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MODELLING HISTORICAL LANDSCAPES

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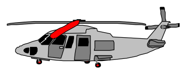
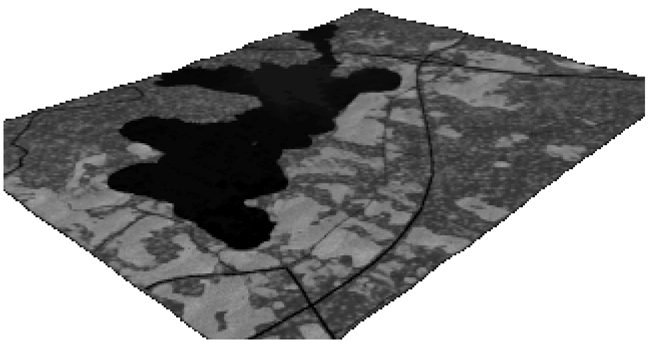
ABSTRACT
Animated historical 3D landscape models are perhaps not the first thing you come to think of when matters concerning environmental planning is discussed. Although the paper map, today, is a natural tool for this type of activities the future offers new means of using the information contained in these maps. This includes distributed digital maps and aerial photographs as well as simulations of 3D historical landscapes, including animations covering both travels in space - and time.
Sweden possesses a unique and vast collection of historical maps, approximately 300.000. In order to give planners and researchers better and safer access to this fragile material, as well as a better understanding of the landscape, a project concerning this matter is being planned at the department of Human Geography, Stockholm University. As a large scale scanning project now is being launched by the national land survey of Sweden, (LMV), vast opportunities are at hand.





Seeing is understanding

- It is a sunny summer afternoon. The helicopter is hovering over a little lake and John Andersson is looking towards some fields on the other shore. As there is some haze in the air he decides to take a closer look and starts flying towards them. Suddenly the look of the landscape changes an he recognizes that the fields now resembles the ones on a 100 years old map he studied some time ago. Then without notice, it is midwinter and the landscape under him is draped with a thick cover of snow.
What is going on? Is it a strange dream?
No it all happened - but only on the computer screen!

At the local planning office John Andersson is currently handling an apply for building permission concerning a group of residential houses. In his job he is supposed to take into consideration any potential effects that this exploitation might have on the landscape. Therefore he needs to know what the site looks like, not only today, but also what it did look like in the past, thus identifying potential conflicts with environmental protection regulations. Only a few years ago this would have rendered him weeks of work, if doing this thoroughly. He would have needed to visit a map library, this probably meaning that he would have to

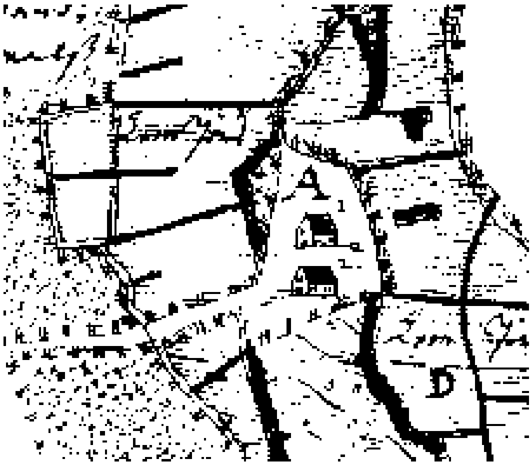
travel to get there. Also, he probably would have to spend some time at the actual spot to get a general idea of the appearance of the place. But times they are changing....
Now most of the information he needs is only a few strokes away on his computers keyboard. He can examine aerial photos and modern, as well as, historic maps covering the area in which he is interested. Also available are 3 D landscape models that gives him the opportunity to travel in space - and time.

To many of us the scenario above is merely a fiction. However, at this moment, the strive to make this a reality has begun.

BACKGROUND - THE MAPS
Sweden is unique in the world considering the fact that within the walls of the central map library of the national land survey, LMV Gävle, an enormous historic map collection is kept. I consists of approximately *300.000* maps, the oldest from the 17th century. Of course the variations in scale, geometric precision and thematic contents are large.
The first surveyors maps was the geometric maps from the first part of the 17th century. They were large scale maps normally in the scale of 1:5000. This maps was in fact the start of the National Land Survey of Sweden. The purpose of this very first maps are not clear, but from the middle of that first century of survey mapping the taxation become a major purpose for geometric mapping. At that time the geographic mapping began to expand. That was the term for the small scaled maps. Later on the surveyors was engaged to solve problems concerning boundaries and division disagreement between neighbors. Working with that landdivision it was agreed in the mid 18th century that the surveyors should try to get the owner to concatenate small land strips into larger fields. That was the start of an enormous increase in landdivision and surveyor mapping. Three different forms of redistributions of the land division was succeeding each other, the *storskift*e, the *enskifte* and finally the *laga skifte*. Almost all of this maps was produced in the scale of 1:4000 Some maps or parts of them were made in 1:2000 or 1:8000. At the peak of this operation, about 1860, no less than 500 surveyors to part in the mapping of different villages all around the country. This large scaled maps was as a source when producing small scaled maps over larger areas. The first printed "economic map" produced in that way came in the begining of the 19th century. The large scale sources was thu very heterogenous as they came from all different timeages. The first smallscaled maps with econimic features and with timely more homogeneous sources was the "häradskarta" begining from 1859. Of particular interest to researchers in the field of historic landscape analysis is that "economic" map series named "häradskartan", (eng. map of hundreds), which maps the landuse of most of southern Sweden around the centennial 1900. The homogeneity and coverage of these maps paired with the fact that they are the product of a dedicated mapping as opposed to many other maps that merely are concatenation of other maps. This map series is also of great interest to planners as relict or fossil remainings of the historic landscape of this period of time most likely may be found today. The homogenity of this map is also a reason for the project to choose it as a starter.

