FROM A RESEARCH PROJECT TO AN INTERNET-BASED EDUCATIONAL PACKAGE

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ABSTRACT

A newly developed method in the mapping sciences is presented by means of an educational package. Animations and hypertexts are used for the explanations, and experiments with changing data sets can be carried out. In such learning by experiments the new mapping method is easier to understand. The Internet-based interactive program can be used by means of a browser and are therefore available for all connected to the Internet. The article describes the experiences of the development and the use of the program.

INTRODUCTION

Results of research work are usually presented as articles which are published in journals and conference proceedings. The Internet is increasingly being used as a medium for publication. Such an approach reduces the time of publication, and it will ease the access of the paper. The Internet offers many new possibilities to present knowledge. The techniques of computer-assisted learning (CAL) can be applied. For example, animations and dynamic figures can be used, and experiments with various data sets can be carried out. This means, that a student has a virtual laboratory on hand, and he or she can better understand and grasp sophisticated methods. Such learning by doing is interesting and therefore motivating. This article describes how the Internet is used for the presentation of a new method in the mapping science and the experiences from the development and use of an interactive learning program about this method.

A RESEARCH PROJECT IN THE MAPPING SCIENCE

The technique to produce maps from aerial photographs is called photogrammetric mapping. Currently a lot of research is going on to automate the production of orthoimages. Orthoimages are digital images which have a unique scale, and accurate coordinates, distances and areas can be derived from them. These orthoimages are therefore maps and are an important layer of a geographic information system. They can be produced quickly and with low costs, and they contain up-to-date information of the landscape and the cities. The European Organization of Experimental Photogrammetric Research (OEEPE) initiated a test for automated methods and

provided test material. A new method was developed by the author and tested with the provided material (5). Existing (old) orthoimages and height data of the landscape are required. The technique applied in this automated process is called "Area-based matching". This means that patches of the new aerial image and of the existing orthoimage are matched with each other. In this way identical image parts (pixels) are identified and then referenced. Orientation data for the new aerial photograph can then be derived. These are the first steps of the production of a new orthoimage. They can occur automatically and the whole production process can then be automated. The matching of image parts is, however, not without errors. The elimination of mismatches needs the use of thresholds for some parameters and some mechanisms to detect blunders. The various influences and the successful measures to prevent and eliminate blunders is part of the research work.

PRESENTATION OF THE RESEARCH PROJECT

Details about this research were presented in a report and published in a book (4). Furthermore, an article about the method was published at the Internet at the address: http://www.i4.auc.dk/jh/orientation.pdf.

However, the new method is rather complex and difficult to describe. Therefore, a learning program was designed and implemented for use at the Internet. The new method can be tried by everyone who is connected to the Internet. Such a hands-on approach gives a much better understanding of the new method. In the following the contents of the educational software are described in more detail.

THE CONTENTS OF THE EDUCATIONAL SOFTWARE

In principle, the educational software consists of two parts: Knowledge and tasks. In the 'Knowledge' part the new mapping method is described, and exercises and experiments can be carried out in the 'Task' part of the learning program. There are also questions to be answered by the user. The program checks his or her answers, and a feedback by voice and text about the correctness of the typed-in answer is given. Additional information about the method is provided from net-based articles. The educational software on the new mapping method was integrated as 'Theme 5' of a more general learning package called "Learning digital photogrammetry at the Internet" or "LDIPInter". In this package several other themes of a more general nature can be used to prepare the understanding of the new mapping method. These themes are described in former publications which were presented at CBLIS '97 and CBLIS '99 (1), (2). In the following, only the new parts of LDIPInter, which deal with the new mapping method, are described.

Knowledge part

The description of the method is done by means of text lines and a figure. The figure is an animation and the changes occur synchronically with the lines of text. More explanations can come up in pop-up windows when clicking on the hypertexts by means of the mouse. The animation can be repeated or stopped. This can be realised by two functional keys. Another functional key is the 'Help' key which leads to information about the use of the program. The user can navigate through the program using 'Return to Main (menu)' or start 'Task'. The designed user interface is very simple, and the knowledge given to the user occurs in small steps. He or she can get more explanations if needed.

