Visualization of Archaeological Sites

Pavel Zemčík, zemcik@dcse.fee.vutbr.cz, http://www.fee.vutbr.cz/~zemcik
Petr Havel, havelp@dcse.fee.vutbr.cz, http://www.fee.vutbr.cz/~havelp

Abstract: This contribution describes the progress that has been achieved in the early stage of the project for rendering and animation of the archaeological site of circular structure in Tesetice, Czech Republic. The model of the site is based on CSG and it was currently rendered using ray tracing. This paper describes how the site was modeled and rendered.

1. Introduction

Computer graphics is not only an interesting and modern field of computer science but it also provides very good tools that help other research activities. One of the non-traditional research topics where computer graphics can be used is visualization of archaeological sites.

The reason why archaeologists benefit from visualization of the sites they are working at is that they need an information about how the sites might have looked in the history. The image of the sites back in the history is never precise and certainly can not be obtained using photographic techniques. Computer graphics allows for relatively easy creation and manipulation of the models of the sites and generating the requested images.

Of course the level of realism that is necessary to serve the purpose of archaeological research differs very much depending on the particular research topic. This article describes an early example of visualization of an archeological site using ray tracing with a perspective of continuing with particle tracing.

2. The Model

The site that has been modeled is the Neolithic circular structure in Tesetice, near Mikulov, Czech Republic. The site was suitable for modeling for its relative simplicity and because the digitized model of the site was already available. Also of importance was the fact, that the purpose of the structure is still unknown and it might be useful for the archaeologists to study the shadows produced by the structure at certain historical dates.

The model of the site has been created in PRAY language [Zemc95'], a proprietary language developed at the Technical University of Brno. The reason why more standard languages were not used was that the required level of realism is not known and it is expected that the level of realism will be the critical point for usability of such models and therefore subject to further research. Concerned is not the level of realismm from the view point of geometry of the scene but from the view point of lighting models, illumination, atmospheric effects, etc..

2.1 Obtaining the Data

The data for the model has been obtained from the digitized data base of Department of archaeology, Masaryk University, Brno. The data was in a form of AutoCAD drawing. In the initial stage only the co-ordinates of the wooden columns and general shape of the terrain were taken into account as the level of realism is sufficient to check the feasibility of the model.

2.2 Model primitives

The data obtained from the AutoCAD format had to be further processed as it was merely just the co-ordinates of centers of the wooden columns and a shape of the pit around the circular structure. As the precise shapes and sizes of the columns are not known, it was estimated that the columns were cylinders around 2 meters high with a diameter of 30 centimeters. The pit was simulated with a generalized cylinder interpolated using a chain of spheres.

The actual source code of the scene was generated using a proprietary file convertor that converted the co-ordinates into a description of the pit and wooden cylinders. The way cylinders and pit are modeled can be seen in the figure 1.

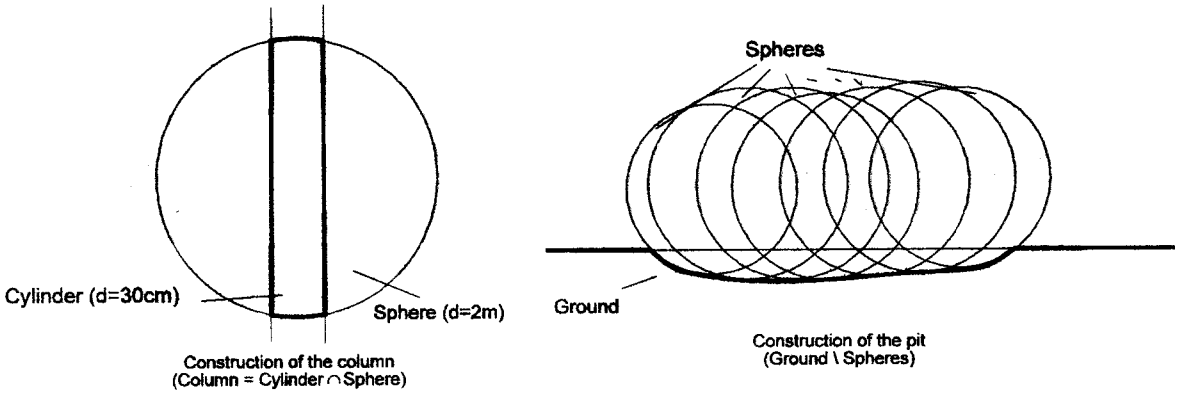


Figure 1: The model of the column and the pit (2D sketches)

Description of the cylinder and pit building blocks could if the PRAY language can be seen in the figure 2.

```
Column = \ // Definition of the wodden column
     sphere(Wood,[0,0,1],1)& \
     cylinder(Wood,[0,0,1],<0,0,1>,0.15)

PitElement = \ // Definition of the pit element
     sphere(Pit,[0,0,Elevation],Radius)

Columns = \ // Tansformation and combination
     Column.[X1,Y1] | \
     Column.[X2,Y2] | \
     .
     .
     .
     Column.[Xn,Yn]
```

Figure 2: Description of the column and the pit in PRAY language

The objects described above can be easily replicated and transformed (moved) into their appropriate positions as seen in the end of the source code fragment in the figure 2.