This old survey maps has high standard of reliability. The surveyors and their assistant lived, and worked with the land division, together with their clients, the local people. Before a division of the land (skifte) the land was graded according to quality, and other resources were valued together with the landowner. Records was not always kept, so it is important to check with the surveyors orginal map witch contain very many annotations of value. The research archive at the national land survey "only have copies of the material. The original with the full records are kept at county administration authorities. We may not forgett the purpose of the

maps. Either the purpose is to divid land according to disagrement or to rationalys landuse or to be a source for taxation, the purpose is not mainly to discribe the landscape. That means that we have to interpreted the maps in order to create the models of historic landscape. In that interpretation we will use anther sources as well, like landscape paintings etc.
A study made on the island of Gotland in the Baltic sea also shows that information of the historic landuse might be of great value to ecologists, botanists, and zoologists as indicators of where an historic flora and fauna still can be
looked for.

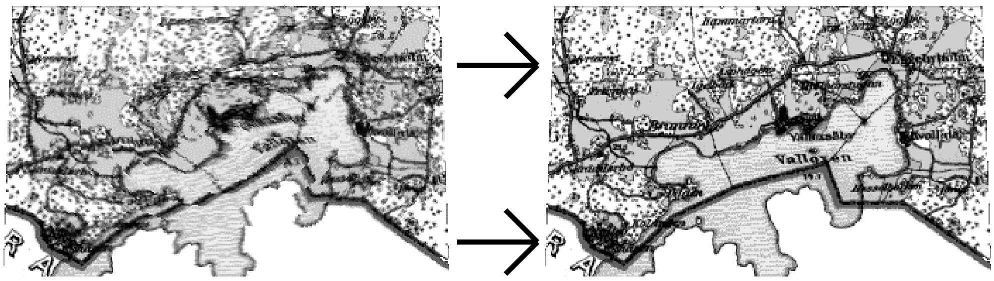


Detail of geometric map covering Skämsta.
Kärrbo parish, Västmanlands län.
Made 1650 by surveyor Johan Åkesson.
Original scale 1:5.000

As most of the historic maps are practically invaluable and fragile, an initiative of the national land survey has resulted in a project where a test series of these maps are to be scanned with the purpose of giving planners and researchers better (- and safer) access to the material. The scanning is done in 24-bit color with a resolution of 0.1mm. As the mapscales ranges from 1:10.000 to 1:50.000 this results in a theoretical ground resolution of 1 to 5 meters. When the scanning is done the result is a digital copy of the map which may be distributed as it is, or further processed.

The most obvious way of using this image of the map is to view it, either on a computer screen or as a (re)printed paper copy. This can be performed by ordinary image software an the scale may be varied according to the preferences of the user. Most software in this category also permits processing of the image in a variety of ways, for example; filtering, color conversions, resolution changes etc. Although the use of this raw, digital image of the map will satisfy many of the needs of different users further processing is requested to accomplish, for example; merging maps together, quantifying information, combining with digital data from other sources.

GEOMETRIC RECTIFICATION



As a first step towards enhanced possibilities of analysis a geometric rectification must be done. Here the image is placed in a defined coordinate system. This process requires that a number of locations (the more the better) in the image, are defined in terms of coordinates in the desired coordinate system. According to this information the image is adjusted so that it fits in the new reference system, (a process commonly called "rubbersheeting"). A problem concerning the use of historical maps is however that the geometry of the maps might vary, not only between maps, but also within maps. This means that the selection of reference points has to be done by people with thorough understanding of the map material. When a geometric rectification has been accomplished we can start talking about a digital map rather than an image. Now different maps can be put together, other information can be overlaid, precise scaling etc. can be done.
However, if we are interested in quantifying the thematic contents of the map additional processing is required - a thematic interpretation.

