# THE USE OF CAT/CAL PROGRAMS FOR IMAGE PROCESSING AND REMOTE SENSING IN DISTANCE LEARNING

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**KEY WORDS:** Computer-assisted learning, computer-assisted teaching, image processing, remote sensing, distance learning.

**ABSTRACT**

Experiences from a distance learning course in image processing and remote sensing are presented. The Internet and a computer conference system were used in the communication between teacher and students. The course is part of the post-graduate education in Geoinformatics which is offered as a two-year education at Aalborg University/Denmark finishing with a "Master of Technology Management" degree in this field.

In this paper special emphasis is laid on to the use of interactive and Internet-based teaching and learning (CAT/CAL) programs which put the students in an active role and allow for a self-assessment. The development and use of such a platform independent program are explained. An intuitive user interface, dynamic images and graphs, attachment of questions and tasks, immediate response to given answers and solutions, and simulation and experiments are some of the building blocks for good learning programs. There is a great need for this type of course material, and a co-operation between teachers and students is necessary to produce, to use successfully and to update good CAT/CAL programs.

**ZUSAMMENFASSUNG**

Die Benutzung von Lernprogrammen für Bildverarbeitung und Fernerkundung im Fernunterricht

Erfahrungen von einem Fernunterrichtskursus für Bildverarbeitung und Fernerkundung werden mitgeteilt. Das Internet und ein Konferenzsystem werden für die Kommunikation zwischen Lehrer und Studenten benutzt. Das Unterrichtsfach ist Teil des postgraduellen Studiums in Geoinformatik, welches als 2-jährige Ausbildung von der Universität Aalborg, Dänemark, angeboten wird und mit einem "Master of Technology Mangement" Grad in diesem Fachbereich abschliesst.

In dem Beitrag wird insbesondere die Benutzung von interaktiven und rechnerunterstützten Lernprogrammen behandelt, welche die Studenten besonders aktivieren und auch eine Selbstbewertung ermöglichen. Die Entwicklung und Benutzung von eines Plattform-unabhängigen Lernprogramm werden diskutiert. Eine intuitive Benutzeroberfläche, dynamische Bilder und Diagramme, Fragen und Aufgaben, sofortige Reaktion zu den gegebenen Antworten und Lösungen samt Simulationen und Experimente sind einige der Bausteine für gute Lernprogramme. Für diese Art von Kursusmaterial besteht ein grosser Bedarf und eine Kooperation von Lehrern und Studenten ist notwendig, um gute Lernprogramme zu schaffen, erfolgreich anzuwenden und laufendzuhalten.

## 1 INTRODUCTION

Image processing and remote sensing have changed rapidly during the last years. Professionals in the surveying, mapping and GIS fields, for example, want to acquire new knowledge and update their previous knowledge beside their regular work. Distance learning can meet the needs of these independent learners. However, the possibilities for frequent communication between the student and the teacher as well as good course material are pre-requisites for motivating and successful learning. Special interactive learning programs with self-assessment functions exist and can possibly be used in distance learning as well. The Internet changes the education at the universities as well as in

distance learning. It is the purpose of this paper to present this new situation first and then by means of an example to explain the potential of CAT/CAL programs and the new possibilities for distance learning.

Finally, a conclusion has to be made how the CAL/CAT technology will develop and how the future distance learning has to be organised.

## 2    DISTANCE LEARNING IN GENERAL

In a rapidly changing labour market a lifelong education by distance learning is very much in demand. Beside their traditional education and training for young students, universities also offer education and training for professional people in practice. These mostly elderly students want to update their knowledge and to learn new subjects in their home town and beside their regular work. This need can be fulfilled by distance learning courses and educational programmes which will give the participants a lift in competence and advancements in their professional career. The demands for good distance learning courses are very high and the educational programs have to adapt to the needs of these students (Lorentsen, 2000). Such needs are for example access to good study materials, communication with teachers and fellow students at all times and active and motivating learning. Good learning and self-assessment methods will give an immediate feed back to the students and bring about experiences of progress and success. The new achievements in the information and communication technologies like the Internet, multimedia, etc. allow all universities to participate in the growing task of such continuing professional development (so-called CPD). This educational task is also a market which becomes very international and competitive.

