A SERVLET BASED TRAINING COURSE FOR REMOTE SENSING

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ABSTRACT:

A training course, covering remote sensing topics, was implemented by staff of the Photogrammetric Department at the Technical University Berlin (TUB) several years ago. Feedback from students encouraged the team to set up a newly designed and improved training system, which is now introduced in this paper.
The main part focuses on development and implementation of the eLearning System. Two important aspects are discussed: course administration and test management, both based on database techniques. MySQL, the popular Open Source, is used as the database management system.
Keeping information in a database allows documentation of students' progress and performance. Depending on the users' capability, the system is able to ask questions corresponding to their individual state of knowledge. This allows guiding the student through the tutorial on an individual learning path.
On the server main parts of the tutorial are programmed in Java using Java Server Pages or servlet technology. Servlets provide a component-based, server and platform-independent method for building web-based applications. Further technologies and extensions are used to design dynamic Web pages and to create attractive lessons which allow user interaction, especially JavaScript modules and Java-Applets. Flash and Quicktime documents are necessary to include animations, as well as stream audio and video data.
Access to the complete set of materials is free.

KURZFASSUNG:

Mit den Arbeiten an Telelearning Modulen zur Fernerkundung wurde an der Technischen Universität Berlin (TUB) im Fachgebiet Photogrammetrie vor mehreren Jahren begonnen. Die Akzeptanz der Web-basierten Lehreinheit ermutigte das Entwicklerteam, eine Neufassung des Lehrgangs in Angriff zu nehmen. Die Überlegungen zur Neugestaltung wurden in diesem Artikel aufgeführt.
Der Hauptteil des Papers beschreibt die Entwicklung und Implementierung des eLearning Systems. Dabei werden zwei wesentliche Aspekte herausgehoben: die Kursverwaltung und die Wissensüberprüfung. In beiden Fällen werden Datenbankstrategien eingesetzt, die durch Verwendung des Open Source Produkts MySQL realisiert wurden.
Durch den Einsatz von Datenbanken ist es möglich, den Lernfortschritt der Studierenden zu dokumentieren. Tests und Fragen im Verlauf des Lehrgangs verschaffen einen Überblick über den Wissensstand der Studierenden. Der Schwierigkeitsgrad der Tests kann an den Leistungsstand angepasst warden. Dies erlaubt es, vom statischen Abarbeiten der Kursmodule abzuweichen und dem Studierenden einen seinen Kenntnissen entsprechenden Lernpfad anzubieten.
Zentrale Teile des Tutorials wurden mit Hilfe der Java Server Pages bzw. Servlets als Server und Plattform unabhängige Methoden für Web-Applikationen herangezogen. Der Einsatz von JavaScript und Java Applets führte zu attraktiven, dynamischen und interaktiven Webseiten. Animationen, Audio- und Videosequenzen wurden mit Flash- und Quicktime Modulen realisiert.
Der Kurs kann von Interessierten kostenfrei beabeitet wurden.

1. INTRODUCTION

Telelearning modules covering Remote Sensing topics have been developed on several spots all over the world. Bejond the well established, excellent designed and maintained CCRS-tuaprtial (http://www.ccrs.nrcan.gc.ca/ccrs/learn/learn_e.html), the extensive Remote Sensing Core Curriculum, (http://www.r-s-c-c.org/index.html), the Remote Sensing Tutorial (http://rst.gsfc.nasa.gov/Front/overview.html) a large number of course- and teachware products is available through the internet, open to users who are interested in Remote Sensing.

International cooperation come to the fore as desribed in papers of the Mid Term Symposium of Commission VI in Sao Jose' dos Campos, Brasil (Candeias 2002, Dias et all., 2002, Nogami et all., 2002, Lichtenegger et all., 2002).

In Germany, the BMBF (Ministry for Education and Research) encouraged several project teams to develop e-learning materials for Geoinformation, which led to the learning platform *geoinformation.net* (Brandt et all. 2004, Plümer et all. 2004). Also of importance ist the *gimolus* project (Weippert, Fritsch, 2002, Müller 2004).

At the Technical University of Berlin a working group set up a web-based training unit, which was introduced during the Amsterdam Congress (Koenig, 2000). This tutorial was

applied as additional information for lectures allowing location and time independent strengthening and intensification of knowledge. Students appreciated this offer and still use the tutorial for brushing up their knowledge, especially before examinations.

