or targeted for not exerting an additional influence on information.

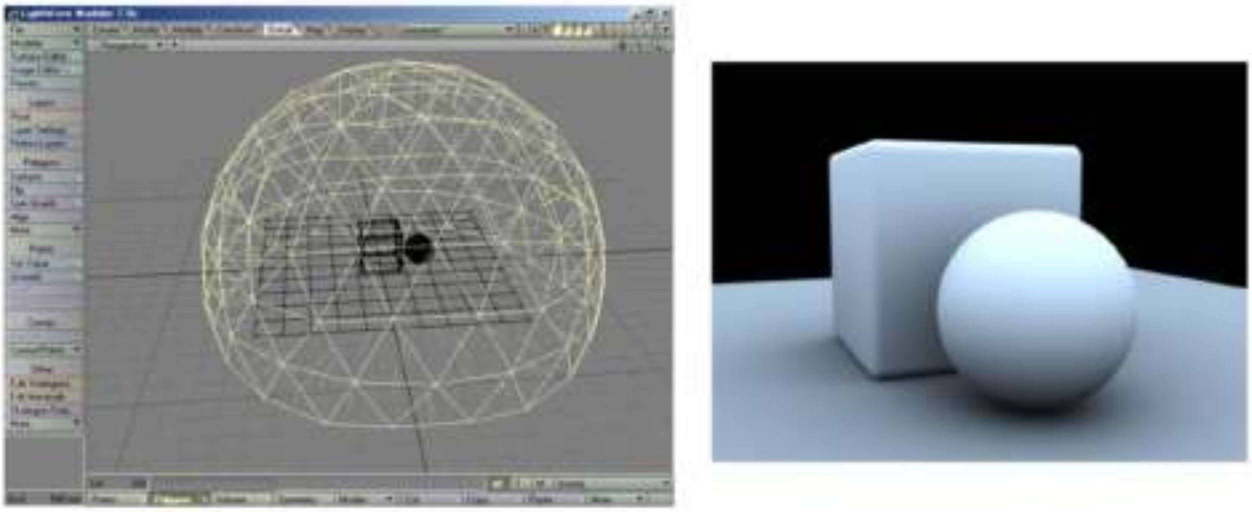

Figure 1: Principle of lightdome rendering, source: www.lightwave3d.com.

3.1 Model complexity

The complexity of a model generally evokes different questions and problems within a real-time cartographic application, which affect processor load and memory processing on one hand and information depth on the other. For instance a modelling of vegetation with vector-based models will consist of an enormous amount of triangles (that should be rendered in real-time), which´s handling may cause bottle-necks in the rendering pipeline (from calling the models on a harddisk to the output on a device) and result in low frame rates and rendering errors. Using different techniques for creating different level of detail (LoD) [MöHaPe04] and combining vector-based models with textures, both regulated by a distance to the camera (a certain scale) and the resolution of the interface, may help to solve these problems. The importance for information transfer lies in an imperceptible transition of the different states with the help of blending or geomorphing algorithms [Wim01]. An imperceptible transition would include that the expressiveness criterion has been incorporated in the contrary way: occurring changes of information depth are not perceivable.

