ABSTRACT

Traditional Geo-Information is mostly visualized 2-dimensional. The question investigated is if a third dimension would add more information to users by browsing their data. The paper focuses on combining three basic Geo-data sets, namely soil, land use and elevation. The data sets are made available through the Intranet (or Internet) for use in landscape planning. Techniques used are at one hand GIS to extract the information from the geo-data base and to handle spatial queries at the server side. At the other hand using VRML as an intermediate to visualize the information by using a VRML-viewer at the client side. Specific problems to tackle are visualizing Geo-data sets in 3-D, use of geo-referencing to build the Virtual Reality scene, spatial queries through the internet, keep performance within certain bounds and using scale as a measure for visualizing a certain level of detail.

Besides creating the Virtual environment for the data layers, also Meta data will be presented using multimedia presentations on each of the geo-data sets. In these presentations the process of deriving the data and its quality will be included.

Finally, the operational prototype for landscape planning and the need for visualizing data in this manner will be discussed.

INTRODUCTION

The title of this paper seems to show obviously a typical geo-information science view of the landscape. In contrary to CAD systems the possibilities to visualize landscapes in 3D were very limited in the world of geo-information systems (GIS). Real world features are merely described by GIS systems in 2D entities. But the field of landscape planning and design demands higher spatial resolutions in 3D with fine quality with respect to accuracy and precision. This type of data becomes more and more strategic and could only be supported by governmental institutes like the Ordnance survey in UK or the Topografische Dienst in the Netherlands. These institutes could continue their specialities in strategic geo-data capture and maintenance. But the need to improve the accessibility of this high quality geo-data is still the main topic.

Another crushing element is the dominance of static forms of visualization, for example the presentation of 2D thematic maps. Related to the passive forms of use, because users of digital maps could only have a glance, a more interactive way should also be a real improvement.

The on going improvement of computer technology offers interesting abilities to this improvement of geo-data visualization. To mention some:
- 3D data sets are becoming recently available;
- the accessibility and availability of geo-data are stimulated by the world wide web;
- dynamic visualization in a wide variety can be easily created and even realised via the web;
- user-friendly ways to manipulate interactively a visualization.

This paper is the result of a project carried out by the Centre for Geo-information of Wageningen-UR (CGI) and Geodan Geodesie. The project is part of the MOOK program funded by the Dutch ministry of Agriculture, Nature development and Fisheries. The purpose of the program is to stimulate innovative activities using multimedia technologies to support the research of (semi) rural areas in its widest variety.
THE AIM OF VISUALIZATION

The project aims on a reconnaissance of the use of multimedia techniques in landscape planning. Strategic data sets\textsuperscript{4} are used to create a 3D virtual world in which the planner is able to explore the data and gather additional information through the use of these kinds of techniques. Special attention is given to access the data visualized as 3D virtual landscapes through the Internet. Usefulness and performance are issues to be examined within the scope of this project. Starting point is a situation that a user can access and explore this virtual world from a standard “office” desktop. It must be clear that this visualization project is mainly focussing on the interaction side of the user and not on the dynamics of the real world entities.

Within landscape planning very often one is interested in a way to visualize the real world as genuine as possible. Modern computer techniques make life easier in a sense that it assists in building this world on screen. Available 3D software is increasingly improved in its possibilities, demand of computer resources and use. Concerning virtual reality related software there can be a distinction made in modelling software for data entry, viewing software for exploring scenes and analytical software to manipulate 3D-scenes and to make calculations and spatial analysis. Within the scope of this paper we did not use any advanced software to create the 3D-model instead we used standard available data to create our virtual world. The 3D-model is built by combining thematic information layers with elevation data. Separate layers are in fact 2.5D, but by introducing more layers a real 3D-scene can be build. No attention is given to create objects such as building trees etc. to be placed into this landscape. The software for viewing the 3D-scenes are standard plug-ins for Internet browsers who are available for free such as Cosmoplayer, Cortona, Worldview, etc\textsuperscript{5}. On purpose we avoid as much as possible the use of licensed software since our goal was to give wide access to the product.

GEO-DATA SETS

To build a 3D-scene three different basic data sets have been used. The soil map exists of two different layers, namely the soil information layer and the groundwater table information layer. So far we only used the soil information layer. By combining elevation and the two thematic layers we were able to create a 3D-model. To have a clear understanding of the data sets used there is a short introduction on each of these data sets.

