DEVELOPMENT OF A GIS SUPPORTED INTERACTIVE "REMOTE SENSING" LEARNING MODULE

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ABSTRACT:

The number of commercial and non-commercial e-learning applications is rapidly increasing. Various products are either available through the internet in terms of tutorials or on CDROM. The main advantage is the time and place independency of education and individual learning speed. Therefore, one can speak of a didactical innovation through more flexible organisation of tuition, whereas the disadvantages are represented by low interactive level, lack of didactical conception, anonymity and confusion by the use of too many media objects. In awareness of the deficiencies of e-learning, the project GIMOLUS (GIS supported model orientated learning modules for environmental sciences) to which the following learning module remote sensing belongs, has a strong focus on interactivity and media didactic. The main targets of the GIMOLUS project are the development of an internet platform for e-learning, support of self-study, sustainable integration in the curricula, development of specific learning modules, creating a virtual landscape which demonstrates the elementary interrelations of the ecosystem and finally the useful inset of multimedia and interactivity through a media didactic concept. Methods and technologies in the fields of GIS and modelling are playing the leading roles in this interdisciplinary learning platform. To unify all the different aspects of the involved disciplines, the above mentioned virtual landscape serves as a common base to explain and to visualize the processes, the interactions and their effects that are taking place in complex ecosystem. The participating institutes have the chance for a more attractive, up-to-date and transparent tuition.

The following paper presents the development of a single learning module on remote sensing. As described below, this special module is part of a global interdisciplinary project called GIMOLUS, which aims at creating an internet platform to improve teaching at universities. At first, a review of the textual and technical concept of the whole project is given. Built on this, an explanation of the explicit content, the thematic emphases and the implemented interactive animations and exercises of the remote sensing module will follow.

1. INTRODUCTION

The project aims at developing scientific learning modules, which improve teaching at the institutes involved by using internet technologies, multimedia presentation and communication technologies in the fields of GIS and modelling. The learning modules will be used for preparation and reinforcement of lectures. Furthermore, their content will be relevant for examinations. The benefit of media based learning platforms on which the different modules are integrated lies in the visualization of complex interdisciplinary interrelations and the possibilities to perform applied exercises and to communicate.

The BMBF (Ministry for Education and Research) which is the financial promoter, encourages the project partners to work out a common concept and to integrate the different curricula and further to search for points of contact to ensure a permanent establishment of the learning modules in teaching. The close interdisciplinary teamwork of the project partners again causes synergy effects profitable for both tuition and research. Altogether six institutes from four German Universities namely University of Oldenburg, Würzburg, Duisburg and finally as the leader of the project the University of Stuttgart are involved. The target group is represented by about 1600 students who have a strong practical reference in their respective study course. The project started in June 2001 and will be finished in August 2003. After that the Computer Center of the University of Stuttgart will be responsible for the technical sustainability of the learning platform whereas the module content is to be actualized by each institute.

