VIRTUAL LANDSCAPES: AN INTERACTIVE E-LEARNING-ENVIRONMENT BASED ON XML ENCODED GEODATA

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E-Learning has become standard during the recent years. Many projects have been carried out in the field of Geoinformation, Cartography and Earth Sciences. Therein mostly text-based learning materials have been developed. However, a few projects also introduced approaches to web-based environments for interacting with real geodata. The development of a "Virtual Landscape" will provide an infrastructure to explore and work with geodata, supporting an action-oriented teaching concept.

The paper describes the idea of an XML-based architecture for delivering 2D and 2,5/ 3-D data via WWW. Experiences gathered will be presented as well as issues regarding the data model, data storage and cartographic presentation. The task of how to add further functionality and interactivity will be addressed. The paper describes an application from a Landscape Planning course where students have to plan a railway line. Finally, the application in the learning process will be evaluated and the benefit for E-Learning shall be discussed.

1. INTRODUCTION

1.1 Motivation and overview over paper

Using the World Wide Web for distributing information and knowledge in the area of learning and teaching has become standard years ago. Reasons for that are the flexibilization of the learning process in terms of time and space but also in terms of individual interest and previous knowledge. The ability to serve different teaching concepts is another point, which brings variety in the conceptual design of those materials. However up to now in the field of so-called "E-Learning" mostly text-based materials exist.

This project is motivated by the idea of providing a learning environment which also utilizes the potentials of the World Wide Web, such as interactivity, dynamics, bundling of distributed data and multimedia. By doing so learning may become a more interactive process, possibly even playful and experimental – like the action-oriented approach of learning concepts demands.

The project is carried out as a cooperation of the "Competence Centre for GIS" at the University of Hannover. ("GIS-Zentrum" der Universität Hannover", http://www.gis-zentrum.uni-hannover.de/). Herein scientists from different disciplines are organised to share their knowledge, experience and ideas, as well as conduct joint research initiatives.

In the presentation, after a review of related work, the concept of the "Virtual Landscape" is depicted firstly. Then, implementation issues are described with a special focus on the infrastructure to set up the "Virtual Landscape" with the main component being a web-based architecture presenting 2D and 2,5/3D vector data. Some words will be put on the issue of how to use the system in a learning scenario. A summary and an outlook conclude the paper.

1.2 Related Work

During the last years several projects have been devoted to E-Learning. Stimulated by e.g. the OpenCourseWare initiative at the MIT similar projects all over the world have been carried out. (http://ocw.mit.edu/index.html). In the field of Geo-Science and Geoinformatics some interesting ideas have been realised.

Already in 1997 e.g. Moore, K. et al. introduced the idea of a web-based learning environment in form of a Virtual Field Course. An important outcome of that initiative was the formulation of requirements on geoVRML (cp. Moore, K. et al., 1997b). Campbell et al. (2002) shows with the Virtual Big Beef Creek another web-based

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3D-learning environment in Ocean Science. For the activities in the German-speaking area during the last years see Katterfeld & Sester (2004). The overview deals notably with the projects 'geoinformation.net', 'gimolus', 'WEBGEO' and 'FerGI' as well as with 'GITTA' – the leading initiative in Switzerland.

2. CONCEPTS OF THE PROJECT "VIRTUAL LANDSCAPE"

The project "Virtual Landscape" is carried out within the scope of the joint project "E-Learning-Academic Network" (ELAN), which aims to provide a broadly spread network of E-Learning in different disciplines in the state of Lower Saxony, Germany (http://www.learninglab.de/elan/).

The idea of this project is to represent the landscape virtually in order to provide an intuitive entry point for studying the landscape, its genesis, the spatial processes occurring on it, but also models for describing and analyzing it. The project consists of three main components: a virtual landscape, learning material related to it, as well as modules in terms of applications or scenarios (cp. Fig. 1). The idea of the Virtual Landscape may open a variety of applications. However within the scope of this project just one distinct application – the planning of a railway line – is about to be carried out as an interdisciplinary project with partners from civil engineering and landscape planning.

2.1 Action-oriented learning

Using the Virtual Landscape supports the action-oriented concept of learning. The advantages of such a concept are described by Riedl, A. & A. Schelten (2002): Cognition and cerebration will only be a complete action when implemented in practise. Human action is mentally tested before acting, depending on cognition and cerebration. The comparison of the mental plan with the real action will feed back on the mental map of the doer. The back coupling to cognition and cerebration will alter and extend these as well as evolve new cognitive structures. Riedl, A. & A. Schelten (2002) further reason that learning without execution of actions remains at the state of mental action and therefore remain distant from real acting. To counter that danger an interactive environment is aspired.