**Soil**

The soil map at scale 1: 50.000 is originally published in sheets covering 20 x 25-km areas. It is accompanied by soil survey reports and is finished in 1995. The legend contains three sections: a section describing the soil units, a section describing groundwater table classes and a section describing special soil features e.g. the occurrence and depth of particular layers and human activity. The soils are classified according to the “system of soil classification for the Netherlands” (De Bakker and Schelling 1966, 1968). Today the soil map 1: 50.000 is digital (polygons and raster 50 x 50 m) available with an extensive database containing soil profile descriptions (BIS: Bodemkundig Informatie Systeem) on point locations.

*Figure 1 Soil map 1:50.000 Texel*
Land use
The Netherlands has a high population density. Because of the increasing concern about the impacts of man's intervention on the environment, timely and accurate information on land cover at regional and national scales was required, especially for agricultural classes and, recently also for nature classes. Land cover data were required to support environmental policy and for physical planning purposes.

In the '80's information on agricultural land cover could be obtained from land use statistics and topographical maps. However, land use statistics were only available for restricted areas (e.g. municipalities or provinces) and cannot be derived for areas with deviating boundaries (e.g. river basins and groundwater protection areas). Topographical maps often did not contain all required land cover classes and were outdated. Because of the lack of suitable land cover data, it is decided in 1987 to produce a national land cover data base of The Netherlands (further to be mentioned 'LGN data base') using satellite images. The first version of the LGN database (LGN1) was produced with Landsat TM satellite images from 1986. The last and third version of the database (LGN3) came available in 1998 based on TM images from 1995 and 1997. The LGN-database consists of raster cells of 25 m x 25 m that cover the entire Netherlands. For each cell land cover is determined.

The LGN1 database was produced by automatic classification of mono-temporal satellite images and some visual manual editing of the result. For LGN2 the production method of the database changed dramatically. A stratified classification methodology, using multi-temporal satellite images and different ancillary data sources, became a common practice. Visual interpretation often appeared to be a valuable tool, complementary to automatic classification. These improvements resulted in a sharp increase of classification accuracy and the number of land cover classes. The LGN3 database has a two level hierarchical nomenclature, consisting of 5 level 1 classes (agricultural area, forest, natural area, built-up area and water) and 40 level 2 classes. The LGN3 database was extensively validated, using field data, aerial photographs, topographical maps and statistical data. Level 1 and level 2 classes of the LGN3-database have a minimum accuracy of respectively 90 and 70%. The LGN3 database is operationally applied in environmental studies and for physical planning purposes on national and regional scales and is produced on a commercial basis. The LGN database is being up-dated every 4 to 5 years. In future, new developments are expected to further improve classification accuracy.

Elevation
A good view on the earth's surface is obtained from the air. For this reason airborne mapping methods are more efficient in comparison to conventional terrestrial techniques. It is for this reason that Geodan Geodesie BV is mapping the earth's surface from the air, which is resulting in accurate elevation data of the terrain and the objects that are present. A focussed laserbeam scans the surface. In combination with advanced measurement systems this delivers an accurate height image of the scanned surface. In comparison with other techniques the data is delivered at lower costs and in a shorter time frame.
For the Netherlands a DEM is built called AHN (Actueel Hoogtebestand Nederland) and on this moment approximately 80% of the national coverage is done. It is planned to have complete coverage in 2001. The accuracy of the measurement is depending from vegetation and relief. On solid surface, little relief and short vegetation average deviation is less then 10 cm. The AHN is available at different scales. The most detailed is one point for 16 m².

The technique of airborne laserscanning is that the centre part of the lasercan system is the invisible infrared laser, which emits up to 5000 short pulses per second. The reflections of the laser pulses from the terrain are received again by the system. From the time interval between the emission of a pulse and the reception of the reflected pulse, which is in the order of millions of a second, follows the distance between the lasercanner in the aircraft and the measured terrain point. The system and the processing software distinguish reflections coming from the actual terrain from those coming from vegetation and buildings. The infrared wavelength of the laser signal means that the system can operate during day and night. In comparison with other types of measurement systems, like photogrammetric measurements, this leads to an increased possibility of using the system. Lasers are characterised by a very narrow bundle; in the case of the system of Geodan Geodesie the spot size is 20 centimetres at the ground surface when flown from the maximum altitude of 1 kilometre. This allows for penetrating vegetation, so that both the vegetation itself and the underlying terrain can be mapped.

THE GEODATA 3D VIEWER

Access to the geo-data sets is through the use of Internet. This promises to be the fastest way to strategic and valid data sets, since they will be retrieved by the organisation responsible for administration and maintenance. However obtaining the data could be delimited by certain constraints. In the Netherlands, as in many other European countries, these data have to be paid. However, the data owners sponsored our project by giving us the use for a certain study area, namely the island Texel in the northern part of the Netherlands. This was an excellent choice because a lot of different landscapes are available within a short distance.