2. LEARNING PLATFORM

2.1 Conception of the learning platform

The students can easily access the GIMOLUS platform through the internet by registered username and password. Dependant on their respective study course they can choose the learning modules they would like to work on.
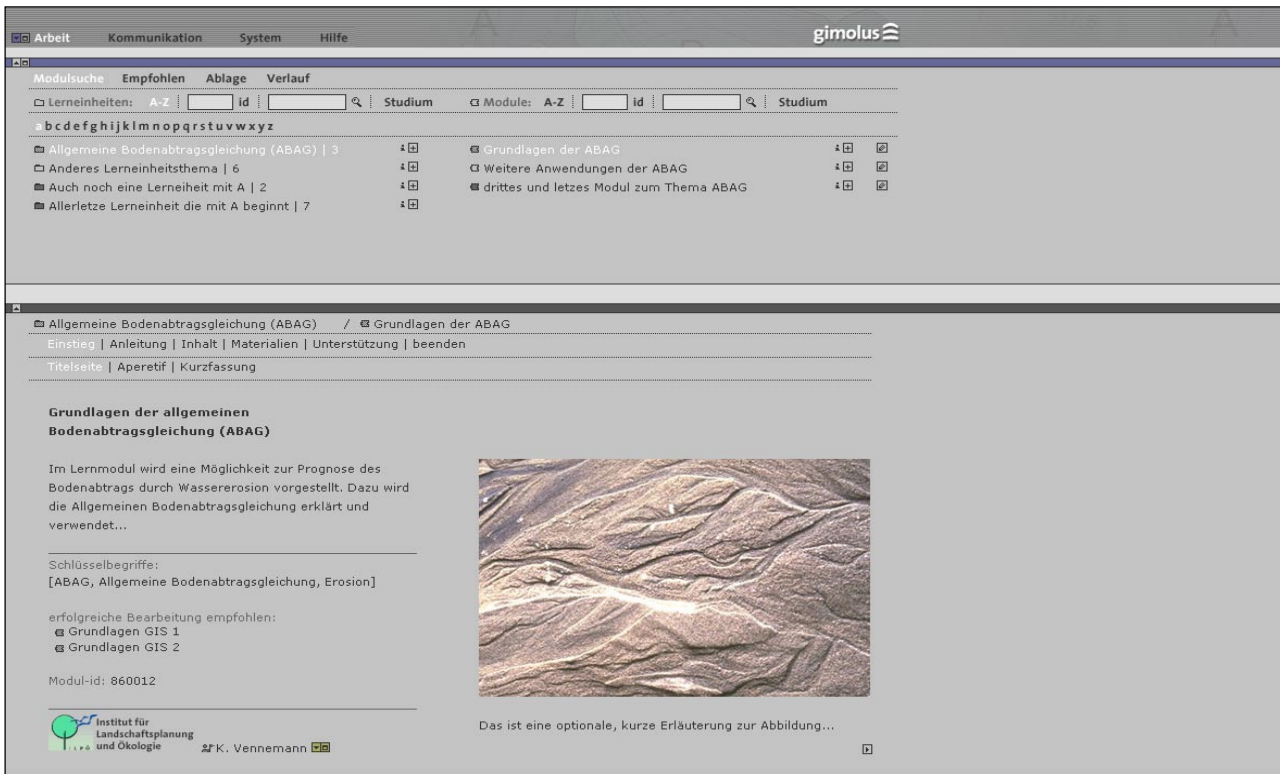
Figure 1: Horizontal navigation structure of the GIMOLUS
user interface

A title page provides basic information about detailed content, process time, previous knowledge and technical prerequisites. Each of the modules follows a specific sequence inside a so-called learning unit. The students can easily navigate through the module`s specific hierarchical structure. The horizontally arranged menu (see figure 1) makes it easy for the user to follow his path during his work on a module. All letters, buttons and icons are developed by a media designer with regard to usability and functionality.

An integrative element for all disciplines is a virtual landscape which is accessible in every module. To explain spatial and time processes in different environmental sciences, a virtual landscape represents an ideal base. The virtual landscape is presented by a quasi realistic landscape located in southwest Germany, in the state of Baden-Württemberg. For this region a geo-database containing all kinds of data like a digital terrain model (DTM), orthophotos and thematical data in different scales is available. It is planned to visualize this landscape also in 3D. Another important component is the communication with other students or tutors to get a feedback while working on a specific module. Communication techniques either asynchronous ones like email, mailing list or newsgroup or synchronous ones like chat, audi- and videoconferencing (Kerres, 2001) will be implemented into the platform insofar as it is useful for practical use in education of each of the institutes involved. An intensive media didactic consulting which is guaranteed by the Institute of Educational Science of the University of Duisburg decides what kind of communication techniques and applied exercises are useful and appropriate. Additionally the above-mentioned institute carries out a successive and comprising evaluation of the whole project with special regard to gender problems.

2.2 Architecture of the module platform

All modules will be created in XML, the meta language which the W3-consortium declared as an official standard in 1998. After a detailed examination of existing e-learning products, an XML-based architecture with a uniform XML-document structure for all module contents is favored. This will be realized through a specific DTD (document-type-definition), therefore a sustainable usability and a unique appearance is guaranteed. For better readability it was decided to present the content in two columns to structure the text, pictures and other elements (see figure 1). Based on the XML modules files, generated through the DTD an XSL-transformation produces web compatible contents. The data management is realized through a combination of a database (MSSQL) and file server systems. Complex elements like flash animations, WebGIS applications, server side scripts such as PHP, JSP or Java applets will be anchored in the XML module file. Each author edits his module content with an XML-Editor (XML-Spy) which offers the user different edit and viewing modes. Figure 2 shows a plan of the main platform elements and techniques.
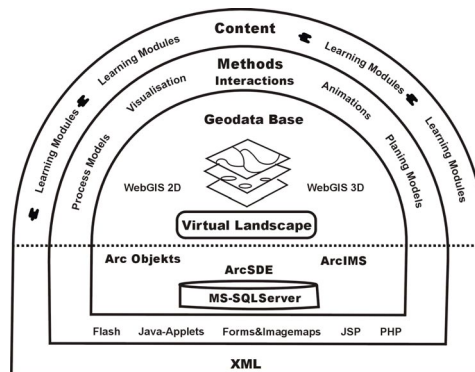