2.2 Content

The target group for using the developed E-Learning-Environment are students in Earth Sciences, such as Geodesy, Geoinformatics, Geography, Environmental Studies, Landscape Planning as well as students of Applied Computer Science. These students have to learn how the landscape evolved, how the processes in it work and are interrelated, as well as how to make decisions concerning the landscape and how these forms and processes may be represented and analyzed in (digital) data.

Figure 1. Components of the project.

Based on fundamental questions raised during the exploration of the Virtual Landscape, course material is attached that explains these phenomena or provides the necessary background for them.

The overall bracket in the Virtual Landscape project consists of learning materials for basic principles of GIS. At the moment courses, such as "Webcartography" and "GIS: structures and architectures for the Internet" are under development. Its content is designed for the use in blended-learning-scenarios. These materials aim to provide the student with knowledge about GIS. By that the student should learn how to considerer the techniques and the data used in the Virtual Landscape, which itself will be used in more applied parts of the education.

2.3 Applications

As illustrated in Figure 1 applications of the mentioned disciplines may be integrated in form of text-based units, enhanced by animations, interactive illustrations and tests. They should provide the base for the so-called "modules", which are designed to guide students through application tasks within the Virtual Landscape and to give the background knowledge for the use of the Virtual Landscape. A "module" will – visually spoken – be put on top of the Virtual Landscape. To work with a task in a module the Virtual Landscape supplies datasets and
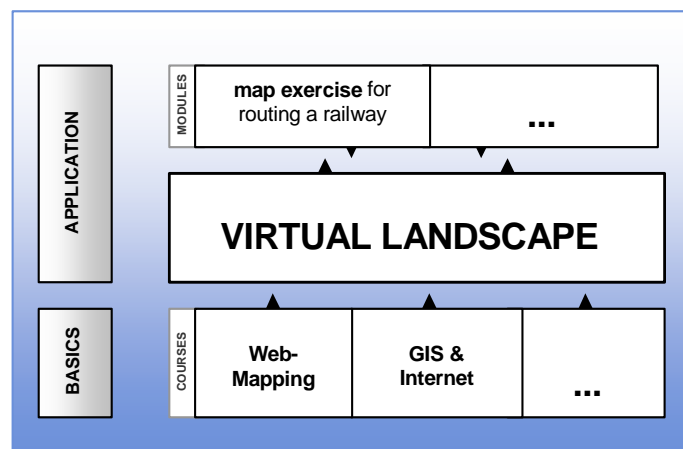
tools for exploring and analysing data. For that an infrastructure – described in section "3. Implementation" - will be provided.

An example for a module is a map exercise of a planning process for routing a railway line. This module is developed by the Institute of Regional Planning and Regional Science of the University of Hannover. The map exercise is carried out within a hands-on seminar. There students should solve a complex task by running through the different stages of decision making: from analysing data according to their relevance for a planned project, via deliberating about alternatives unto disputing the decision.

For the developed map exercise the process of planning a railway line in the Hameln-Pyrmont-county was chosen. The routing process takes place within the scope of the extension of a existing route, basically used for freight traffic. The extension is necessary to disburden another route, and to avoid the high-frequented traffic agglomeration of Hannover.

There are lectures that give detailed information and an introduction into the task. Thereby personal attendance is compulsory. In terms of a blended-learning concept the planning process will be exercised within the Virtual Landscape. For this the basic geodata and the data of a landscape framework plan are provided. The latter contains data like different soil parameters, areas of groundwater regeneration, water protection areas, flooding areas, areas of biotope protection, areas of recreation, noise corridors etc. Tools for exploring and analyzing data are supplied in the web-based environment.

For visualization and analysis 2D and 2.5/3D-views are used. For many applications, mainly in the field of analyzing, 2D-data is not only reasonable but also better and more easy to handle. However, for many other tasks perspective views are necessary. Such tasks are e.g. visibility analysis, dissemination of noise or visualization in planning processes, how much volume is affected, are there any shadowing effects and so on (Petschek, P. & E. Lange, 2004; Tiede, D. & T. Blaschke, 2005).

3. IMPLEMENTATION

The learning materials for basic knowledge ("courses") consists of texts, images, interactively explorable illustrations, animations and tests. The websites are usual HTML, generated by PHP. For the creation of assets PHP, JavaScript or Flash were used. More about these Course Material and didactic issues of realizing web-based learning material may be gleaned in Katterfeld & Sester (2004), Buchholz, G.A., 2003; Nielsen, J. 1997 or Nielsen, J., 1999.

3.1 Technical issues implementing the Virtual Landscape

As illustrated in Figure 1 the Virtual Landscape is laid on the top of the course content. In most cases it may be directly accessed from the learning materials. Depending on a special task dealt in the materials, a distinct view upon the landscape will be opened. When carrying out a map exercise for planning tasks, e.g. data of sanctuaries are provided. Analysis of soil erosion potentials requires e.g. data of soil type, soil texture, description of soil horizons or precipitation.