Meanwhile a newly designed teaching module is being constructed, considering recent developments in eLearning and software technology. The modules are designed by the academic staff and students based on Open Source software. They are maintained and updated unregularily, due to lack of time and depending on student's motivation and commitment.

Cooperation with other authors in Germany has recently been discussed and will play an important role in the near future.

2. OBJECTIVES

The central idea of the new approach was the aim to adapt the training course to the learners' knowledge. This implied developing independent but consistent small segmented learning modules. Subjects were supposed to be parallelly described in units of different levels of difficulty. The content, for example may be splitted into 10 units for students without pre knowledge, but only 4 for those who don't need futher assistance. This modular conception allows adaptive linking of the lessons, dependent on the learner's knowledge. Individual learning tracks allow the students to access only the material relevant to their needs.

This approach implies a specific course organization, user and content administration, which is discussed in Chapter 4 in more detail.

Another just as important aspect is the definition and creation of a centralized pool of questions, allowing learners' assessment. Assessments/tests and surveys are the presumption for an adaptive learning scenario. Test questions are also assigned to different grades. Classification in easy and difficult questions allow a more precise distinction of the learners knowledge and a better guidance through the training course. Of course, assessments need to be repeated continuously allowing differenciated and self paced work.

Guiding learners through the course by formulating problems and by skilled questioning should also be possible. The modular approach will help to form an individual solution track. At present, project oriented learning is still being constructed.

Of course the usual demands for easy use, nice design, high interactivity and using standards form a general objective which the developers have to take care of.

The authors hope that the adaptive strategy will encourage students and optimize their learning outcome.

3. CONTENT

Up to now the course covers several topics of Remote Sensing. Chapters contain information about the physical principles, analogue and digital data acquisition techniques, sensor platforms (aerial photography, scanner and radar systems) as well as information about how and where to obtain Remote Sensing imagery. Special interest is focused on online catalogues maintained by the different data suppliers. Data analysis methods, such as visual interpretation, photogrammetric and digital image processing, form another main focus of the tutorial. At least, a brief overview of applications in several fields is given. Each chapter is divided into different lessons or sub-chapters, which are again divided into several pages illustrating the logical context, forming a hierarchical tree structure (see Figure 1).
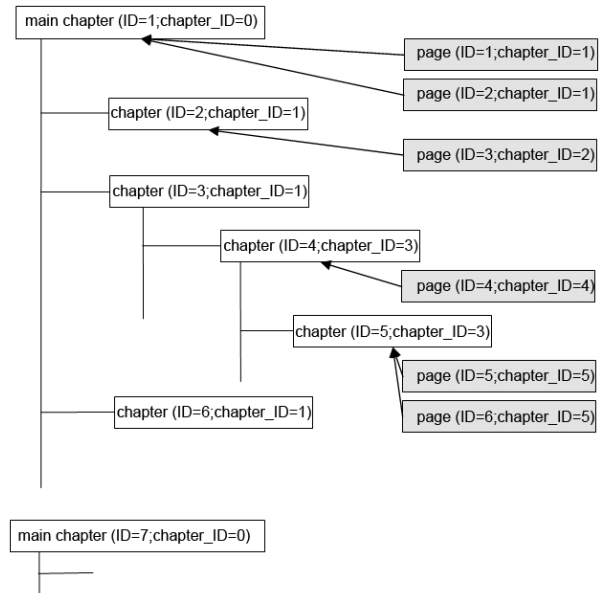

Figure 1. Chapter construction tree

4. REALIZATION

4.1 Preliminary reflections

Implementation of the learning program had to follow budget constraints. Commercial learning systems are not available. To keep costs short, LAMP (Linux in conjunction with, Apache, MySQL and PHP) is the platform of choice for the development of and the deployment during the course. It is a solid and reliable platform, for robust web applications.

First reflections concern user administration. Controlled access to the learning unit is prerequisite. This requires the use of a database, in which all activities of users are stored. In tables related to the learner time of access is recorded as well as information about modules already handled and how much time was needed for work. Also test results are stored in the database. Information about the users' knowledge is preconditionary for an individual course of the learning program.

Also test questions need to be administered by a database, ranked by its level of difficulty. Setting up a question tool is one of the main topics of the learning system. At present mainly multiple choice questions are implemented. If numeric calculations are demanded, textfield input is necessary. Clozes and project oriented tasks are under development.