Figure 2: Elements and Technologies of the Learning Platform

The integration of WebGIS is mainly based on the use of components from ArcGIS – the product family of ESRI. The latest available clients for Arc Internet Map Server (ArcIMS) allow extensive configurable reading access on geo-data with Java or HTML-based "Viewers". As mentioned above, even a client for 3D-visualization of the virtual landscape is provided. For model calculations and complex intersections of geo-data, implementation on the server and supervision through a Windows Terminal Server (WTS) on the client is intended. For operations with a lower calculation complexity an integration to the standard viewers is intended whereas the functionalities of ArcMap can be used by means of the above-mentioned WTS.

3. IMPLEMENTATION OF GIS LEARNING MODULES

3.1 Module structure

The Institute for Photogrammetry (ifp) and the Institute for Applications of Geodesy to Engineering (IAGB) at the University of Stuttgart are designing and developing learning modules which will be used as a supplementation for the lectures "Data Acquisition and Management" and "GIS". The following curricula are affected by these lectures: "Geodesy and Geoinformatics", "Geography", "Informatics", "Environmental Protection Technology", "Biology", "Infrastructure Planning", "Water Resources Engineering and Management" and "Architecture". For the newly established master study course "Air Pollution and Waste Management" an implementation is being prepared.

Figure 3 shows the structure of the modules which have to be developed by ifp (light grey) and the IAGB (dark grey). The structure of the learning modules orients itself to the IMAP-Model (Chalkin, 1977). This model fully describes all the functionalities of a GIS, like data input, management, analysis and presentation.
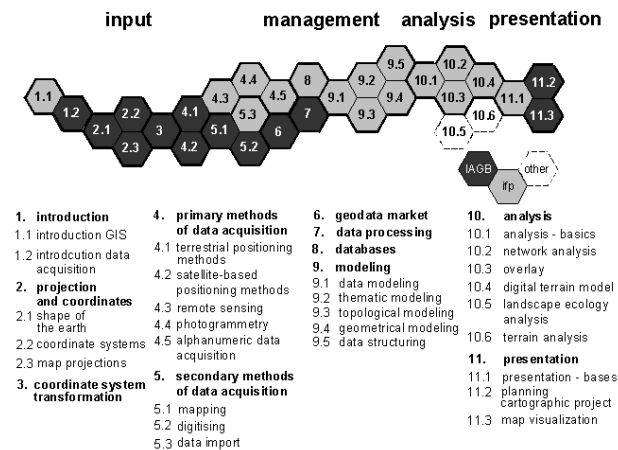
Figure 3: Learning modules developed by ifp and IAGB

A learning module is a closed, self explaining information unit consisting of a combination of textual explanations and other external components such as images, animations or other programs. They are connected to each other and refer to other internal or external modules. Qualified authors or students will be responsible for the content of the learning modules. As you can see in figure 3 some modules are combined together into learning units. The learning units in the structure model are

introduction, projection, coordinate system und transformation, primary methods of data acquisition, secondary methods of data acquisition, geodata market, data processing, databases, modelling, analysis and finally presentation.

All learning modules are structured consistently into declarative, procedural and contextual parts. Declarative parts can be described as the transfer of knowledge by text and graphics whereas procedural parts contain interactive elements for a better understanding of spatial processes. The contextual part imbeds the knowledge in its application.

4. REMOTE SENSING MODULE

As can be seen in figure 3, the remote sensing module belongs to the learning unit "primary methods of data acquisition" which is next to the modules of photogrammetry and satellite based positioning methods. Remote Sensing is therefore a very important data source when working with GIS (see figure 4). GIS represents an effective method to handle huge data files for planning, conservation of natural resources and protection of the environment (Albertz, 2001). The gradual coalescence of GIS and digital image processing technologies makes the user more familiar with its methods even if they don't have a comprehensive education in remote sensing.
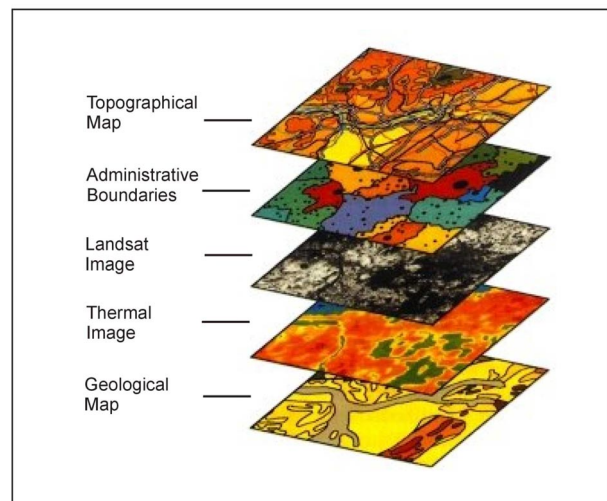
Figure 4: Different layers integreate in a GIS including remote sensing data (Albertz, 2001)