A commercial WMS has been used in the first stage. It provided a lot of functionalities, but no possibility to access data in a perspective view, notably 2.5D or 3D. Interoperability is also not a standard in commercial WMS, although sometimes stated. As Altmaier & Kolbe (2003) state, applications that employ OGC web services for 3D geo-visualization are rare.

The main developments in this field are two specifications which are at the state of discussion papers at the OGC at the moment. One is the Web Terrrain Service (WTS)(OGC, 2001). The WTS extends the WMS. It allows the display of maps in perspective views by definition of a 3D arrival point, an azimuth and the pitch of a virtual camera. 3D objects may be considered as well. Digital Elevation Models may be used as well as maps or orthophotos. The problem of that system is, that just raster images will be generated. However different layers of raster images can not be overlaid. Interaction with and navigation in the WTS is not possible either (Kolbe, 2004; OCG, 2001). An important feature thus is missing. The other development is the Web 3D Service (W3DS)(OGC, 2005). In comparison to the WTS the W3DS combines all objects in a scenegraph before rendering as the last step of the visualisation pipeline. The rendering is done by a client. Such a Client is introduced as the so-called Cooperative Web Map Client (http://wmc.ikg.uni-bonn.de/) from the Institute of Cartography and Geoinformatics, Bonn, which was leading in evolving the W3DS discussion paper as well. The main request are:

- GetCapabilities: to obtain service metadata. This operation in mandatory for all OGS web services and is described in the OWS Common Implementation Specification and the ISO/ DIS 19128 Web Map Service standard.
- GetScene (main operation): returns the 3D scene graph. Instructions to request a scene have to be assigned by parameters, like selected spatial reference system (SRS), bounding box, desired output

format and parameters to define a virtual camera. The operation GetScene is based on the GetMap-request defined in ISO/DIS 19128 Web Map Service standard.

The introduced Virtual Landscape follows pretty much the idea of combining all objects before rendering. The result of the combined objects is output as GML. This idea applies to the 2D and the 2.5/3D data. While the depiction of 2D-data will try to follow the WMS-specification, the creation of perspective views in 2.5D/3D will follow the ideas of a W3DS as much as possible.

The system to be implemented for the Virtual Landscape has to dispose on its own retrieval service to be able to access data in any dimension (2D or 2,5/3D) and to add the desired functionality. The use of GML3 is indispensable, due to its ability to code coordinates with a Z-dimension. The following basic requirements are compulsory for the learning environment:

- allowing easy data access on possibly distributed data sets,
- visualization of data in 2D,
- visualization of data in 2.5D/ 3D and
- basic analysis tools in 2D (and 2.5D/3D).

In terms of retrieval of 2.5/ 3D-data these demands exceed the WFS, WMS and the W3DS specification (OGC, 1999; OGC, 2002b; OGC, 2005) on the one hand – because adding more GIS-functionality is not considered in any of the mentioned specifications – but do not take use of all requirements in this specifications on the other hand. Like stated above the mentioned specifications give the main part of orientation and inspiration to develop the system of the Virtual Landscape.

To implement such a system a serverside Java-Environment has been chosen. Java provides the functionalities to work in the WWW on the one hand. On the other hand there exist some libraries, e.g. JUMP or JTS which supply with appropriate data structures (e.g. Class Coordinate or Class FeatureCollection) as well as GIS functionalities (e.g. Class Overlay or Class Buffer).

An architecture, according to the OGC-conform visualization process – described by Cuthbert's Portrayal Model (cp. Fig. 2) – was set up (cp. May et al., 2003; Fitzke, J. & K. Greve, 2002).
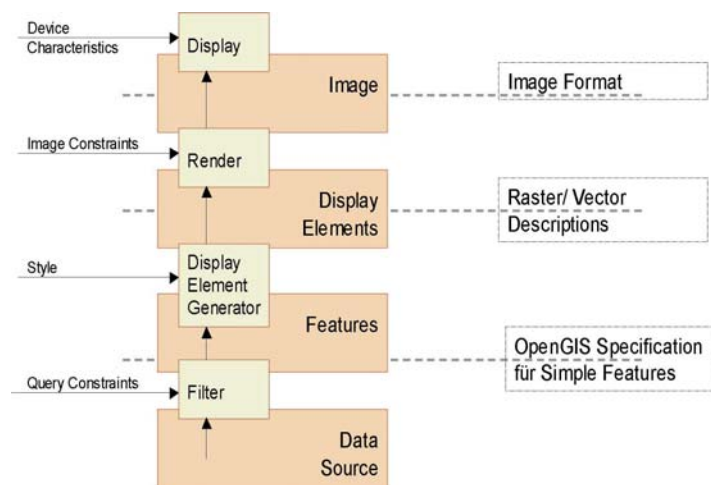