Tasks and experiments

Four tasks are designed to understand the method and to carry out experiments. The first task includes the *matching* between patches of the orthoimages and the aerial image. In an animated diagram the target area (aerial image patch) moves over the search area (orthoimage patch) in steps of one pixel and a correlation coefficient is calculated. The position where the correlation coefficient has its maximum is the position of best fit. It is marked, and the corresponding pixel coordinates and the maximum correlation coefficient are displayed. Questions regarding the quality of the matching have then to be answered.
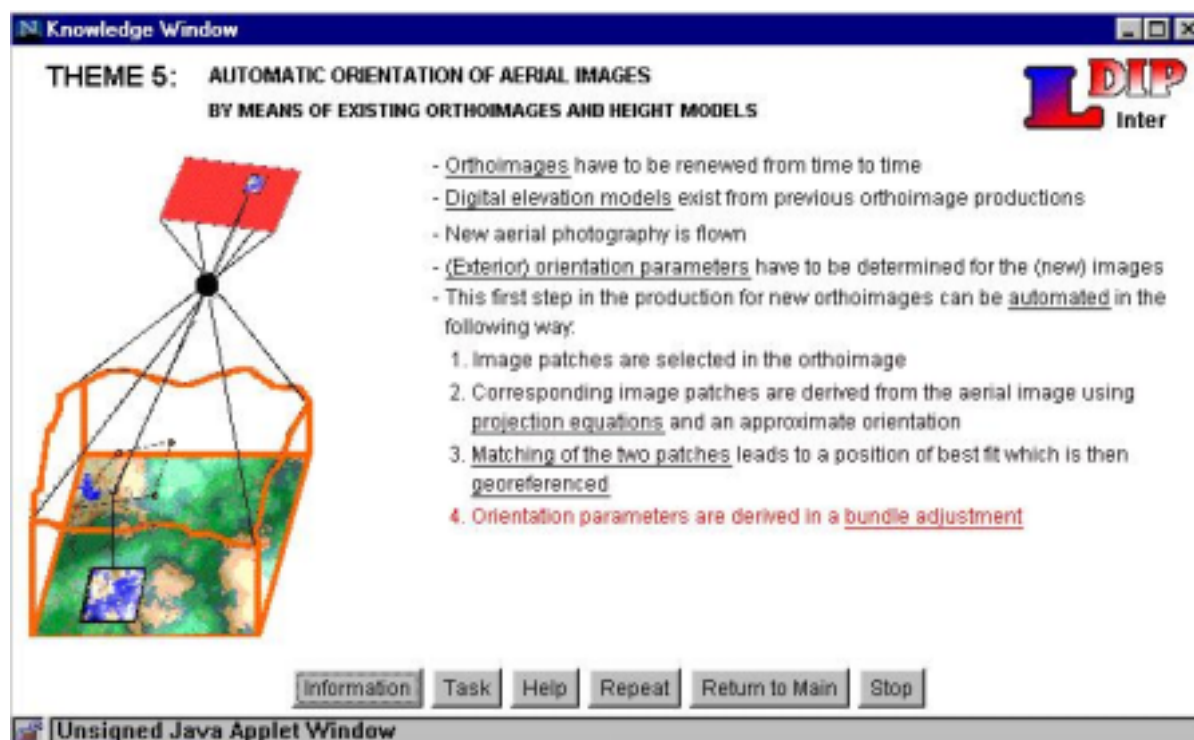

Fig. 1 Knowledge part of the learning software for a mapping method. Lines of texts and a figure change synchronically. More explanations can be obtained when clicking with the mouse on the underlined key words (hypertexts) or on the functional key 'Information'. Another functional key leads to 'Tasks' which are exercises and experiments with the mapping method.

The second task concerns the *usability of the matching*. A threshold for the correlation coefficient can be set, and patches of poor correlation are eliminated in this way. The effect of a threshold is shown graphically. A certain amount of patches has to remain and their distribution over the whole image must be ensured. The user of the learning program has to check if these two conditions are fulfilled and to decide whether another threshold has to be applied. This means that he will carry out experiments and find the proper thresholds.

The third task deals with the *geo-referencing* of the position of best fit. The user will calculate coordinates in a national coordinate system by means of a built-in spreadsheet. The relevant formulas and figures can be displayed in a pop-up window. Finally, the *calculation of the orientation parameters* of the new aerial image can be started and the results as well as a measure for the obtained accuracy will be displayed. Experiments can be carried out using different initial values or different thresholds for the correlation coefficient. The comprehensive calculations are always carried out with the actual data sets.