4.1 Aims of the remote sensing module

It is impossible to give a complete overview of the state of the art of remote sensing in the module. But some of the possibilites will be outlined especially with regard to the GIS perspective. "Remote Sensing is the observation of a target by a device separated from it by a distance" (Barret and Curtis, 1976). Therefore in the respective module exploration through earth observing satellite systems will be the thematical focus. These satellite systems deliver images which could be thematically interpreted either by competent users or by means of mathematical statistical methods of multivariate classification. To get discrete categories of surface phenomena one needs to extract continuous image information. Unsupervised classification methods like cluster analysis and supervised classification methods like maximum-likelihood method or minimum distance classification will be focused. To get familiar with the most important operating satellite systems,

to know about the application difference and to process these remote sensing data in a GIS is the main objective of this learning module.

4.2 Structure of the remote sensing module

The bilingual remote sensing module is structured in an introductory part, the content itself, applied exercises, the additional materials and finally communication possiblities. The introduction part presents all the necessary information about the operating time, the difficulty level and the previous knowledge as well as the technical requirements. In the following content the physical basics like the electromagnetic radiation, its quantitative parameters and the representation of all existing wavelenghths in the eletromagnetic spectrum will be explained.

After that, active and passive sensors and their use in modern satellite systems will be described. A distinction is made between optical mechanical scanners, to which for example Landsat belongs and optical electronical scanners like SPOT, IKONOS, MOMS, ERS and IRS. Radarsat and the recently launched Envisat are representatives for active remote sensing systems. The modern development of high resolution mini-satellites and their applications will also be discussed. All the above-mentioned satellite systems and their specific parameters and techniques will be compared and explained with regard to their specific applications.

For the content, educational books about remote sensing and its application will be used (Albertz, 2001, Barret and Curtis, 1992, Barthelme, 2000; Bill and Fritsch, 1991, Lillesand and Kiefer, 1999, Sabins, 1997). Interactive animations (see Figure 5 and 6) will be executed in an external window supporting the explaining text.
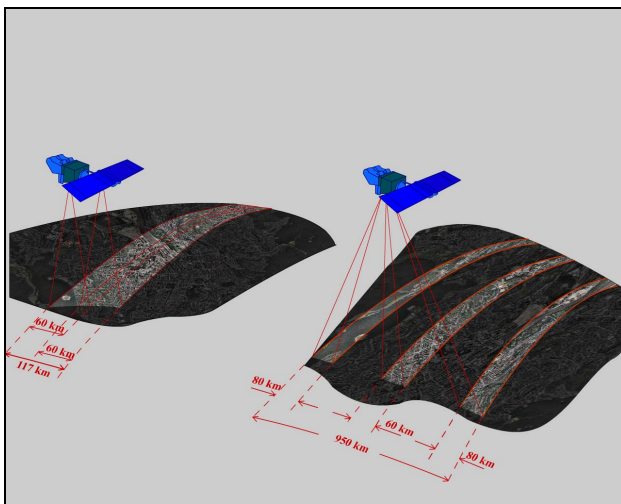

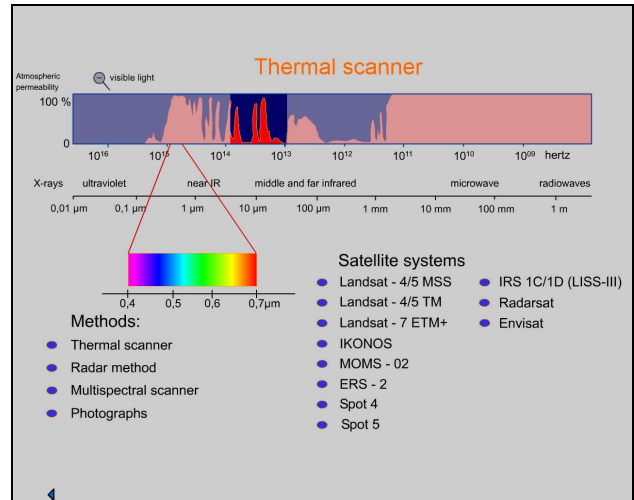Figure 5: Animation of the different recording modes of SPOT