Figure 2. Cuthbert's Portrayal Model – reference for the visualisation pipeline
(cp. May et al., 2003; Fitzke, J. & K. Greve, 2002 after Doyle, A. & A. Cuthbert, 1998)

3.1.1 Available Data, Data Formats, Metadata and Data access:

Vector data of the Digital Landscape Model and the data of the Landscape Framework Plan are stored in a database (PostGIS) according to the Simple Feature Specification (OGC, 1999). This data are modeled just for 2D, which means that the data consists of points or lines and polygons, constructed by points, which have just X- and Y-coordinates assigned to them. There do not exist much 'real' 2.5/3D-vector data, therefore artificial 2.5D-data had be generated by extrusion to test the system. E.g. bridges, pylons or buildings play an important role in planning processes.

Due to the fact that the GML-specification is concerned with the OGC Simple Features (OGC, 1999) the features' geometry properties is restricted to 'simple', such as point, curve, linestring/line/linear ring, surface and polygon. However unlike the Simple Feature Specification, GML allows for 3D coordinates, but it does not directly support 3D geometry constructs (Dorninger, P., 2003). Therefore these data have been converted in 2.5 by using the force_3d()-function of PostGIS. Now all the coordinates have a Z-Dimension, which is set to 0 by default in the database. The user may assign an individual height value to every layer.

Raster data of the Digital Elevation Model is currently still stored in a textfile (as raw data), but will be stored as an image-file (e.G. TIFF) in an Oracle-database in the future.

The description of all data is stored in a meta-database (cp. Katterfeld & Sester, 2004). The idea is to connect this meta-information catalogue to the database storing the geodata to allow meta-information-based selection. By using the meta-database's search-feature the data associated to a keyword or an area may be identified and queried from the database. However due to the implementation work of the proper system, the connection to the meta-database has not yet been established.

Vector Data

Querying the desired geodata from the database is – according to Cuthbert's Portrayal Model (cp. Fig. 2) – accomplished by a Web Feature Server (WFS). Herein query constraints (e.g. by specifying filters) may be added. This process corresponds to the filter-process visualized in Fig. 3 (OGC, 2002b). Special filters must be modeled to create the desired view upon the Virtual Landscape like stated in the beginning of chapter 3.1 of this paper. An example for a OCG-conform Web Feature Server for 2D-data is the Open-Source product Geoserver (http://geoserver.sourceforge.net/html/index.php). It is not known to the authors that any of the commercial or OpenSource WFS are able to retrieve 3D-data. Even the mentioned W3DS-service does not demand an explicit GetFeature-request, which means that it does not provide a component comparable to an individual WFS. Therefore the system of the Virtual Landscape has to cope with that and keep this functionality in principle ready. However the depicted system is not able to cover all the OCG-required requests and filter options yet. As a OCG-conform basic (i.e. read-only) WFS for 2 and 2.5D/ 3D data the service must – additionally to the available GetFeature-function – be able to provide further options, such as:
-   GetCapabilities: to describe its capabilities, indicate which feature types it can serve and what operations are supported on each feature type,
-   DescribeFeatureType: to describe – upon request – the structure of any feature type it can serve (OGC, 2002b).

Figure 3 and Figure 4 illustrate the mode of operation of our system. The "GetFeature"-functionality is realized by an SQL-request, which retrieves – depending on the user's input – the data from the database and returns a FeatureDataset. This is a data structure from the JUMP-library, which is made up of a collection of coordinates. The geometry object model according to the SFS can be detected in an additional method. The Feature Dataset may be used to perform different kind of GIS-analysis. Independent from the fact if any analysis has been done or not, the Feature Dataset may be translated in an XML-schema for output. The received GML application schema is an XML Schema written according to the GML3 rules. Theses rules keep a huge variety of model cases ready. Just the needed application is implemented, which is quite slender in the first stage in our case. Extensions will be added with growing functionalities of the system. Within the geo-community different GML-types are in use. One GML does not need to be compatible with another GML. Hence the structure of our distinct GML is defined in an appropriate XML schema description (XSD).
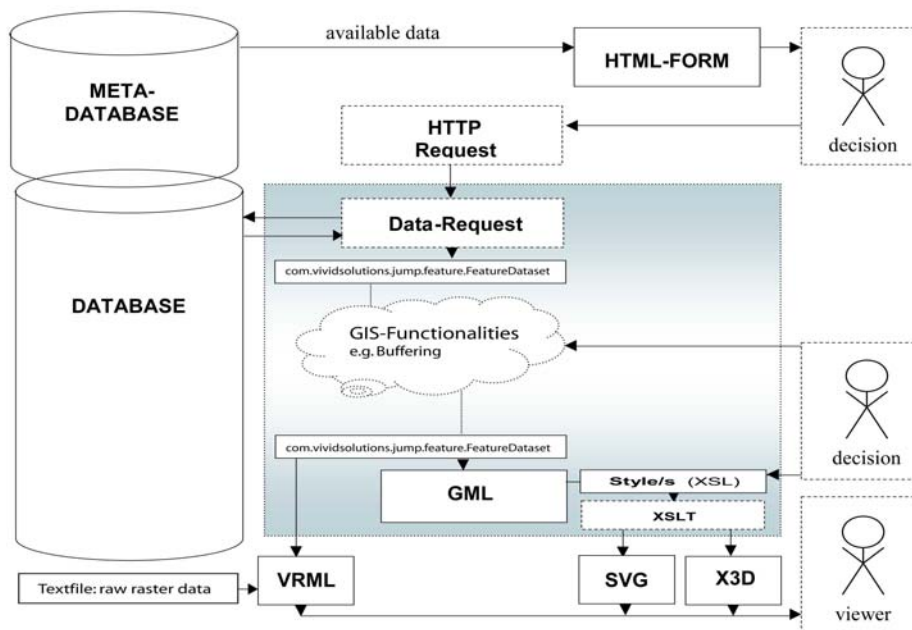

