Digital terrain modelling in archaeology: three-dimensional GIS, examples from Birka and Vendel
Persson, Kjell
Fornvännen 2002(97):3, s. [191]-196
Ingår i: samla.raa.se
Digital Terrain Modelling in Archaeology

Three-dimensional GIS, examples from Birka and Vendel

By Kjell Persson


Digital terrain modelling (DTM, 3D GIS) is briefly described and two case studies, from Birka and Vendel, presented. DTM methodology allows the combination of different spatial data categories in a three-dimensional terrain model. The case studies show how landscapes of the past that have been dramatically altered—at Birka by shore displacement, at Vendel by recent landscaping—can be reconstructed and visualised with the aid of a computer.

Kjell Persson, Archaeological Research Laboratory, Stockholm University, SE-106 91 Stockholm, Sweden.
Kjell.Persson@arklab.su.se

Urban and regional planners sometimes use digital three-dimensional terrain models to combine topographic and other information in a Geographical Information System (GIS). Complementary information about e.g. geology, precipitation, cultivation and road networks can be added to these models. Areas for possible development can then be analysed and evaluated from their accessibility, suitability or exposure. The method is suitable for visually simulating e.g. the effects of damming for hydro-electric power or traffic noise protection.

DTM methodology (Digital Terrain Modelling) provides a better basis for decisions in social planning as it allows the combination of different spatial data categories in a three-dimensional terrain model. It is an important tool in environmental consequences studies. The method makes it possible to test comprehensively and visually analyse different combinations of data. The result is available in the computer immediately after analysis and can at low cost be presented in printed reports or directly from the computer in slide shows (Aronoff 1991, Bonham 1994, Malmström 1995).

In archaeology, two-dimensional GIS methodology has been used, but archaeologists also need methods to combine different spatial data applied to three-dimensional terrain models. DTM is especially applicable in investigations of slope activities, such as building terraces, shore-connected activities, or in regional analyses of landscape changes caused by shore displacement.

Furthermore the method is well suited to reconstructing the three-dimensional terrain of an archaeological site even if it has been excavated and then covered by buildings or changed in some other way. If early maps with topographic information are available it is possible to digitally collect a large number of coordinates and build a database with the original XYZ data. In excavation reports one sometimes finds contour maps drawn on the basis of a sur-
survey with a levelling instrument. These maps often use local coordinate systems, but if a few still existing points can be identified on the map, one can convert the data to a generally used coordinate system. Then the model can be combined with new spatial information gathered from surveying, prospecting or excavation.

At the Archaeological Research Laboratory of Stockholm University we have for many years tested different CAD (Computer Aided Design) and GIS programs and tried to adapt them to our archaeological needs. Above all we have tried to develop methods meant not only to visually present the results from our excavations but also to be used interactively as interpretational tools during excavations. For ten years, our laboratory has successfully worked with two-dimensional GIS, and lately also with three-dimensional modelling techniques.

From databases with XYZ coordinates, vector based systems can construct triangulated three-dimensional models of the terrain. Coordinates are collected with total stations or GPS (Global Positioning System) or digitised from contour maps. Often several data sources are combined. By statistic interpolation the digitised coordinates can be used to calculate new coordinates and hence increase the accuracy of the triangulated surface.

Shoreline studies at Björkö
We have used this technique to study shore displacement at the island of Björkö in Lake Mälaren, Middle Sweden, in an attempt to find suitable locations for harbours or landing spots for boats connected to the garrison of Birka (Stålberg 2000). From a topographic map with five-meter equidistance we digitised a number of coordinates along each elevation contour. The mapping program SURFER was used to interpolate a great number of new points through the Kriging method (Cressie 1990), and from the digitised and interpolated coordinates a three-dimensional model of Birka was constructed (fig. 1). The shoreline of the Viking Period is calculated to have been situated about 4–5 meters above the present one, and the new map shows the island to have been divided in two at the time. By rotating the model and possibly increasing the height scale we can study these islands from different views to search for suitable locations at which to land boats. It is also possible to measure volumes.

