Landscapes of the past

"Seeing is believing"

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ABSTRACT

Animated, historical, three-dimensional landscape models are perhaps not the first thing you come to think of when matters concerning environmental planning and historical landscape research are 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 animation's covering both travels in space - and time.

ViSC TO EXPLORE THE PAST

I usually spend my summer vacation on the island of Gotland in the Baltic Sea, staying in a small cottage about 30 km north of the town Visby.
Very often I have to drive into the town for one reason or another and as I see the winding road cutting through the rural landscape I often start wondering - what if I had been here 50 years ago? - 100 years ago, or more?

Weather you are driving, flying, or walking you are looking at a landscape that is a function of its past. Maybe our awareness of the genetics of the landscape, *our landscape*, is as important for our cultural stability, and our identity, as our family roots. Today we tend to appreciate more the diversified, heterogeneous landscape that in some places still remains as a relic from an older form of farming rather than the homogenous landscape produced by modern, highly efficient, farming .
What is it that we are attracted to? How did the landscape evolve? How did it appear, not as todays relic, but as a part of the holistic landscape of yesterday?

Timetravelling have always fascinated people. We will hardly be able to actually travel in time, but visualization techniques and methods may be used to give people an impression of timechanges.

Visual SCience -*ViSC*- has been used by many to present and visualize features that we plan to create. e.g. " How will the new bridge fit in to the landscape?" Not so many attempts have been made to use this technology for presentation of the past, our history. The reason is obvious. Until recently ViSC has mainly been used by skilled, technically oriented scientists and more humanistic oriented researchers have not yet adopted these methods to communicate.

BACKGROUND

During the 1970's and 1980's -the field of responsibility for the environmental planning, (heritage planning), in Sweden was widened from an earlier focus on objects - artifacts and buildings - towards a more wider view of the historical content of the landscape. The department of Human Geography at Stockholm University then started the work on an historical land-use database. We choosed the island of Gotland as investigation area. That database of Gotland represents the first attempt to widen the base of knowledge for environmental planning by looking at the landscape as a unit (Ene-Persson-Widgren 1990).

The logical consequence of the change of focus was that a different base of knowledge serving environmental planning had to be accomplished. Earlier used methods and existing registers were found to posses two serious limitations; first they were primarily built upon single point objects in the terrain (artifacts and buildings), secondly the prehistoric remainings are totally dominating in these registers. In practice this means that these features also possesses a stronger protection.

A method of separating the historical contents of the landscape have been tried out in earlier studies. (Lindquist 1979). Using this method the creation of areas with a specific content, or "signature", of historical landscape can be done, not only based on the amounts and concentrations of objects, but on the qualitative and quantitative areal contents of the landscape. This leads to the second purpose of the Landuse Database of Gotland; to develop automatic methods of interpretation and separation of the contents of the landscape.

Preserving complete and complex parts of the landscape are far more useful in order to explain living conditions in the past, but the data capture is expensive and presentation of landscapes that do not exist anymore are of course problematic. It is for that purpose we have been interested to use ViSC methods.

VISUALIZING TIME CHANGES

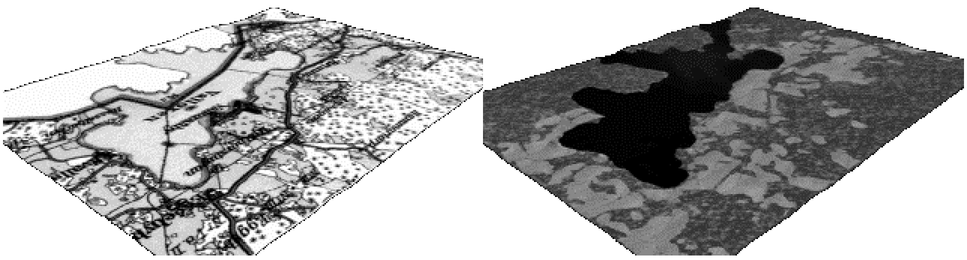
Visualization of change over time could be categorized in three different ways of which two are of interest to us (Maceachren 1994). First fly-over's, which simple means that we **change viewpoint** while we study our mapmodel. We travel within one specific timeperiod and study how the landscape appeared according to our sources. Secondly as **timeseries**, in our case we look at changes of the landscape between different periods of time (e.g. between different agriculture enclosures). We could even, with knowledge of soilsurface, terrain etc., interpolate the landuse for the period between our given timeslices.