Figure 3. The architecture of the system, delivering vector data

Raster Data

All the described facts apply to vector data. To obtain a mapping of the landscape's situation, the terrain has to be modeled by a Elevation Model based on the raster data. The WTS provides images of perspective views on the terrain. However the landscape may be displayed as a surface in VRML as well. This is even more advantageous because it may be treated like an object and therefore distinctly addressable in e.g. adding user-desired style or added by functionality. According to the idea of the W3DS it can be part of a scenegraph. Due to the fact that the GML-specification deals only with primitives, complexes and aggregates, but not with surfaces (OGC, 2003), the height data obtained from the text-file-based raster data is converted into VRML directly. Any

concepts which serve the demand of interoperability have to be developed for raster data as well. Even though this step is not yet implemented in an interoperable way (due to the lack of standards), it is an essential part of the realization of the Virtual Landscape.

A challenging task at this point is to integrate the raster with the vector data in real time, because both data may come from different sources. This will be achieved in the way, that for every point of a vector object the height value must be interpolated from the terrain model by e.g. bilinear interpolation and stored e.g. like an attribute. Lenk (2001) annotates that there is the problem, that the density of points describing the vector data is not corresponding to the density of height values in the raster. E.g. in the case that the raster data is more dense than the vector data points have to be added to achieve a well integrated data set.

3.1.2   Data presentation in 2D and 3D:

GML is not concerned with visualization of the data. According to Cuthbert's Portrayal Model (cp. Figure 2) the data has to be rendered by assigning raster- or vector descriptions.

Within an OGC-conform architecture these work is run by a Web Map Service (WMS)(OCG, 2004) for 2D and a W3DS (OGC, 2005) for 2.5/3D. An example for such a WMS is the Geoserver WMS (http://geoserver.sourceforge.net/html/index.php), which is set on top of the geoserver WFS or the UMN-Mapserver (http://mapserver.gis.umn.edu/) and controls the work of a WFS internally. An example for the W3DS is the above mentioned service of the Institute of Cartography and Geoinformatics, Bonn.

The job of visualization – comparable with the GetMap or GetScene-request – is implemented in the system of the Virtual Landscape as well (cp. Fig. 4). Likewise mentioned for the data retrieval, the task of visualization of 2.5D/ 3D-data has to be coped with. A goal is that the system – defined by decisions of the user – has direct influence on visualization, like using special style or displaying distinct data, selected by attributes, as well as adding further functionality to the system. By developing the visualization process individually this aim was followed.

Output Formats

Due to the fact that GML is an XML-description for geodata, it may be transformed – like other kinds of XML-schema – into a different XML-structure, such as SVG or X3D formats used for web-presentation of vector data (Dorninger, 2003). Hence SVG was chosen within the described system to visualize 2D-data. Like SVG X3D is XML and in terms of interoperability more sophisticated, however X3D-Viewers are not so much in use yet, experiences have not yet been gathered very intensely – so work is basically done with VRML up to now. Kolbe (2004) adds to this arguments that many 3D-Programms are able to import VRML97 and thus could import data from a 3D-Web Service directly. The same applies to programs which are able to export VRML97. However it is assumed that – for interoperability's sake – the system should be carried over to X3D later as well. To X3D's credit is to count its advanced syntax. It disposes of six so-called profiles. Each of it covers different functionalities at different stages of complexity. Full implementation of the X3D-specification features the "Full profile". In contrary the "Immersive profile" covers the VRML-standard, for which X3D is downward compatible (Krone, O, 2003; Web 3D Consortium).