## 3    OPEN UNIVERSITY EDUCATION IN GEOINFORMATICS AT AAU

Since 1996 Aalborg University has offered a distance learning education in Geo- informatics which lasts two years and finishes with a Master Degree in Technology Management in that subject. It is currently held for the third time, and about 35 students from Denmark and other Scandinavian countries participated each time. The students are mainly Danish chartered surveyors who are half-way in their career, but also active professionals from the mapping and geodata sector with a Bachelor or Master Degree and at least three to five years in practice are participating. The programme of that two-year education includes 13 different courses, two projects, six weekend seminars and two study tours. It requires about 20 hours of study per week or 900 hours per year. More details about that open education are given in (Sørensen, 1998) or at the homepage of the MTM education (www.i4.auc.dk/mtm/default.htm).
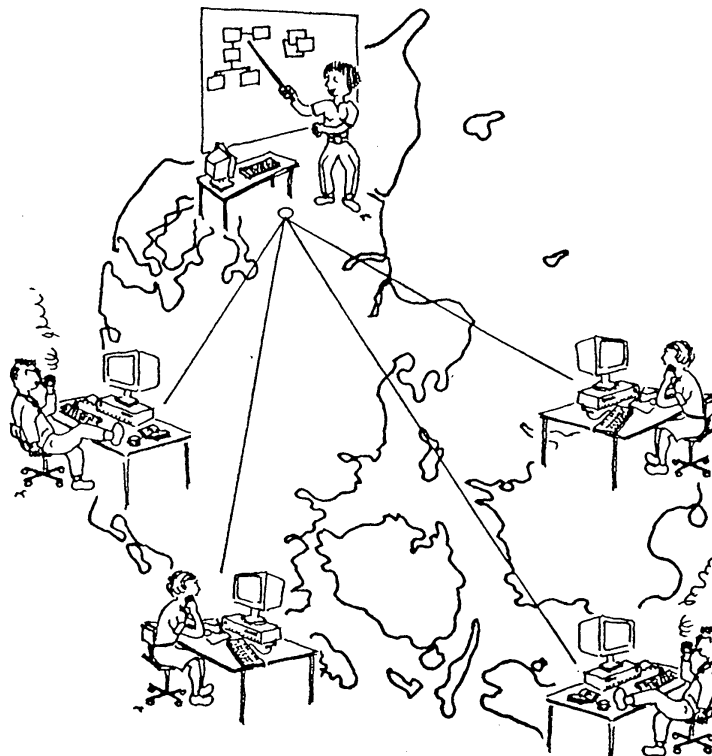


Figure 1: The virtual electronic classroom with remote participants around in Denmark