Fig. 2 Patches of the aerial image and the orthoimage are matched and pixel coordinates (drow, dcol) will be found at the position of best fit.
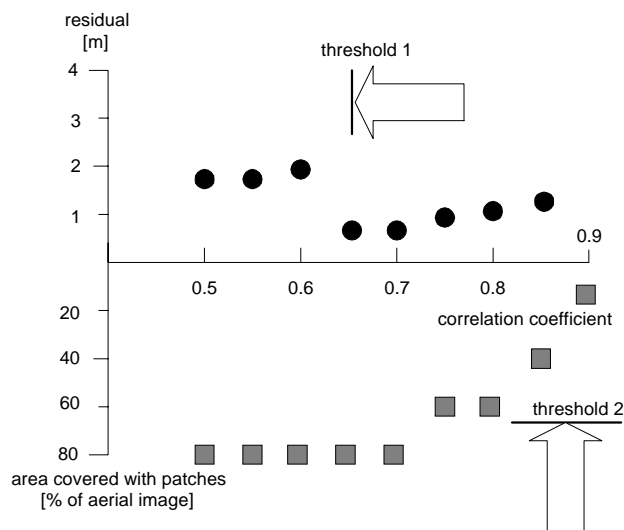

Fig. 3 The effect of thresholds on the accuracy of the orientation (size of residuals). Two thresholds will eliminate blunders and render possible small residuals. Threshold 1 eliminates patches with a correlation coefficient smaller than 0.65, and threshold 2 will ensure that 70% of the aerial image will be covered by patches. The values for the threshold are found by experimenting with the used data set.

The mapping method can be tried out, and experience about the influence of various parameters on the results can be collected from experiments.

Additional information from net-based articles

More detailed information on the method and experiences with its use is published in several articles (3), (4). They are published at the Internet and linked to the educational package.

REMARKS ON THE DEVELOPMENT

The Internet is a changing tool. It is difficult to predict which technologies will stay at the Internet and which will disappear. In this chapter the technologies used in the development for LDIPInter are described.

Java language

For the implementation of LDIPInter the programming language Java has been used. Java is a platform-independent and object-oriented programming language which can be downloaded free of charge from the Internet. Java supports both standard applications and client side Internet applications (Applets). The Java version used for developing LDIPInter is the Java Development Kit 1.1.6 (JDK 1.1.6). At the moment, virtual machines which support JDK 1.1.6 are included as standard in the two leading browsers: Netscape Communicator and Microsoft Internet Explorer. However it is always possible to let the browsers take advantage of the newest JDK versions, by downloading it and configuring the browser for the new version.

Java has been on the market for more than 5 years and is used widely both as programming language for applications and applets. Java is constantly extended and refined, new versions are released about every half year, and each new version is backward compatible with earlier versions. The popularity and continuous development of Java make us believe that Java and, thereby, applets will be usable at the Internet in the future.

Kawa

For the development of LDIPInter the Integrated Development Environment (IDE) Kawa v4.0 has been used. An evaluation copy of Kawa can be downloaded free of charge from the Internet, but can only be used freely for 30 days as it is shareware. The main features of Kawa are:

- Debugging facilities
- Classes are collected in projects
- Hotkeys for compilation and execution

The debugging facilities of Kawa let the user enter break points and watch variables at any point in the program. This makes it very easy to detect and recover from bugs in the source code. In LDIPInter a lot of bugs were found and corrected at an early point of the development phase before the different versions of the program were transferred to the Internet server. Kawa is able to debug both applications and applets like e.g. LDIPInter.

Kawa enables developers to create projects and to include the Java source files into the project. This makes the source files of the project appear as a tree-like structure in the left side of the program. For a project like LDIPInter (which consists of more than 300 class files), it is then

easy to navigate through the class hierarchy. If the project is an applet, the HTML file which launches the applet can be included in the project, and with a single hotkey the applet is executed by using the applet viewer of the JDK.