Stylesheet Transformation

To create SVG for 2D-visualization the transformation instructions for the conversion from one XML-Schema into another XML is described in the XSLT („Extensible Stylesheet Language Transformation") 1.0 Recommendation (Lehto, 2001) and was applied according to the step of generating display elements (cp. Fug. 4). XSLT is designed for use as part of XSL, which is a stylesheet language for XML, i. e. it includes an XML vocabulary for specifying formatting (http://www.w3.org/TR/xslt). The transformation proceeds when a XSL-transformation engine processes an XML-document (e.g. a GML-document) and an XSL-stylesheet. A list of available XSLT-engines and editors may be found at http://www.w3.org/Style/XSL/. Within a Java Environment the Java API for XML Processing (JAXP) may be used. This is integrated in Java 2 versions higher than SDK 1.4. For older version it may be downloaded from http://java.sun.com/xml/. JAXP was designed in a way that developers may choose between different XML parsers without affecting the code, likewise database-drivers. With JAXP XML documents may be edited with SAX 2.0 and DOM Level 2 as well as XSLT transformed (Ullenboom, 2003). The step of stylesheet-transformation which was carried out for conversion of 2D-data in SVG conforms to the "Display Element Generator" in Figure 2.

For conversion of the extruded 3D (vector-)objects until now VRML97 is – according to the mentioned reasons – derivated directly from the FeatureDatasets by a server side Java program. The surface description (i.e. the raster data) is – due to a lack of standardization in the interoperable use of raster data – conveyed into VRML directly by a server side Java program. The surface information is provided in form of height values for a regular cells raster to use in the "ElevationGrid"-Node. The vector object provide their height information in form of coordinates, which are uses in the "IndexedFaceSet"-Node of VRML to model the compounds.

Rendering

The rendering job according to Cuthbert's Portrayal Model (see Fig. 4) is carried out by the SVG and VRML-viewers, which must be available on the client's side. Examples for such PlugIns are Adobe SVG-Viewer (http://www.adobe.de/support/downloads/main.html) and the Cortona Viewer (http://www.parallelgraphics.com/products/downloads). Due to that allocation (Filtering and Display Element Generation on the server's side and Rendering and Displaying on the client's side) a Medium Server - Medium Client-Architecture according to Schmidt et al. (2003) is provided. As Altmaier & Kolbe (2003) state, the advantage of medium clients is that plug-ins typically provide functionalities for realtime rendering and navigation and therefore allow high degree of interaction.
Figure 4 summarizes the architecture of the Virtual Landscape in comparison to Cuthbert's Portrayal Model (see Fig. 2).
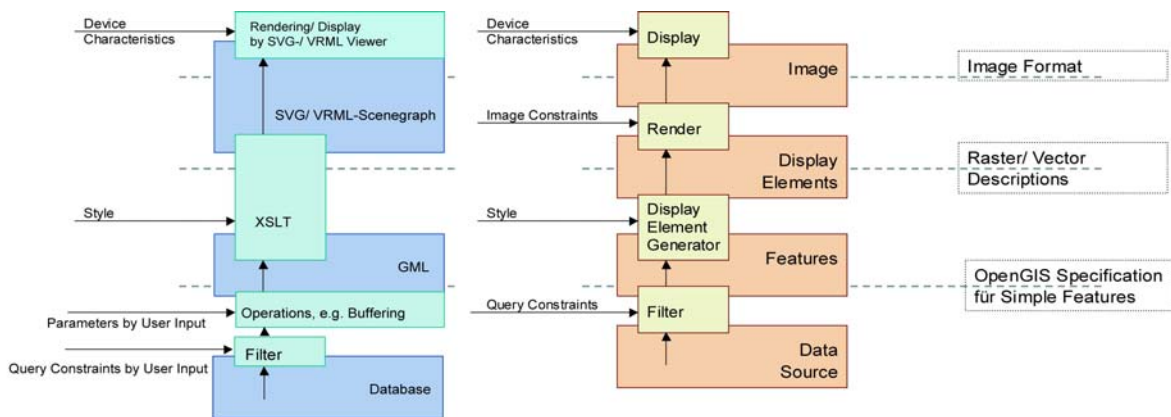

Figure 4: Architecture of the Virtual Landscape (left) compared to Cuthbert's Portrayal Model (right).