This and several other Open University Education programmes of Aalborg University use the software package "FirstClass" (FC) of SoftArc Inc. for the communication between the participants (teachers, students, technical support and administration). FC supports electronic mail, conferencing and online chatting. The students located in different parts of Denmark and some other countries are connected to the AAU server by modem, ISDN or network. FC has a graphic user interface, and it is therefore easy to operate with (compare figure 2). The most used functions are 'MAILBOX' and 'CONFERENCE'. 'MAILBOX' sends mail to individuals and 'CONFERENCE' to a group of people which are the participants in a special course or project. Text and image files in various formats can be attached. Response can be given by quoting the previously received text. A new feature in the latest version of FC (named FC GOLD) includes a 'WHITEBOARD' where images and graphs can be placed.
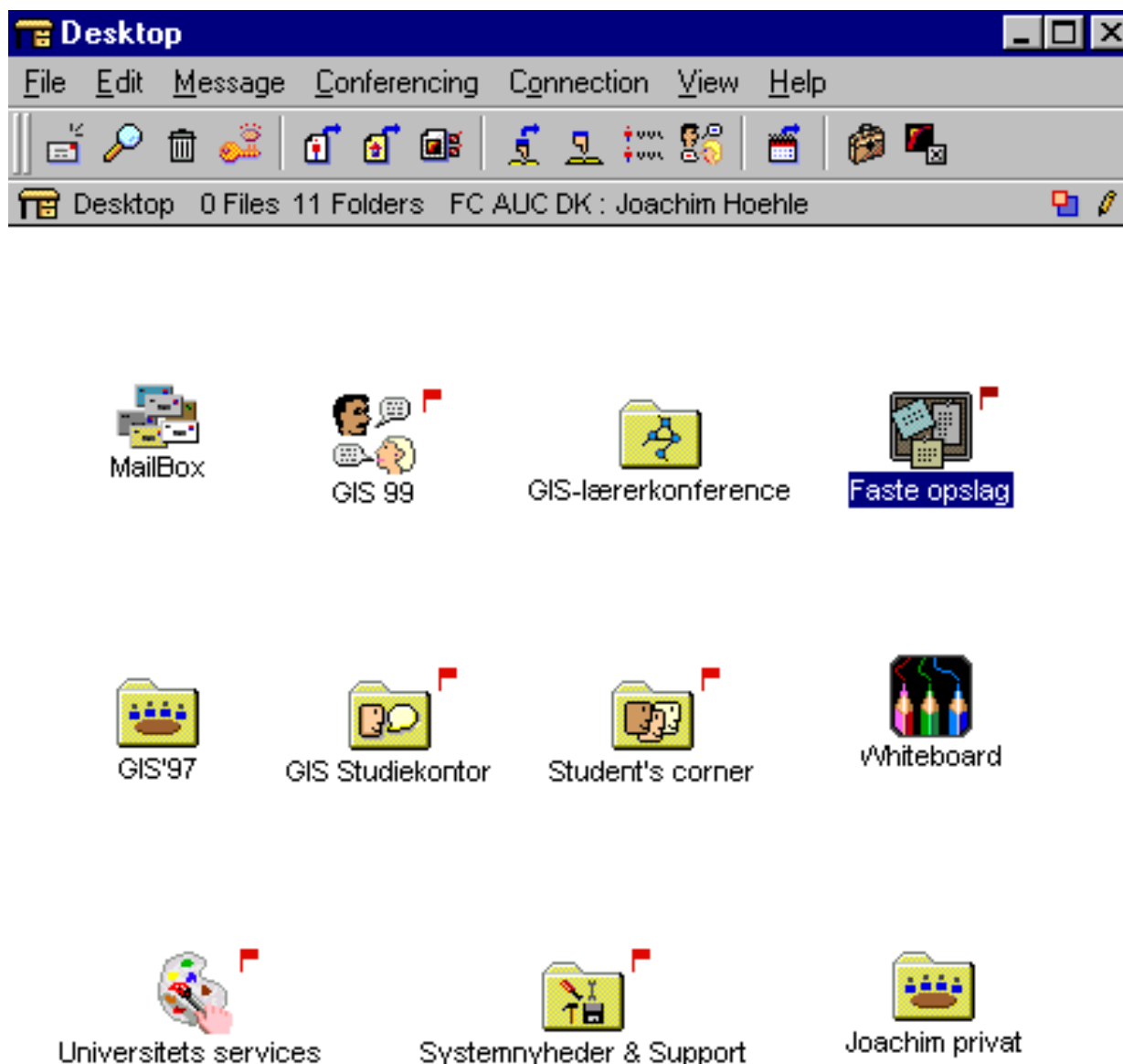


Figure 2: User interface to the conference system "FirstClass". (The red flags indicate that new mail has arrived in a conference or folder. By means of a function "History" it can be seen if the mail was read by the person it was sent to.)

## 4    THE COURSE "IMAGE PROCESSING AND REMOTE SENSING"

The course comprises five topics: recording and storage of remote sensing data, image data as background for thematic maps, image rectification and image enhancement, automatic measurements and classification, examples of applications in GIS. The study material is a textbook, various articles and interactive learning software (compare next chapter). The activities for the teacher, student and the organisation in this course are listed in table 1. There it can be seen that the steps 2-7 are taking place in the "virtual electronic classroom" using the computer conference system "FirstClass" and the Internet. The communication is mainly taking place in the "CONFERENCE" labelled  with the name of the course. For this course the efforts in time for an average student are scheduled to be 30 hours only. It is anticipated that the acquired knowledge from this course will be used in the projects, and further knowledge in the field may be acquired in group work or self-studies using AAU's library or the many resources on the Web .