Access to the data sets is not direct. The user is given access through an Internet map server to make a selection for an area of interest. The map server application will handle the request for data retrieval. A server application retrieves the requested data into one data set and transfers it to the user. The data set contains data layers for the two thematic basic data sets. This means that both layers, land use and soil, will be combined with the elevation data.

Since we used a WEB browser to give access to our geo-data sets we selected the VRML-file format to present our 3D-virtual scenes. This format is suitable for use on the Internet. Once the user requested the data for a certain area of interest the server collects the data from the database. The data for the thematic information layers is enriched with information for elevation. In this way a 3D representation of the surface is created. The procedural follow up drapes the thematic information on its geometrically corresponding 3D surface data. Since we used two thematic layers with the same elevation model, these two information layers are presented on top of each other. By activating a Java button the layers can be separated to be

Figure 4 Frame for selecting an area of interest
examined individually. If groundwater table information, one of the information section of the soil map, was used a separate surface had to be constructed subtracting groundwater depth from the ground level surface. Information is presented in different colours on the surface. A legend for each layer explains the meaning of each map unit. Showing a legend in this stage is done because of its ease of use. Shading in the 3D scene affects the role of colours. In a next version of the application this problem will be tackled by cursor interaction. By moving the cursor through the 3D-scene thematic information will be shown, for example, on the status bar of your browser. VRML-viewers very often offer possibilities to turn off shading.

VRML is a language to describe a 3D-model. There are no rules defined to reference this to real world co-ordinates. Currently a special interest group is defining a standard for Geo-VRML in which these rules exists and are well described together with extra functionality to be able to make spatial queries and analysis’. For our server application we did not use Geo-VRML. Instead we used Map Objects (ESRI), to perform zooming and by using this software also we were able to retrieve the co-ordinates of our area of interest. These are used as a reference to extract data from our basic data sets. To make use of this co-ordinate system we built a Geo-cursor to query x, y and z co-ordinates directly from the VRML. No attention is given to the projection rules used to build the geo-data sets. In future the use of Geo-VRML will help to handle map projections on geo-data sets.

**TECHNICAL ARCHITECTURE**

The system architecture is a server/client type. This means a server side where resides usually more demanding software and data. At the client side there is software that is necessary for communication with the server (e.g. an Internet browser) and there could be software that is necessary for handling of special functions. An example of the last category is a plug-in (Cosmoplayer, etc) for the browser to view the VRML-files. With such architecture a less powerful workstation at the client side is needed. This is also referred to as a thin client.

The user interacts by using the Internet browser. Basically the first action to deal with is selecting an area for which the 3D-scene will be built. This is the part in which geographic reference plays an important role. To implement this we used software provided by ESRI (Map Objects and MO-Internet Map Server) and made an application with Delphi. This application is located at the server side. Its task is to respond user requests to zoom or pan and return the result of this action. At the client side the map is shown in an HTML page and interaction is made possible by the ESRI-applets (Java) associated with the map display object. Information presented in this frame is built up dynamically after each request to draw a new map. If the user is satisfied with the selected area by pushing a button a request is send to build the 3D-scene. The server application retrieves the data from the database using the co-ordinates of the extent of the selected area to query the database. For the different layers data are enriched with the elevation data (each layer has its own surface) and a VRML is created. This VRML is sent to the user and displayed in a VRML-viewer. Inside the VRML additional functionality by using JavaScript and Java is added to make direct interaction possible between VRML and user. In the prototype two different types of functionality is added. The first action is the use of a button to manipulate the layers. The user is offered the possibility to separate the layers in the VRML. The second action is related to geo-referencing. With this button a so-called geo-cursor can be activated. It can be positioned anywhere on one of the layers and it will
return x, y, and z values for its location. For these actions no communication is needed with the server which will speed up performance and flexibility. To summarise the following components can be distinguished:

- server-side
  - Web server application
  - Map Object Internet Map Server (MO-IMS)
  - Server Application. Built with Delphi using ActiveX components from Map Objects and MO-IMS.
  - Geo-database (For this prototype we used a file-based database)

- Client side
  - Internet browser
  - VRML-viewer as a plugin for the internet browser
  - Applets and JavaScript embedded in the loaded HTML-pages