To satisfy database needs, MySQL as a relational Open Source database was chosen. MySQL is popular in a variety of operating systems and runs in stable conditions.

The more interactivity is needed, the more inevitable is the use of a program language. Java provides the most flexible solution and allows web-applications based on applets. Applets are loaded together with the web page from the server and are executed in the client's virtual machine.

If it is necessary to compose a website in dependence of a user input, an interface has to be available, which allow the web-server to call external programs, which generate HTML code and send it back to the client.

In this case the Java Server Pages (JSPs) concept is appropriate, which allows a separation of content and visualization. On the server, JSPs are compiled on first call and a servlet is generated. A so called container for servlet administration has to be implemented. This task is managed by the reference implementation Tomcat (see Figure 2).
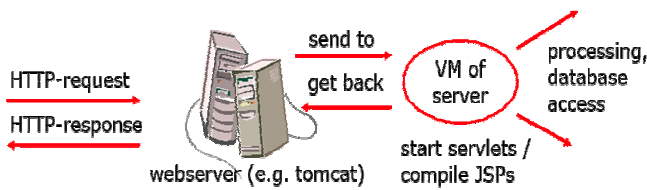

Figure 2.   JSP technology

4.2 User Management

As already mentioned, it is necessary to introduce a user management for adapting the training course to the learners' knowledge. All information about user activities is stored in a user database.
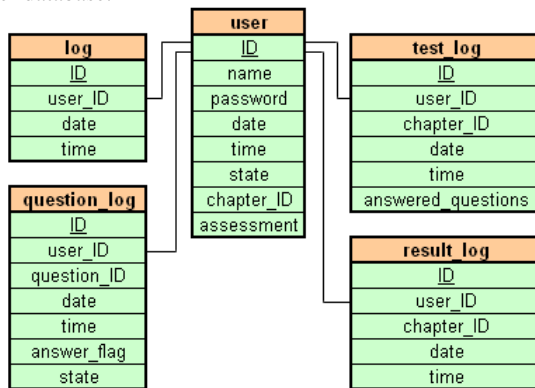

Figure 3.   Tables needed for user administration

After successful registration and authentication a new user and several other tables are created, recording all information needed for obtaining the user state and assessing the students' capability (see Figure 3).

Each *user* record contains fields for user *name* and *password*, *date* and *time* of first registration. The *state* and the *chapter_id* field gives information about the chapter which has recently been worked on. These keys allow the user to continue working at the point he had left the course before. In the *assessment* column the performance ratio of the student is stored. Information in the *result_log* and *question_log* tables is needed for the calculation of this assessment value. More details are given in chapter 4.4.

4.3 Administration of Chapters

The modular approach of the learning system requires administration of course content, which is structured in hierarchical chapters as seen in Figure 1. Storing informations about the modules in a database allows separation of context from the sequence of the tutorial. Once the learning path is defined, linking the modules and generation of the table of contents are processed automatically. Later changes in course and structure will be assisted by a seperate management tool, which will be developed in the near future.
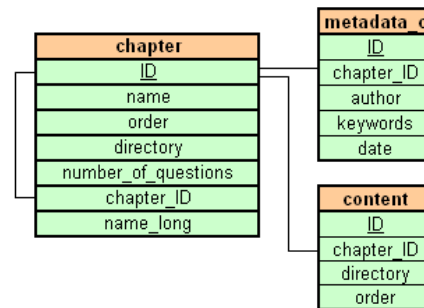

Figure 4.   Data base tables for chapters

The structure of database tables used for chapter organization is seen in Figure 4. An individual *ID* is assigned to each chapter automatically by the system. The field *name* characterizes the content and is used for building the main menue of the training course. *Directory* describes the file location in the file system. Other significant columns are *chapter_id*, which marks the relation of the chapter in the hierarchical tree structure (compare with Figure 1), *order*, *number_of_questions* and *name_long*. As explaind by the name, the *order* field is responsible for the sequenze the learning path follows. *Number_of_questions* defines the amount of questions the student has to answer in the specific chapter throughout the test procedure, *name_long* is used in the automatically generated table of content which forms the main menue of the training course (right column in Figure 8). *Level_of_ difficulty* in the content table influences the sequence of the learning path. Depending on learners' capability a simpler or more advanced course is offered. An example of the MySQL user table is illustrated in Table 1. Metadata information about the *author*, *keywords* and *date* of creation are stored in a separate table which make the chapters re-usable in future.