Further issues

In the course of the visualization process some issues have to be coped with. One is that different cases of simple features exist. As long as they are expressed in GML, just the type has to be determined to e.g. define whether a </gml:innerBoundaryIs> - tag has to be introduced into the polygon-type in case of holes in it and which coordinates have to be sorted in which tag. However for visualization lots of templates have to be produced, mostly dynamically. For managing this task, a sophisticated stylesheet-management, perhaps even based upon a database would be desirable. Functionalities, where the user may influence the style would be nice as well. The stylesheet management could include a calculation of the appropriate scales of objects as well. If for example a point has to be visualized as a sphere, the dimension of the sphere has to depend upon the scale of the display map. Appropriate ratios have to be assigned automatically. Within the styles further parameters like the appropriate viewbox (for SVG) or the appropriate viewpoint (for VRML) has to be defined.
Another problem is the layer-management. GIS is well-known for the principle to organize themes in layers, starting with the most-area-covering on the bottom and ending with the points on the top. Keeping this order in an automatic way, is also a demanding task. Here the system has to develop effective routines, which have to work at the stage of the Display Element Generator (cp. Fig. 2) already, but come not apparent until visualized.
Lots of further cartographic problems have to be solved. Some issues for web-, respectively screen cartography have not been consolidated, other principles are established (cp. e.g Brown, A., 1993; Dickmann, F., 2001; Kraak, M. 2001).
Another, problem is the indication of the scale. It may just be assigned graphically, because by using coordinates distances are implicit. Just the problem of automatic placement of the scale bar has to be solved. More striking is the task to indicate the scale numerically. It is not possible without 'asking' the user for his screen size. Even though the resolution may be detected by JavaScript, the translation can only be solved when knowing the real screen size in inch or cm.
The issue of orientation and navigation within a 3D-scene should not be underestimated. When moving the scene once it may be hard to find out afterwards where north and south or even button and top is. Therefore some help for orientation, e.g. a raster or at least a north arrow should be added.
Another big issue is the amount of data. The disadvantageous file sizes of the wordy XML format result in quite long waiting time for the website. Here compression algorithms like e.g. SVGZ have to be applied. Another approach is to reduce the amount of data at the state of the generation of Display Elements already. One can assume that the scale of display of the data is different than the data are modelled for. In the case of display in smaller scales real-time generalisation can be applied. In Sester et al. (2004) such an approach is described for 2D data. Approaches for 2.5/3D have to be investigated.

3.1.3　Analysis Methods:

To explore the delivered 2D- and 2,5/3D-data functionalities like Pan, Zoom, Select and Query are provided. Zooming and panning are features included in the SVG- and VRML/ X3D-Viewers. Queries may be implemented using e.g. JavaScript, triggering a database query based on addressable objects in a scenegraph.

Carrying out spatial analysis, functionalities like buffering or clipping are desirable. A buffer-operation has been implemented using the JUMP and JTS-library to give an example of the operation mode of such functionalities. Figure 3 illustrates the principle of how the system works.

Further desired functions are overlay-operations, like clipping or union. Selection either based on geometric objects or attributes is a further issue to be addressed. The Virtual Landscape aspires a lot of functionalities of a Geographical Information System. However it does not aim to feature the full functionalities. Advanced analysis does not have to be carried out in a web-based environment. However, within the educational scope students might not have access to GIS-software at any time or place. For them an introduction into the ideas and basic functionality should be provided, for which the designed architecture is very suitable.

Figure 5 shows the prototype of the Virtual Landscape. In the right field of the table all datasets which are available from the database are listed. Using the buttons 2D-Display and 3D-Display will generate SVG and VRML-outputs of the selected dataset according to the specified bounding box. When requesting the 3D display an extrusion height must be assigned to the dataset by using the provided textbox. Figure 5 illustrates the buffer-operation for 2D and 3D as well. The user may specify the distance of the buffer in the provided textbox.
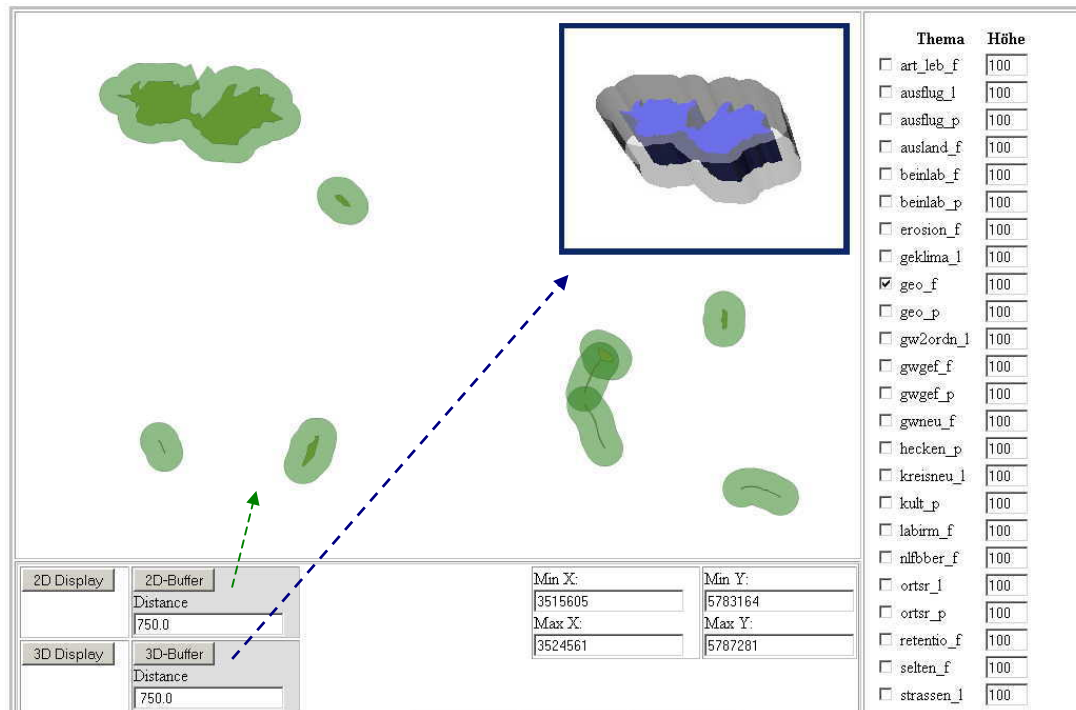