Interaction between the different tools and their changes with the time

An application like LDIPInter relies heavily on the current technologies of the Internet. The current Java virtual machines of the two most used browsers support JDK 1.1.6 and lower.[1] This is illustrated in figure 4 which reflects the dynamics of the current Internet technologies. They will affect the use of LDIPInter.
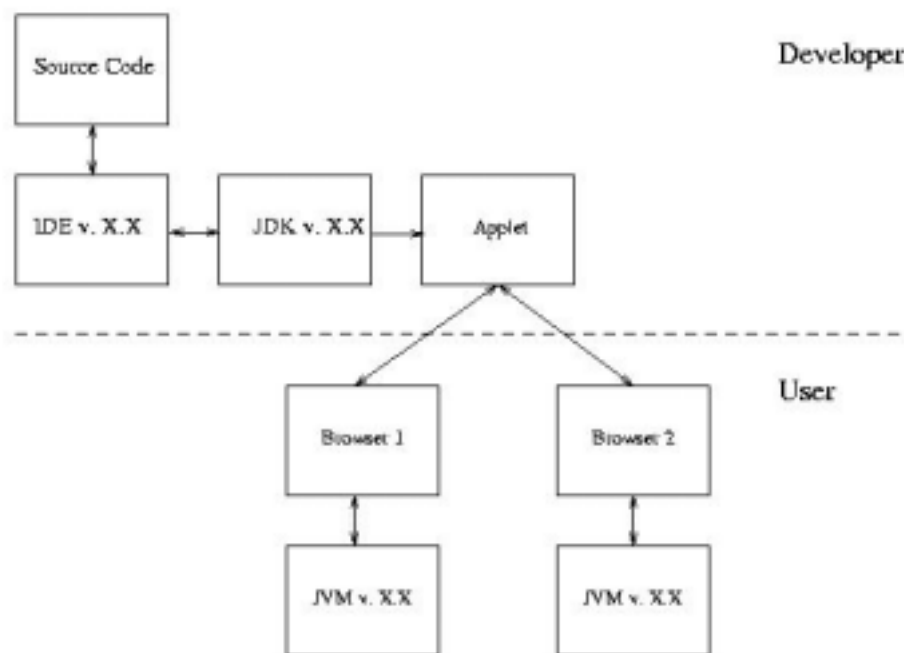
Fig. 4 Internet technologies and their dependencies

The source code is written in the used IDE (Kawa). As shown in the figure, the IDE can have versions with e.g. different project files. The IDE is closely related to the JDK and its version. The source code is compiled (by means of the compiler in the JDK) to an applet, which is executed on the browser of the user. The first condition which must be satisfied by the browser is the presence of a Java Virtual Machine (JVM). If a JVM is present, the browser can contain different versions of JVMs which support different versions of JDKs. As seen in figure 4, the developer is free to choose the tools and their versions during the development, but he has no influence on the browsers of the user. Thus, the developers must concentrate on using the technologies, which are compatible with the most common browsers on the market.

The Internet as a medium for a joint development

Each time a new part of LDIPInter has to be developed, a meeting is held, where the layout and functionality of the part is discussed. At these meetings milestones are set. For each

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[1] During the writing of this article, Netscape 6.0 was released, which supports JDK 2.0 as standard.

implemented milestone, LDIPInter is updated at the Internet. The implemented part is then discussed by means of e-mail communication and after agreement on the design and functionality the development moves on.

Currently, only two persons are busy with the project. Discussing via e-mail and testing the program at the Internet has worked sufficiently for this two-man team. The use of e-mail for discussions may, however, produce some misunderstandings between the developers, but some face-to-face discussions can eliminate misunderstandings. Also the updates of the program at the Internet enabled testing and corrections of the program. Such a proceeding can be applied for a larger development team as well. The object-oriented nature of Java makes it easy for a development team to distribute the workload between them.