Corresponding to the entries in the database, all web pages are stored in the appropriate directory. Up to now this is handled manually, automatic support is planed in the future.

ID	name	order	directory	nr	chapter_ID	name_long
3	Aufnahmesysteme	3	inhalt_neu/kap2/	3	0	Aufnahmesysteme fuer Luft und Satellitenbilder
36	Einführung	0	inhalt_neu/einführung	0	0	Einführung
35	Physikalische Grundlagen	2	inhalt_neu/pg	0	0	Physikalische Grundlagen der Fernerkundung
12	Photographische	1	inhalt_neu/kap2/	0	3	Photographische Aufnahmesysteme
13	Prozess	1	inhalt_neu/kap2/	0	12	Photographischer Prozess
14	Empfindlichkeit	2	inhalt_neu/kap2/	0	12	Spektrale Empfindlichkeit photographischer Schichten
15	Farben/Filter	3	inhalt_neu/kap2/	0	12	Farben und Filter
16	Farbphotographie	4	inhalt_neu/kap2/	0	12	Farbphotographie
17	Filme	5	inhalt_neu/kap2/	0	12	Filme zur Luftbildaufnahme

Table 1.   Example of a MySQL user table, representing a small part of chapter 2, data acquisition techniques.

4.4 Tests

Web-based learning, as well as conventional learning only is successful, if the knowledge is applied correctly. Tests make a fundamental contribution to the assessment of course participants. During the tutorial students' knowledge is tested in different stages.

After first authentication, existing knowledge is checked by solving questions on a multiple choice basis. This gives the system the ability to relate the user to one of three classes - beginner, average student, advanced student. The more tests the user has fulfilled, the more precise this classification will be. In chapter 4.5 you will get more information about the assessment's calculation.

Next, small tasks must be solved while going through the lessons. If these questions are answered incorrectly, the system gives support to find the correct solution. In the expert's *advice* table the information where to look for additional support is stored. Possibly the student has to repeat the test. How the system tries to avoid putting same questions again is explained in chapter 4.6. These pre-tests have no influence on learners' assessment, but control the sequences of learning modules.

After completing main chapters, new tests follow which decide on participants marking. During a final test, covering the entire area of remote sensing, the learner has to prove his knowledge. Comparable to an examination situation, the questions are adjusted to the students' level of achievement.
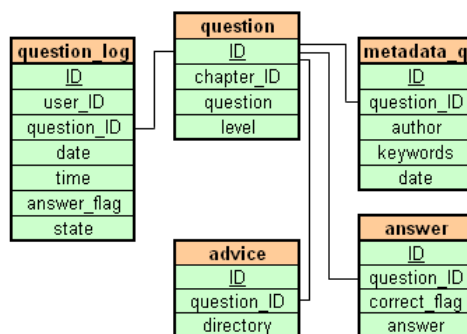

Figure 5.   Layout of the question database.

Of course, this could only be achieved, if also test questions are handled in a database. Questions are classified into three levels. Figure 5 gives an impression of the tables used. Please recognize the table for expert's advice, if a question was answered incorrectly. The questions the students tried to solve are registered in the protocol table as well as the time needed and if the question was answered successfully.

4.5 Control of navigation

Administrating the content and tests in databases is a prior condition for adapting the training course to the student's skills. As mentioned before, the course allows an achievement oriented, adapted navigation. The sequence of actions is controlled by tests, which need to be analysed carefully. As measure affecting the workflow the weighted quotient of questions answered correctly in relation to all answers is calculated. See Table 2 as example:

Number	Level of Difficulty	State	Score	Maximum Score
5	3	correct	15	15
2	3	false	0	6
0	2	correct	0	0
2	2	false	0	4
4	1	correct	4	4
4	1	false	0	4
17		Sum	19	33

Table 2.   Performance ratio - example.

You can see, that 17 questions were answered in total and the student solved 9 correctly, 8 answeres were wrong. Among the 9 correct answeres, 5 were weighted with 3 and 4 with factor 1. Taking no notice of the weights, the quotient is calculated as $9 / 17 = 0,52$. If the level of difficulty is considered, a better result is allocated $(19 / 33 = 0,58)$. This weighted performance factor is calculated after every test and is stored in the user database (see Figure 3).