The scene description of the simplified model (shown in the figure 3) of circular structure in Tesetice consists of approximately 1000 primitive objects and 500 CSG nodes (CSG nodes being extended to n-ary). The full model consists of approximately 3000 primitive objects and 2000 CSG nodes.

2.3 Postprocessing and Editing

The semi-automatically created model of the scene can be further edited using the interactive CSG editor [Novo95] to add features or objects that are required by the archaeologists, like buildings at their estimated position, or to make changes to the shape of the terrain, etc.

Recently available is also an algorithm for conversion of the CSG models into boundary representation [Petk96] which allows for converting the model into the VRML language so that it could be browsed using commercial VRML browsers (if the level of realism provided by those browsers is high enough).

3. Rendering and Animation

The scene has been rendered to get the schematic view of the site. The main purpose of this kind of rendering was to check whether the site was modeled properly, to be able to add some objects that were sure to be missing in the information from excavations, and to get the approximate shape of shadows produced by the columns at certain historic dates.

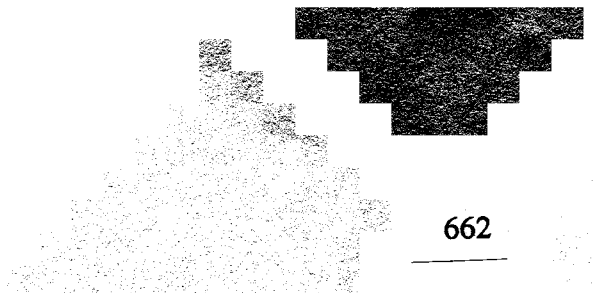
The scene has also been animated for presentation purposes.

3.1 Rendering Method

The scene has been currently rendered only using highly accelerated ray tracing of the CSG model [Zemc95]. The Phong's lighting model was used for all the objects in the scene.

Certainly, for more realistic rendering of the images (than the one presented in the image 3), texturing and background bitmaps are needed (and can easily be added in PRAY). In the presented image, the focus is given to precise representation of the excavation data.

In the figure 3, the rendered image of the site can be seen with highlights on those parts of the circular structure that was not possible to reconstruct precisely during the archaeological excavations.