3.2 Lighting issues

The insertion of light sources within the rendering process has a central meaning and impact on the understanding, presentation and perception of a virtual 3D environment. Without any lighting in the 3D application, absolutely nothing is visible. Components or models have to be illuminated to be seen. In addition to that, improperly lit models appear flat and unnatural. Lighting gives its contribution to the overall design solution of a project and reaches from "providing a basic illumination" to "establishing mood" and "support of perception". Thus there are two basic goals in lighting: First one allows users to see the environment and the models. The second one is modeling a scene, which means that the focus is on revealing as well as concealing geometry. The purpose of illumination is to reveal the overall environment containing as many models as possible. The second goal "modeling" use lights as modeling aids for describing the sculptural and dimensional qualities of models and their geospatial relationship within a scene. "Modeling" in terms of light-modeling describes the accentuation with light and not some modification of geometry.
In general several types of light with unique characteristics are available. The main representatives are called "ambient", "directional", "point" and "spot", where the primary purpose of "ambient" is illumination, of "directional" and "point" is illumination and modelling and of "spot" is modelling and focusing.
The *ambient* light represents the reflected light within a scene. It is omnipresent and permeates the whole scene including all models. This light source has the fewest parameters to approximate an overall brightness and contrast of a scene, which is the lighting colour, and do not hold any position or orientation.
A *directional* light source affects the scene in an uniform manner because the rays of light are exactly parallel without having a position/distance in space. There is no difference if a model is closer to the light or farther away. Therefore this light source is often compared to sunlight, which is used for illumination and modeling the three key areas highlight, midtone and shaded regions on models. Available properties of this light source to influence a scene are colour, and light direction.
Point lights imitate bare light bulbs, where light rays emanate from the bulb in all directions. The three defining properties are colour, specular and position. This light affects all surfaces that are directed to the emitted light, so these models are the main candidates for providing general illumination.
Spot lights are light sources that offer the most control. Their properties cover position, direction, colour, specular, spotangle and spotdecay. The rays of light form a cone, which changes its size and extension due to values of the properties.
The preceding list of light sources provides adequate possibilities for lighting a virtual environment. But some situations, especially complex arrangements of different models and landscapes, call for a special light situation: visibility and perceivable structure within shadows. The technique of "skydome rendering" delivers some kind of artistic rendering. It has expressive power due to the high degree of detail and the quality of the shadows [RD03], which help to understand 3D structure [Dret04]. The skydome rendering is one sort of global illumination algorithm, that takes also the light, which has undergone reflection from other surfaces in the environment, into account and not only the light which has taken a path directly from the light source [see figure 1].

3.3 Texturing methods

One important part of visualisation methods is the shading and texturing of models within the environment. Each model consists of a shader, whose properties control these models´ colour and brightness of realistic highlights (ambient), mid-tones (diffuse) and shadow areas (specular), shininess, emission, blending, transparency, renderstyle and texturing. Thus the texture is an instance of shader, which again is an instance of a model or surface. The set of shader properties provides a tool to simulate specific surface types, like matte surfaces, shiny non-metals, shiny metals or semi-transparent objects.
A texture is made of a 2D graphic that is mapped onto the object´s surface. This graphic can also be an animated picture or film. The position and dimension of a texture may be influenced by various parameters and projections on the surface. It may be tiled or stretched. The projection style of a texture on the object causes different wrappings, for instance in planar, cylindrical or spherical style.
Pictures and graphics in use for a textural mapping help to bring more detail in simple models. For example in case of buildings doors and windows may be added, simulated and visualized with textures instead of modelling geometry, which would increase file size in storage aspects and processing power in rendering aspects unequal more than graphics do. Thus textures may be used to pretend high detailed geometry of the model. A blending of different detailed pictures may then adapt the presentation of the model/object to different scales or camera distances.
Supplementary methods in model rendering involve toon-, newsprint- or blueprint shaders, which are non-realistic rendering methods. For instance a toon shader embosses edges of a model with a certain intensity. According to this the importance of edges will be accentuated. In archaeologic-cartographic use this technique may help to explain and clear the difference of recorded data and digitally reconstructed parts of a building or to visualise the difference of following construction phases due to rebuilding of ancient objects. The unrealistic rendering may be a tool to visually indicate uncertainty in the data, to focus attention in items of special interest or to indicate changes of "map-elements" over time. In case of terrain-changes over time, coloured line drawings were successfully employed [Pot03, STCG04]. Examples and ongoing research show that blueprint rendering may be used as an effective tool for interactively visualize, explore and communicate the design and spatial structure of ancient architecture by outlining and enhancing their visible and occluded features [NiDö04].

A distinction from reconstruction and recorded data or the indication and direct presentation of uncertainty in the data inside an interactive archaeologic-cartographic application may be a first step to a sustainable presentation model. Visualised and multimedial presented objects may use reconstructed information (by different expert groups) for demonstrating historic landscapes, but if there is the need to access and explore the state of on-site findings, the system will support this need.