According to this quotient, the student is guided through the lecture. Appropriate to his knowledge, he is assigned to one of three classes (beginner, average, advanced). Nevertheless the system allows that the student also answers questions of a different level of difficulty. Two indices, defined by the course author, regulate the probability of how the questions are distributed. As seen in Figure 6, experts could expect 20% questions to be easy, 30% to be medium and 50% to be difficult, whereas a beginner will expect a ratio 50:40:10. The

final assignment is handled by a random number, restricted by the interval [0,100]. Assuming 61 advanced students have to answer a difficult question, beginner and average students a medium one.
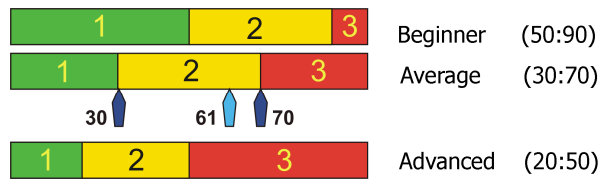

Figure 6.   Indices (30,70) and a random number (61) influence the decision about the questions to put.

This approach allows a faster jump to another class and a more sophisticated adjustment to the learner's knowledge.

4.6   Choice of Questions

Another idea of the tutorial is to implement a pool of questions, which allows an individual selection. Main advantage of this approach is, that in case of retaking a test, same questions are not asked again. Figure 7 shows, that at a specific moment only a limited part of the pool of questions can be chosen. The relevant questions, determined by the chapter in use, limited to the level of difficulty and reduced by questions already put, are ascertained by the information in the database.

At the end of the tutorial, students must pass a final test, in which a representative selection of all questions covering remote sensing topics is chosen from the question database.
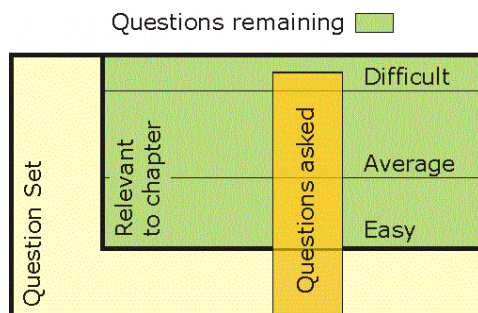

Figure 7.   Set of questions

The results of all tests are stored in the database. Of course students have access to their assessments at any time. Storage of test results could also be analysed by the authors. This is of special interest, because it allows checking which questions made the most difficulties. This probably makes clear that there are gaps in the course content or that some tasks are not clear enough and will help to correct and improve the tutorial.

5.   DESIGN ASPECTS

The tutorial must be clear and self-explanatory to the course participants. An unambiguous screen design is an important requirement for successful learning. Therefore, the screen is divided into different sections (Figure 8). The right frame includes the table of contents. Its appearance varies depending on the selected chapter and is modified dynamically as the student moves from one chapter to another. Colored highlighting is used for emphasis which allows easy orientation.

Other information and navigation tools which influence the sequence of the program are available at the bottom of the frame. If required, operating instructions, the main menu, access to the glossary, or a calculator are retrieved by clicking the relevant button. Arrow buttons which allow scrolling to previous or following pages are also integrated in this frame. Using these control buttons, students are able to move back and forth between lessons or chapters at their own pace.

Particular attention is given to restricting the individual topics to one page in order to avoid confusing scrolling.

6.   CONCLUSION

With the work done, a basis is developed, which allows embedding future extensions to the training course. A modular, database administrated tutorial was designed, which allows first steps to fit to the individual knowledge of the students. This means that on the one side a beginner (hopefully) will not be overtaxed with the text and tasks he has to solve and on the other side that advanced students will not necessarily be burdened with annoying pages and questions. This approach also makes a step to action oriented learning if the authors succeed to encourage students who will help to integrate remote sensing oriented projects or other complex tasks.

There is still much work to do. Future activities will contain administration tools for facilitating linking of content to the database. Also, the demand to comply with recent standards which open the door to greater flexibility (for example XML) still has to be satisfied. And of course, even more interactive multimedia applications need to be integrated.

Also the translation of the course in English language is being discussed.

The more sophisticated computer games come to the market, the more increasing is the demand on highly developed learning stuff. It's a race with no end…

Figure 8.   Dynamic tutorial page, realized as Flash element (http://www.fpk.tu-berlin.de/wbt/fernerkundung)

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