For the moment, let us focus on changing viewpoints to visualize our historical landscape information.

In our case the information consumers, the environmental planners, may have very different background knowledge concerning both the historical landscape and the historical source material (the maps).

When we are dealing with historical maps no single map are another alike. For example the cartographer might have used colors and symbols differently. A thematic classification 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 may also use photo elements from modern aerial photos draped on top of the map representing the different thematic information. This will give us the impression of an aerial photograph - an historic one. Additional visual impact may be achieved by draping this simulated aerial photo on top of a digital terrain model. We now have created a 3D-landscape model.

In the "smallscale" model (when we fly on high altitudes) we just paste the photomaterial on the DTM, but on lower altitudes where we have to emphasis different structures in the vegetation, the photomaterial must be used with great care. Although we used the term 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. However , 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 within the thematic information by manipulating the terrain model. For instance, areas covered by forest can be raised, say 20 m, relatively to grasslands etc. If we would like to get really close, however, this will not give us a satisfactory result. In that case we would have to build the landcover out of individual 3D objects. A forest should actually be built out of trees, a tree should actually be built out of branches and leaves, and so on and so forth. How deep down in the 3D world we have to go is totally dependent on the need for detail in the model, that is how close we want to be able to go. We must, however, be aware that a very detailed 3D model will consume a lot of computer power when processed and a lot of storage space to save, two facts that must be taken into consideration when striving for more details. By adding the ability to move around in a 3D-landscape model we are in fact closing up with something that might be called "virtual reality".



As digital maps enables you to change viewpoint freely we can hardly anymore include scale as one of the cornerstones in the definition of a map. Though the digital map does not have a given scale it does have a certain degree of precision and resolution. The **precision** - the accuracy by which the features are mapped, is in our case very dependent on the source material. The **resolution** - how much detail the features possesses, also depends on our sourcematerial but even more with choice of viewpoint. Although the scale of the digital map may be varied, the precision and resolution remains constant. This is a fact that may seem obvious but nevertheless often is neglected. When modelling 3D-landscapes these facts becomes more obvious. Objects that are close to the viewer ought to have a higher resolution than object further away. We can 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 at what distance we may view our landscape model and still getting a fair impression of reality.

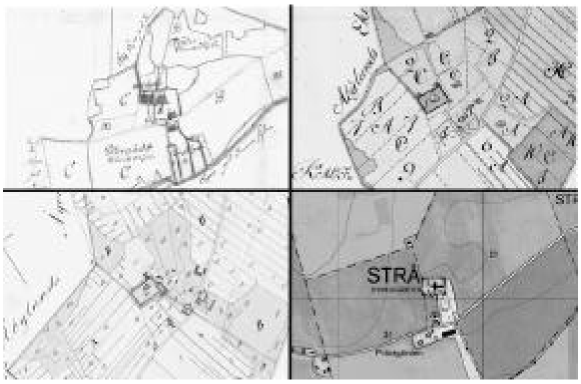
When animating a 3D-landscape, for example creating a fly-over, another factor becomes important - the speed of the movement. The faster we move in the modeled landscape, the less detail the human eye can distinguish, which makes it possible to use lower resolutions compared to when we have a fixed viewpoint. We should also note that the more peripheral objects are to the target of our eyes the less resolution is required.

In this case we face an animation problem - that is how and when do we change the resolution during our flight over the historic landscape?