4. THE ASPECT OF SUSTAINABILITY IN CONTEXT WITH CARTOGRAPHIC PRESENTATION METHODS

Asking for a sustainable communication methodology calls for a definition of "sustainable". According to the definition of the Brundland Commission (World Commission on Environment and Development, *Our Common Future*, Oxford University Press, 1987) it is defined as: "to meet the needs of the present without compromising the ability of future generations to meet their own needs". The author´s understanding of this definition, in context with cultural heritage and the work of cartography, means that the original natural and cultural objects on one hand and models, recorded data, cartographic communication models and applications as well as spatial connected knowledge – including maps for reconstruction and cartographic interpretations of real objects – on the other hand should be "archivable" and usable for future generations.

From this point of view photogrammetric and geodetic models as content of the primary communication model require open data standards. It can be expected that proprietary formats will not be readable in near future [http://www.rlg.org]. For the cartography point of view, the knowledge presented with the help of maps and cartographic applications after creating the secondary/presentation model should be available in the future. In addition to seminal programming standards of applications, maps need to be readable and understandable, independent from its semiotics and preliminary knowledge.

The dilemma of sustainability in cartographic communication mainly roots to the different support of multimedia. Traditional maps on paper-based media do not support multimedia components like interactivity or multi-modality. The transmission of spatial-based knowledge is restricted to few modalities and assumes preliminary knowledge in map reading. A user requires a specific knowledge basis to make use of this media for knowledge acquisition. Computer-based interfaces may offer the whole range of multimedia support and immersive environments. Depending on the grade of immersion a familiar environment can be established for the communication process. In general a user employs basic behaviour of movement and knowledge acquisition.

Figure 2: Texturing methods: light-map, toon shading, simple texturing and multitexturing (from left to right), source: Olaf Lubansky.

Various historic examples show that paper-based or similar (papyrus, stone) media can be transferred through time sufficiently. Of course time leaves some remaining of use or influence of light, but generally the content is perceivable and often also readable, if the used semiotic is known. In contrast computer-based media present their content only, if the media is not damaged and can be connected to a working computer (or read with an appropriate device), the formatting of the media is readable, the format of content/data is supported and requirements for file execution are fulfilled. The access to a CD, DVD or harddrive in 100 years from now is highly disputable on account of this amount of influencing parameters.
A possible solution for a sustainable access to spatial-related datasets can be seen with the technique of migration: Worth while datasets need to be copied to the latest media in redundant form (to overcome media damages). In addition the information entities of datasets should be diverse, which means that digital entities should cover any available computer platform and non-digital information entities should be created [BOR03]. First concepts and considerations in this direction are made and subsumed in the notion "cross-media". It describes the technique of using the same content on different media. Beside a various intense implementation of generalisation methods due to the different characteristics of media, problems in transforming multimedia contents to different media are obvious.

5. CONCLUSION

The development of rendering methods and presentation techniques seem to enable an objective information transmission of archaeological-architectural on-site findings with cartographic presentation methods. The possibility to accentuate uncertainty of data on one hand and to distinct various virtual reconstructions from recorded data on the other encourages this objective communication process. In addition the expressive power of skydome lighting due to the high degree of detail and the quality of shadows removes fragmentary and bad evaluations of presented models due to lighting influences.

In case of a sustainable access, management and usage of archaeological data in context with its spatial relation, a distinction within the communication process between the primary model and the secondary model has to be done.
The primary model of communication process contains recorded data coming from on-site measurements in different qualities. It is the task within this model to combine different qualities, describe the data and enable an effective management and analysis. Sustainability aspects affect data and metadata formats, which should be open data standards.
The secondary or presentation model account for the human and technical perceptional bandwidth, applicable information depth, highlighting of specific data and transformation of presented data to individual knowledge. Subsumed by the criteria of effectiveness and expressiveness, a developer of a cartographic application aims at a successfull communication process. Sustainability aspects affect data formats as well as requirements of hard- and software and playing devices.

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