To further study the effects we imported the database into the CAD program MicroStation for handling in 3D. Here we can apply a colored and textured “skin” to the triangulated surface, simulating, for instance, grass. The lighting can be varied to increase the visibility of selected structures. A simulated, movable water-table can be added to study the effects of different sea levels (figs. 2–3). We can also measure length and areas. Finally, we have access to all the CAD program’s drawing facilities in three
dimensions, and information about known structures such as the town rampart, underwater palisades, cemeteries and excavation trenches can be added to the surface.

**Reconstruction of a house terrace in Vendel**

We have also used the DTM technique within the SIV (Svealand in the Vendel and Viking Periods) project, which is a co-operation between the Archaeological Research Laboratory and the Department of Archaeology and Ancient History at Uppsala University. Comprehensive geophysical and geochemical prospecting in Vendel, central Sweden, indicated a possible settlement on the slope just south of the church and near the famous boat graves (Persson 1998).

Surveying with GPR (Ground Penetrating Radar) along a line down the southern slope of the ridge revealed a horizontal underground reflection, which was interpreted as a former terrace surface, covered by later sedimentation. Excavations confirmed this interpretation, and on the terrace we found a settlement with house remains contemporary with the boat graves (Isaksson 1997).

In the 1960s the southern slope landscaped to a smooth lawn and the terrace is not visible today. In 1930, however, professor Nils Åberg mapped the area when searching for further boat graves, and the terrace is visible on his contour map (fig 4).

By replacing the topographic information from the present map with Åberg’s results...
Fig. 4. Topographic map showing the area south of Vendel church measured by Nils Åberg 1930. — Topografisk karta över området söder om Vendels kyrka upprättad av Nils Åberg 1930.

Fig. 5. Reconstruction of the topography at Vendel church according to Åberg’s survey of 1930, with the subsequently destroyed prehistoric terrace at the arrow. — Rekonstruktion av topografin vid Vendels kyrka utifrån Åbergs kartering från 1930, med den sedermera förstörda förhistoriska terrassen vid pilen.
Fig. 6. The Late Iron Age house at Vendel church with excavated postholes and wall-line emphasised. Reconstruction in thin lines. — Yngre-järnåldershuset vid Vendels kyrka. Stolphål och vägglinje markerad. Rekonstruktion i tunna linjer.

Fig. 7. The Late Iron Age house at Vendel church, reconstruction of posts and supporting stone line. — Yngre-järnåldershuset vid Vendels kyrka. Rekonstruktion av stolpar och sylfstenrad.
south of the church we have constructed a topographic map of the ridge at Vendel church as it looked in 1930. From that map we have digitised a number of points along the different elevation contours and built a database of XYZ coordinates. After interpolation in SURFER we constructed a three-dimensional model of the terrain as it looked before the lawn was laid out (fig. 5).

The database with both the digitised and the statistically interpolated coordinates was then imported into MicroStation and a terrain surface was triangulated. This surface can now be edited in the CAD program. It is possible to "excavate digitally" by drawing the trenches and the profiles. We have added information from the excavation plans with postholes and a stone wall at the terrace foot. A gravel pit from the time of the building of the church in the 13th century had destroyed the deposits at the upper part of the house. Only the postholes of the two southern gable posts and seven roof supporting posts were preserved (fig. 6). It was thus not possible to determine the length of the house, but from Åberg's information we can see that altogether five pairs of roof supporting posts and the four gable-posts would have fitted in on the terrace, and that the length of the house would have been about thirty meters at the most.

In the CAD program one can dig postholes and erect posts which makes it possible to visually test the result and reconstruct the house. One can also add all available information, background, texture and shading, to get a realistic model of the excavation results. In our model you can see the posts of the reconstructed house, some posts from another building and the supporting stone wall at the terrace foot (fig. 7). Vendel church now occupies the top of the ridge but there are indications of another house terrace there.

DTM methodology provides a realistic three-dimensional picture of our interpretation of the excavation. It is of great pedagogical value to be able to look at the site from different angles and, especially, to measure length and areas. We have found this methodology very useful and we hope that others will do likewise.

References

Sammanfattning

Fornvännen 97 (2002)