As mentioned, the traditional printed map does have a scale, but it does also have a certain degree of precision and resolution. Dealing with historical maps we face specific complications related to the precision and resolution. The geometry might even vary 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. But more about that below.

SOURCES - THE HISTORICAL MAPS

Sweden has a unique collection of historical maps at the central map library of the National Land Survey. The library 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 *(Ehrensvärd, 1990).*



The first maps made by surveyors was the geometric map series from the first part of the 17th century. These large scale maps was normally on the scale of 1:5,000 and did in fact become the beginning of the National Land Survey of Sweden. The purpose of these very first maps are debated, but from the last decades of that first century of survey mapping, taxation became a major purpose for geometric mapping *(Örback, 1990)*. At that time the geographic mapping began to expand. The expression "geographic mapping" was used for maps in smaller scales. Later on the surveyors were engaged in solving problems concerning boundaries and division disagreements 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 land-division and surveyor mapping in Sweden.

Three different forms of redistribution's of the land, (i.e.. enclosure), were succeeding each other, the *storskift*e, the *enskifte* and finally the *laga skifte*. The maps were produced on the scale of 1:4,000. Some maps or parts of them were made on the scales of 1:2,000 or 1:8,000. At the peak of this operation, about 1860, no less than 500 surveyors took part in the mapping of different parishes all around the country. These large-scale maps acted as a source when producing small-scale maps covering larger areas. The first printed "topographical map" produced in that way came in the beginning of the 19th century. The large-scale sources used was a very heterogeneous material as they dated from all different periods of time. The first small-scale maps with economic features and based upon more time-homogeneous sources was the "häradskarta", (Eng. "map of hundreds"), entering production in 1859 *(Jansson, 1993)*. It maps the landuse of most of southern Sweden before and around the centennial 1900. This map series is of special interest to researchers in the field of historical landscape analysis due to 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 compilations of other mapmaterial. This map series is also of great interest to planners as relict or fossil remainings of the historical landscape of this period of time, most likely may be found today.

The old survey maps has a high standard of reliability. The surveyors and their assistants lived, and worked with the land division, together with their clients - the local people. Before a division of the land was done, the land was graded according to quality and other resources *(Sporrong, 1990)*. This was a process in which the landowner took active part. In order to get exquisite information it is important to examine the original map of the surveyor, which contains detailed annotations. The research archive at the National Land Survey does only keep "copies" of the material. The originals, with the full records, are kept at county administration authorities. We must not forget the purpose of the maps, which was to divide land according to disagreement, to rationalize landuse, or to act as a source for taxation. Describing the landscape was not the main purpose. This means that we have to interpret the maps in order to create models of the historical landscape. In that interpretation we may use other sources in order to get a more detailed impression of the actual appearance of the landscape, for example landscape paintings *(Olwig, 1984)*. At the department a student project, with the purpose of comparing landscape drawings and maps from early 19th century, has been initiated.

Although the "deciphering" of the historic map material might have to be done by experts, the information accommodated may be of great value to many. A study made on the island of Gotland in the Baltic Sea *(Lindqvist, 1979) (Ene-Kamsvåg 1984)* reveals that knowledge of the historical landscape might be of great value to a variety of different researchers and planners, not only the ones explicitly interested in the historical landscape. For example ecologists, botanists, and zoologists might use this information as indicators of where remainings of an historic flora and fauna still can be found *(Ene-Persson-Widgren, 1990)*.