**RELEVANT IMPROVEMENTS**

For developing the prototype geodata 3D viewer we used VRML. This format does not specifically deal with geo-relational topics. To overcome this we used conversions based an information retrieved from specific GIS-software. However, there is a working group to define an extension to the VRML format, namely the GeoVRML. In this format several of the specific geo-related topics are dealt with. This GeoVRML working group submitted a proposal to the 3D-Web Consortium to appoint and release GeoVRML 1.0. GeoVRML will have the following features:

- Co-ordinate systems: a Java package for performing transforms between various geographic co-ordinate systems, and we have a number of new nodes to enable geometry and animation to be specified in geographic co-ordinates.
• Resolution and Accuracy produced an RFC that includes solutions for managing the single-
precision problems of VRML97. The current GeoVRML nodes implement the first level proposal
for double-precision support.
• Levels of detail: are produced the VisibilityInline and QuadLOD nodes that improve the level of
detail support in VRML97 with specific support for large, multi-resolution terrain visualization.
• Terrain Representation: SRI has developed an infrastructure for representing large multi-
resolution terrain’s using VRML and produced examples of this. SRI has also Open Sourced their
library for producing these data sets.
• New Nodes: GeoLocation, GeoViewpoint, GeoMetadata
• Need to show all nodes working in 2 different browser combinations

The GeoVRML working group has more ideas for future extension of GeoVRML. For demanding of
future applications this means we have less dependency on specific GIS-software. At the other hand
for more complicated analysis and conversion of geo-data formats we still need a variety of different
(GIS-) software packages but this can be handled at the server-side. An advantage is that more and
more software and data formats fulfil open development standards.

CONCLUSIONS

Visualization like we do in the geodata 3D viewer is different from traditional way of viewing 2D. In our opinion it will add value, but it is still difficult to prove. A study to investigate effectiveness of 2D compared to 3D visualization on a small group of researchers and students is carried out in 1998 by S. Bos. It appeared that there are differences in interpreting data the way they are visualized. It strongly depends on the kind of information wanted in connection to the scale of the data. Detailed information and measures are better retrieved on 2D-maps. 3D-scenes are much more quickly interpreted, but easier as areas were smaller. An interesting fact that appeared was that researchers, more familiar with working with data in 2D, could better interpret in 2D opposed to students who were relatively new in the field who had less trouble with interpreting 3D. So learning experience to look at a certain way of visualization can influence its value. It is to be expected that when use of Internet will grow as it does now, in future this way of viewing at spatial data will become more and more common practise so that it will be easier to work with and to understand. In a technical sense we can conclude that the methods and procedures chosen meet our expectations. Even performance using the Web as a communication intermediate is acceptable. It is expected that improvements in the Web infrastructure will even make this better in future. Interaction by the user is possible in the way we had foreseen. Java and/or JavaScript are adequate to build the user interface. Using software resources from many different vendors did complicate, but at the other hand it does work well together. Interaction by the user possible in the way we had foreseen. Java and/or JavaScript are adequate to build the user interface.
The way the VRML is manipulated in the prototype we have built is promising for the future. In this
way it is to be possible to change visualization dynamically. Positive is that this can be handled on
the Client-side. The 3D-scene can be dynamically changed up to the point that the landscape has its
“new” appearance according to the manipulating user. Maybe it must be investigated if the data
should be stored at the client side. This can be used for more complicated analysis with more
powerful software. If data are to be stored with the client, quality has to be assured in a way that
certain meta-information is connected to the data.
This way of visualization is applicable in a very broad field. It can vary from fundamental research to
landscape design and lead to public participation in the process of decision making. By making it
available and easy accessible by use of the Web it could be a powerful tool for all people concerned.
NOTES

1 The Wageningen UR Centre for Geo-information is a merger of the Wageningen Agricultural University and the Winand Staring Centre. Geo-information science activities in Wageningen are being integrated to allow adequate and innovative answers to scientific and policy questions. Developments in information processing and communication technology have augmented the significance of geo-information and remote sensing. The Wageningen UR Centre for Geo-information will collaborate with related institutes and use its network of expert advisors to provide university-level education and research on geo-information science, with a view to supporting policy development and the design and management of rural areas. Geodan Geodesy bv is an organisation for consulting, supporting and product development in the field of Geo-information. Geodan Geodesie BV is stimulating the latest development in Geo-information technology. This comprises methods and techniques for Geographic Information Systems as well as modern data gathering such as airborne laserscanning.

2 MOOK Internet site: http://haiku.kennis.org/kus/mook.htm (in Dutch).


5 URL: Geo-VRML working group: http://www.ai.sri.com/~reddy/geovrml/home/geovrml/