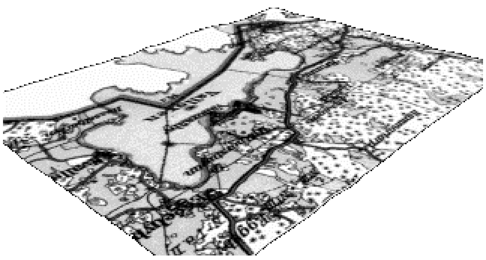
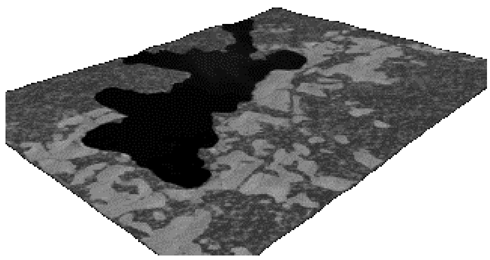
THEMATIC INTERPRETATION

A traditional visual analysis combined with on-screen digitizing is one way of doing a thematic interpretation, but if you have large amounts of digital map data this manual interpretation can be very time consuming. Another way of interpreting the thematic information in the map is to apply image processing techniques an let the computer deal with the bulk of the classification. Without going into details, these techniques have their limitations. For example difficulties exists when we want to define areas that are represented on the map as cartographic symbols. In these cases a more or less manual interpretation is required. Further more, we must not forget that a map is a cartographers "view" of the real world. This must be taken into consideration and a thorough evaluation of what to classify, what to leave out, and how to treat this information, must be done. A property border on the map does obviously not mean that the landuse covered by this line is "none" or "border". In general we can say that the accuracy and precision of the automated thematic interpretation is inferior to the manual,

"human-brain" assisted, method. Normally the use image processing techniques on a map material of this kind involves excessive use of filters and data aggregation.
Although these remarks could seem as strong limitations to "automated" thematic classification, the fact is that this method is a "fast" way to thematically interpret a large map material. (In practice you will may often find that a combination of the manual and automatic interpretation is fair compromise of speed and accuracy.
No matter how we choose to deal with the problem of thematic interpretation the result of this process is a thematic digital map that, as described above, does have a homogenous geometry which gives us new possibilities of further exploration. Now we can quantify the thematic information and combine it with digital data from other sources. In short all suitable methods of spatial analysis can be applied.

There are some critical points in the process described above that are related to the fact that we are dealing with historic maps. One, as mentioned before, is that the geometry of the maps might vary, not only between maps, but also within maps. Another is that the thematic information might vary. This does not only mean that different maps contains different information but also that the definitions might vary over time. For example the term meadow in the 17th century does not have the same meaning as what we today consider as being meadow. Furthermore we often can assume that the (economic) "value" of the landuse will be reflected in the thoroughness by which the mapping was done. This is also a potential source of geometric error as discussed above. Nevertheless, if we can achieve an adequate geometric and thematic "correct" digital map we now can use this as a major source when entering the field of visualization of the historic landscape.

HISTORICAL "AERIAL PHOTOGRAPHS" AND 3D

When we are dealing with, certainly not mass-produced, historic maps no single map will be another alike. For example the cartographer might have used colors and symbols differently. Our thematic interpretation of the map enables us to use any cartographic manner we prefer, hereby making the maps easier to understand for the non-experienced map-reader.
We can also paste photographic elements on top of the map representing different thematic information. This will give use the impression of an aerial photograph - an historic one. Additional visualization may be achieved by draping this simulated aerial photo on top of a digital terrain model.

A printed map does have a scale, but it does also has a certain degree of precision - the accuracy by which the features are mapped. It also features a resolution - how much detail the features possesses. Dealing with historic maps we face specific complications related to precision and resolution. As mentioned earlier the geometry might be varying within the map and this might also apply to precision and resolution. We might find that different types of features may be mapped with different precision and resolution.

ADDING MOTION

By adding the ability to move around in our 3D landscape model we are in fact closing up with something that might be called "virtual reality".
The digital map, as opposed to the analogue printed map, does not have a fixed scale, but although the scale can be varied - the precision and resolution remains constant. This is a fact that may seem obvious but nevertheless often is neglected. When modelling 3-D landscapes these rules becomes more obvious. Objects that are close to the viewer ought to have a higher resolution than object further away. We take advantage of that fact by designing a model with a heterogeneous resolution although this would restrict our movements within the model. In practice the resolution determines how near we can view our landscape model. When animating a 3-D landscape, for example creating a fly-over, another factor becomes important - the speed of movement. The faster we move in the modelled landscape the less detail the human eye can distinguish, which makes it possible to use lower resolutions then when we have a fixed viewpoint. We should also note that the more peripheral objects are to the target of our eyes the less resolution i required.

Although we used the phrase 3D landscape in the previous paragraph this is in a way not perfectly true. The photographic elements draping the digital terrain model are actually 2D objects. If we do not view the model at a too close distance we would not notice that fact. To some extent we can also compensate for the lack of a third dimension in the thematic information by manipulating the terrain model. For instance, Areas covered by forest can raised, say 20 m, relatively to grasslands etc. If we would like to get really close, however, this will not give us a decent impression. Then we would have to build the landcover out of individual 3D objects. A forest should actually be built out of trees. How deep down in the 3D world we have to go is totally dependant on the need for detail in the model. We must also be aware that a very detailed 3D model will consume computer power when processed and storage medium to store, two facts that must be taken into consideration when striving for more detail.

FINALLY
In this paper we have been discussing some of the opportunities and related problems of concern to our specific use of unique historical maps. Naturally these methods and techniques may be applied to a variety of map sources. We anticipate that in a near future many researchers will see the advantages in multidimensional cartographic visualization. This will, as always, boost development in this field of geography.

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