PROCESSING THE HISTORICAL MAPS

Material	**Processing**	**Use**
Paper map		Manual interpretation
	Scanning	
Digital image		Scaling and hardcopy
	Geometric rectification	
Digital Map		Precise scaling, overlay etc.
	Thematic interpretation	
Thematic map		Quantifying, Spatial analysis
	Pasting of photo-graphic elements	
Simulated aerial photo		Visualization
	Draping on an DTM	
3D landscapemodel		Visualization
	Animation	
		Visualization

SCANNING

As most of the historical maps are practically invaluable and fragile, an initiative of the National Land Survey of Sweden has resulted in a project where 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. With a mapscale of 1:10,000 this results in a theoretical ground resolution of 1 meter. 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 and 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 ability of getting access to this raw, digital image of the map will satisfy many of the needs of different users, further processing is required to accomplish tasks as, for example; merging maps together, quantifying information, combining it 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 the image is given a number of reference points. These 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 referred to as "rubbersheeting"). A problem concerning the use of historical maps is that the geometry of the maps might vary, not only between maps, but also within maps *(Johnsson, 1965)*. This means that the selection of reference points has to be done by people with thorough understanding of the map material.

Rectification of the oldest maps are preferably made, not to the modern maps, but to rectified smallscaled maps from the 19th century. They possesses a good geometry, as mention above, and they show older forms of landuse which is to great help when selecting reference points.

A separate work is initiated which will look in to the measurements and visualization of those geometric data errors that occur in the oldest maps. The aim of this work is to find patterns of geometrical errors and compare it to landvalue and mapping purpose, and in a good way present that information to the reader of the rectified maps. So far 3D surfaces and sound has been tried out in order to present the error variable. The visualization of data quality has been inspired by work of e.g. Fisher (Fisher 1994a and 1994b) and articles like Visualization of Data Quality (Frans et al 1994).

When a geometric rectification has been accomplished we can start talking about a digital map rather than an image *(Ene-Bengtsson, 1993)*. Now different maps can be put together, other information can be overlaid, precise scaling can be done, etc.

However, if we are interested in quantifying the thematic contents of the map additional processing is required - a thematic classification.

THEMATIC INTERPRETATION

A traditional visual analysis combined with on-screen digitizing is one way of doing a thematic classification, but if you have large amounts of digital map data this manual interpretation can be very time consuming.

Another way of classifying the thematic information in the map is to apply image processing techniques an let the computer deal with the bulk of the thematic classification. However, these image processing techniques have their limitations. For example difficulties exists when we want to define areas that are represented on the map by cartographic symbols. In these cases a more or less manual classification might be required. Further more, we must not forget that a map is a cartographer's "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. For example; a property border on the map does definitely not mean that the land-use covered by this line is "none" or "border". In general we can say that the accuracy and precision of the automated thematic classification is inferior to the manual, "human-brain" assisted, method. Normally the use of 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. The manual and "automated" methods does of course not exclude each other and we might end up using a combination of both.

No matter how we choose to deal with the problem of thematic classification 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.

SOURCE CRITICISM

There are some critical points in the process described above which 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 contain 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 to be a meadow. Furthermore we often can assume that the (economic) "value" of the land-use and the mapping purpose 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 can use this as a major source when entering the field of visualization of the historic landscape.

FINALLY

In this paper we have been discussing some of the opportunities and related problems of concern to our specific use of a unique historical map material. Of course the methods and techniques mentioned may be applied to a variety of map sources. We anticipate that in a near future many researchers and planners will see the advantages in multidimensional cartographic visualization.

Just one more comment. We have found, during our initial experiments, that the concept of modelling historic landscapes does have a public impact. This fact should not be underestimated as it gives the novice access to, and increased understanding of, an important part of our historical heritage - the landscape.

Acknowledgments

This visualization project was initiated during discussions at the EGIS conference in Munich 1992. The scanning project by National Land Survey was of course an important injection as it deals with an essential and tough work -capturing raw data. During the fall of 1994 we had fruitful discussions with Robert B. McMaster from University of Minnesota, who visited our department. In the field of research concerning historical landscapes and maps we have daily co-operation we researchers at the department. To reach the relatively high technical standard that is a necessity for this work- we have received resources from The Swedish Council for Planning and Co-ordination of Research.

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