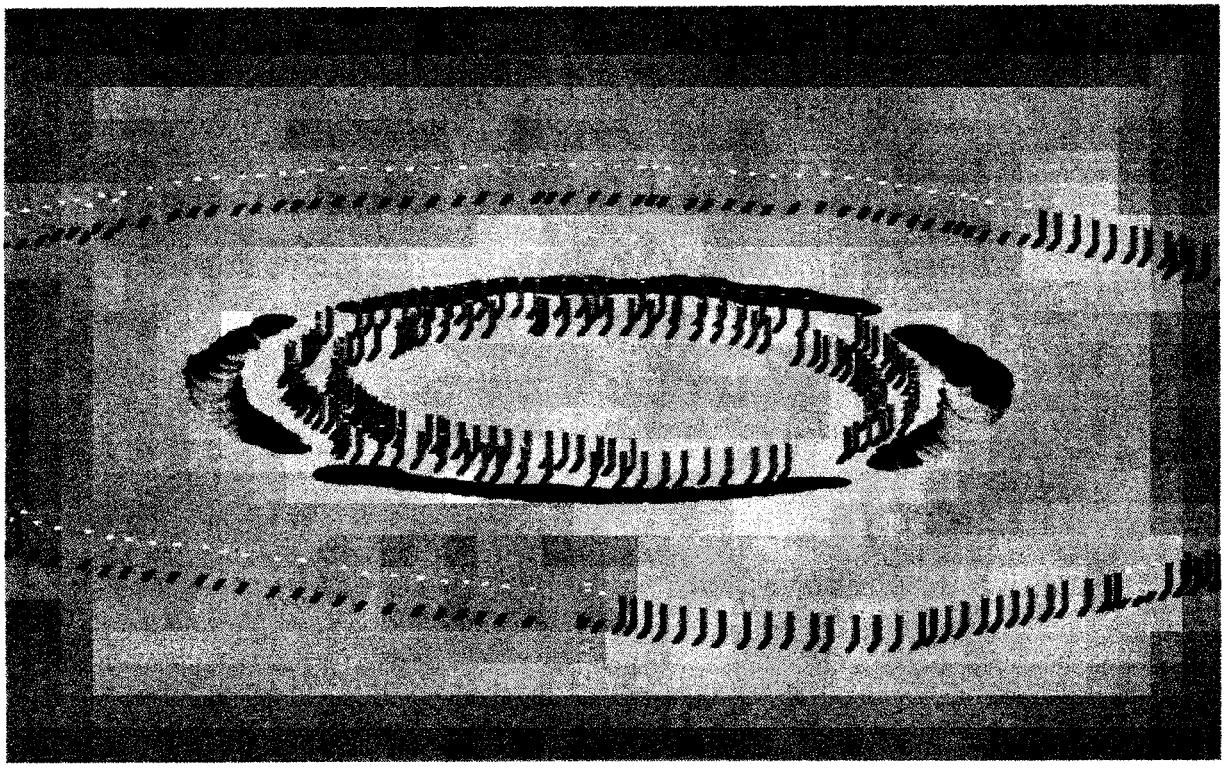


Figure 3: The scene rendered using PRAY
(columns with only estimated positions are highlighted; come columns are omitted for readability)

3.2 Animation

The scene was animated using PRAY program. The PRAY language, which was used for scene description, does not include direct animation support. The language, however, allows for easy generation of animation sequences by programming the view point and the "look at" point sequence in time. The other parameters of the view are calculated based on the two above parameters, the presumption that the vertical direction in the model will be vertical also in the images, and the viewing angle of the camera. See figure 4.

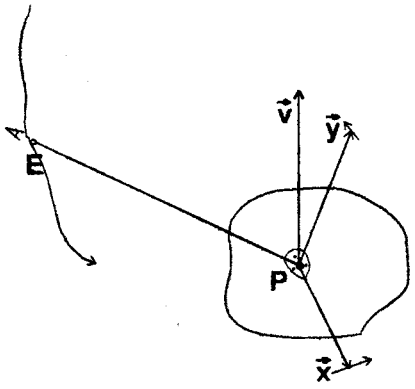


Figure 4: Animation view parameters

The eye point **E** in the figure 4 is moving, while the view point **P** is stable. The **x** and **y** vectors representing the image plane directions are calculated so that their sizes are proportional to the

current viewing angle and that EP ⊥ x, EP ⊥ y, and x ⊥ y. Also the vector v that is vertical in the model space should be projected as vector y in the image space.

The results of the animation experiment can be seen at the WWW site of the Technical University Brno http://www.fee.vutbr.cz/~havelp/research (available in .AVI or :MPG format).

4. Conclusion

The final goal of the presented work is to exploit the research previously done in computer graphics in a non-traditional application -- in archaeology. This attempt to apply the results of graphics research, as the authors believe, will not only help the archaeologists but will also bring an interesting feedback to the graphics research.

The model that has been shown can serve the indended purpose and does provide information to the archaeologists. The techniques used for modeling and rendering presented in this contribution could be considered inadequate for just what has been presented. However, taken into account that the future work includes improvement of rendering, including particle tracing of CSG, the detailed control over the model data and rendering techniques was necessary. Of course, an option always exist to use generally available commercial modeling and rendering tools and convert the existing data if it proves to be more efficient.

Future work involves not only improvement in the rendering techniques, but also further development of specialized modeling tools [Pecl96].

The project for visualization of archaeological sites is a joint project of University of Bristol, UK, University of Cambridge, UK, Masaryk University, Brno, CZ, and Technical University, Brno, CZ. The British Council, Prague, CZ is supporting the project under the Academic Link scheme.

5. Literature

[Novo95] Novotný, Z: CSG Scene Editor, diploma thesis, Technical University Brno, 1995 (in Czech)

[Zemc95] Zemcik P, Chalmers A: Optimized CSG Tree Evaluation for Space Subdivision, Computer Graphics Forum, vol. 14, no. 2, June 1995, pp. 139-146, EUROGRAPHICS UK

[Zemc95'] Zemčík, P: Realistic Rendering, Ph.D. thesis, Technical University Brno, 1995 (in Czech)

[Petk96] Petkov, J.: Conversion of the CSG Model into the Boundary Representation, diploma thesis, Technical University Brno, 1996 (in Czech)

[Pecl96] Pecl, R: Building Editor for Archaeology, diploma thesis, Technical University Brno, 1996 (in Czech)