Figure 5. The display of a buffer in 2D and 3D

To implement functionalities, which demand for direct interaction with the geometrical objects, techniques like JavaScript for SVG and possibly the External Authoring Interface (EAI, http://www.frontiernet.net/~imaging/eaifaq.html) for VRML or the Scene Access Interface (SAI) for X3D (http://www.web3d.org/x3d/specifications/ISO-IEC-19775-IS-X3DAbstractSpecification/Part02/index.html) have to be used.

3.2　Using the System in a Learning Scenario

During the last teaching period an approach to integrate such web-based data delivery and -analysing techniques into the teaching process has been tested with a commercial WMS. With that tool the students should carry out an exercise. Based on data of a landscape framework plan the optimal corridor for a railway line had to be found using operations like attribute-based selection, overlay and buffer. The results of the exercises of all students were also displayed by the WMS for information towards each other afterwards. The echo on students' side was quite well and the results satisfactorily. Using the new implemented system of the Virtual Landscape will bring the third dimension into the work. Students may browse and partly analyse their data in 2.5/3D. Results of the exercised planning process may be viewed in a perspective way (because mapped into the terrain by the Virtual

Landscape). Hence a surplus when evaluating the planning scenario in a perspective view may be achieved. We hope to achieve a similar well echo when using the system of the Virtual Landscape with its limited but goal-orientated functionalities in 2D as well as in the perspective option.

However to add more inherent knowledge to the system the geodata could be enriched with further information. This knowledge can relate both to the application itself but also to the learning scenario. E.g. for a scenario of planning a railway offsets for legally required distances from certain areas (e.g. water protection areas, nature reserves or settlements) could be assigned to the data itself. As another example, information of how to act in the planning process with such areas – e.g. are there any further investigation or compensation necessary – could be added to certain data (e.g. areas endangered by erosion). Those information could be transported by XML, which of course requires dedicated XML-schemas, i.e. schemas which regulate the kind as well as the form of information to be given (e.g. for the railway planning scenario: <distance in m from planned railway>1000</distance in m from planned railway> or <compensation in case of invasion>renaturation of 120% of the destructed area in another place</compensation in case of invasion>). The information have – of course – to be formulated conforming to standards. Standards have to be developed based on models and the input from experts. The added information could be used in the learning process to e.g. generate automatic tests or some warning when the student e.g. disregarded an offset.

How to derive the information to be added and how to structure it for the use in a learning system will be discussed and elaborated in more detail within the further work.

4. CONCLUSION AND OUTLOOK

The paper introduced an idea of how to approach E-Learning demands without extensive text-materials. The idea of a system, orientated on OGC-standards for web-based geodata delivery has been pictured. Issues of the implementation have been addressed in both general and detailed way. Finally a glance at the use as learning environment has been opened, even thought the system has not yet been tested in real conditions within a distinct lesson.

In the course of the paper many problems have been brought up and ideas how to approach the tasks were discussed. As a final outlook it may be summarized that the implementation of the described system will be continued in a way it is described above. Additionally the issue of how to enrich geodata for learning purposes should be addressed as well as testing the whole system within the apprenticeship in the future. Ideally further application (so-called 'modules', cp. Figure 1) could be developed.

Much discussion had been done about the surplus of web-based learning. Providing 'perfect' animations and simulations does not activate students to reflect about problems and it does not train abstraction. Hence this project does not aim to emphasize on text-materials, but on an interactive data-based environment. This environment is – in its basic principles – alike a GIS, just not so complete. According to the mentioned action-orientated learning approach the students learn to approach a GIS and – when concentrating on other issues firstly (like planning a railway line) – do not have to care so much about handling the GI-system.

Together with the facts of time- and place- independent as well as the interest-dependent use of the interactive environment the benefits of the Virtual Landscape are to be seen.

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