Figure 6: Animation of the recording techniques and satellite systems in dependence to the electromagnetic spectrum

Image processing focuses on the differences between analog and digital images and geometrical and radiometrical transformation of these data. A special focus is put on the possibiliy of combining data sets of different spectral channels. In the following only the digital image interpretation with the method of the multispectral classification will be described. An interactive animation concerning band combinations (see figure 7) shows a satellite image of Landsat 7 in different channels of an area between Novi Sad and Belgrad, Serbia in June 2000.
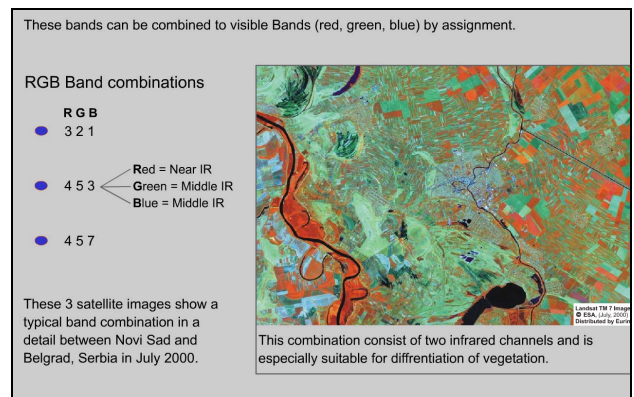

Figure 7: Interactive animation of Landsat 7 band combinations

4.3 Applied GIS exercises

The applied interactive exercise will be executed in ArcInfo. Citrix Metaframe is used for the access to the virtual landscape. The Citrix Metaframe solution is an upgrading of Windows Terminal Server Technology (WTS) and is also suited for low transfer band widths like 56 k modems. In this case client specific instances of ArcMap will be called from the ArcMap MXD files on the server. The MXD files are referencing all project relevant geo-data and configurations of the GUI as well as all ArcObjects applications including the GUI extensions. For each user an ArcMap instance will be started and executed on the server.

The basis for the GIS exercise in ArcInfo are seven channels of a Landsat scene encoded in grey scales. The student will be instructed about how to find the most suitable band combination

to locate vegetation differences near a river. They can experiment with different band combinations and visualize the result to see what kind of landscape elements are better to interprete with specific combination (see figure 8). For a defined area in the landsat scene the student has to digitise on-screen different polygons which characterize the landscape elements and classify them. The generated layer has to be saved and will be controlled and evaluated by a tutor.

The main aspect of the applied exercise is to get familiar with GIS software, and to see how remote sensing data can be processed.
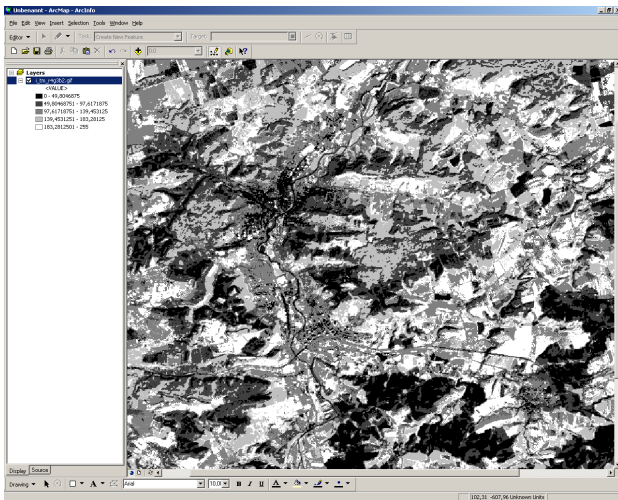

Figure 8: The interface of ArcMap with a classified band combination of Landsat 7 in Jena, Thüringen

5. PERSPECTIVE

The "Remote Sensing" module described is one of fifteen modules developed by the ifp. They are all part of the lectures GIS I und II. In the forthcoming winter semester 2002/2003 some of the modules will be implemented in teaching. At the end of the developing phase in August 2003 there will be a final project evaluation of the whole interdisciplinary learning platform.

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