Development techniques

In the research activities for the new mapping method, the computations were performed by means of Pascal programs. As LDIPInter is a pure Java applet, the code of LDIPInter written in Pascal could not be implemented directly in the package. Two approaches exist for including the code fragments from the research activities in LDIPInter:
- Re-writing of Pascal programs in Java
- Conversion of the Pascal programs (by software tools) into Java

The first approach has the major disadvantage that errors can easily be introduced, as the code is often a computational code. It is also time consuming to identify and correct errors. Besides it is both time consuming and tedious to re-write the code from scratch. In the second approach the tested Pascal code is converted directly, and no errors are introduced. Thus the second approach is an obvious choice. Unfortunately, no Pascal to Java converter exists, but by taking advantage of the syntactical similarity of C/C++ and Java, a Pascal to C/C++ converter can be used. The used converter is Ptoc v.3.34 which is a freeware Pascal to C converter. As the source code mainly consisted of control structures (*if*, *while* and *for* loops), the only parts that had to be manually changed were array definitions.

EXPERIENCE FROM THE USE

In this chapter, the technical details, which are necessary for running LDIPInter, and the experiences from the use of the program, are described.

Modes of the use

Two modes exist for executing LDIPInter. It can either be run online at the Internet by means of a browser or it can be downloaded and executed directly from a local disk. We have chosen to offer the package for downloading too, because some slow Internet connections might affect the execution speed of the program. However, the trend goes towards high-speed Internet connections. In Denmark, for example, an upgrade from 56 Kbps modems to 256+ Kbps ADSL lines for private users is taking place at the moment. An advantage of the online approach is that the program is always the newest version of LDIPInter. By downloading the program it is up to the user to check for new updates.

Downloading

LDIPInter can easily be downloaded from the Internet, but some application programs must be

present to unpack and run the package. The following software is required for downloading and executing the program.

- Netscape v. 4.7
- WinZip or Zip v3.0+

When the program is downloaded it must be unpacked by Zip or WinZip, and can then be executed by Netscape. The introduction of the new Netscape v. 6.0, has made this browser the standard browser to download. We are currently investigating whether the future use can be carried out with Netscape v. 6.0 or whether it must be configured to utilize JDK 1.1.6. Any new information on this topic will be available on the download page at http://sunsite.auc.dk/LDIPInter

Stability of the program

At tests and practical use, LDIPInter has been very stable at fast Internet connections (>33 Kbps). If the transmission speed drops below 33 Kbps, then the program cannot load images fast enough. One of the reasons is that Netscape Communicator is unable to load all images before the applet is executed. The images must be loaded during the execution of the program, and this can in some cases delay the execution of the program. In order to make the downloading of the LDIPInter package faster, it is compressed and placed at the Internet in a single file (jar file).

Use with other browsers

As mentioned before, LDIPInter only runs on Netscape Communicator v. 4.7. Differences in Netscape and MS Internet Explorer have forced us to focus on one browser only. As Netscape is available on Windows, Linux and most Unix operating systems, we have chosen to focus on Netscape. However, it has turned out that some Windows users had to download Netscape, when executing LDIPInter for the first time.

Use in demonstrations and exercises

The presentation of this new mapping method is sometimes done by the author with a downloaded version of LDIPInter. A portable computer is then used together with a multimedia projector. In exercises with students from Aalborg University the on-line version is used with several PCs, where all the PCs are connected to the Internet and where Netscape is installed in advance. In both situations no problems were encountered when running the program. If the Netscape browser has to be installed first (for example in distance learning courses), some problems may occur during the downloading, extracting or tuning of the browser (setting of proxys). If the proposed procedure for downloading Netscape at the address: http://sunsite.dk/LDIPInter
is followed, no problems should occur. Then Netscape version 4.7 with the Java 1.1.6 plug-in will be installed.

Learning effect

The experiences from the use of the "Theme 5" is limited. At the point of writing only 35 students used this part of LDIPInter. Thereafter some corrections were made which improved

the program. It is planned to carry out an investigation on the learning effect of LDIPInter with more students in the near future.

CONCLUSION

Research work can be presented as an interactive learning program. The knowledge is presented by dynamic figures and hypertexts, and experiments can be carried out with different data sets. The user can answer questions, and the program will check the correctness of the answer and give a feedback to the user by sound and text. Good learning is achieved by doing and by self-assessment. Internet-based programs have a great potential, because they can be used at all computers connected to the Internet, the up-dating of the programs is continuous and the development can be carried out by several persons at different locations. The development of such interactive and Internet-based programs takes quite some efforts. The browsers and the JAVA development tools are under constant change, and it is difficult to maintain a universal version of the program. A usable browser, however, can be downloaded from the server of Aalborg University.

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