| Step | Teacher | Student | Organisation |
|---|---|---|---|
| 1 | information about course organisation, introduction to the topic incl. PC demos | solves small tasks in groups | weekend seminar |
| 2 | | study of course material, installation of CAL software | home study incl. use of  the learning programs |
| 3 | forwards questions/tasks about the topics to be studied | answers the questions, evt. after communication with the teacher and fellow students | computer conference system incl. attachments |
| 4 | sends sample solutions to the questions | study of the sample answers (self-assessment) and preparation of the examination | computer conference system incl. attachments |
| 5 | sends examination questions | sends written answers | computer conference system incl. attachments |
| 6 | evaluation of solutions to the questions and info about results | re-examination (due to failure or illness) | computer conference system incl. attachments |
| 7 | discussion of the results and of details in  all topics | evaluation of the course | weekend seminar |

Table1: Steps in the distance learning course "Image processing and remote sensing" for a teacher, a student and the organisation behind the program "MTM - Geo-informatics" at AAU.

## 5    CAL PROGRAMS IN DISTANCE LEARNING

The learning can be supported by special computer programs. The technology is called '**C**omputer **A**ssisted **L**earning' or CAL. It uses pedagogical principles requiring that for example

-    knowledge is presented in small units, from easy ones to more difficult ones.
-    questions and exercises are attached.
-    the answers of the students to the questions are analysed for immediate response.
-    simulations and experiments are integrated.
-    success and progress can be experienced.

Furthermore, special features of the computer and of software tools are used in CAL. For example, hypertext, animated graphs, dynamic images, sound, etc. can be integrated and combined. The student has an active role in the learning process, and he or she can determine the speed, the time and the place of learning by him/herself. A typical CAL system is depicted in figure 3.

Various kinds of CAL software have been developed for personal computers (PCs) or workstations in the past. However, different types of computers, operating systems and storage media require different versions of the software. This incompatibility was a big disadvantage for the distribution and updating of the CAL software. Nowadays, platform-independent programs can be developed with the JAVA language. Anyone whose computer is connected to the Internet can use those programs with a JAVA compatible browser such as Netscape Communicator or Microsoft Explorer. Figure 4 summarises the benefits of Internet based CAL programs.  PC, workstation, or Internet-based
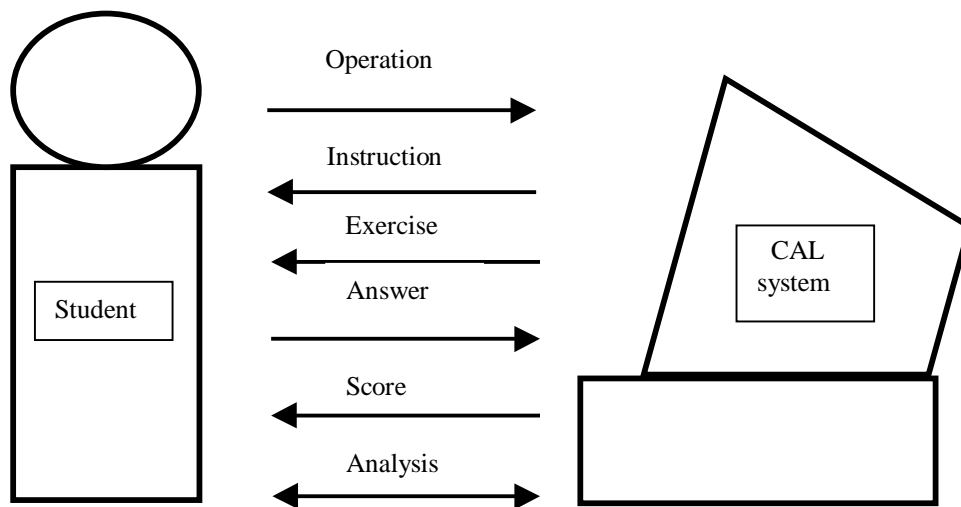
Figure 3: The computer assisted learning (CAL) system puts the student in an active role.

programs can be used during a lecture, in an exercise room, or at remote places. Especially the distance learning benefits from such interactive learning programs.
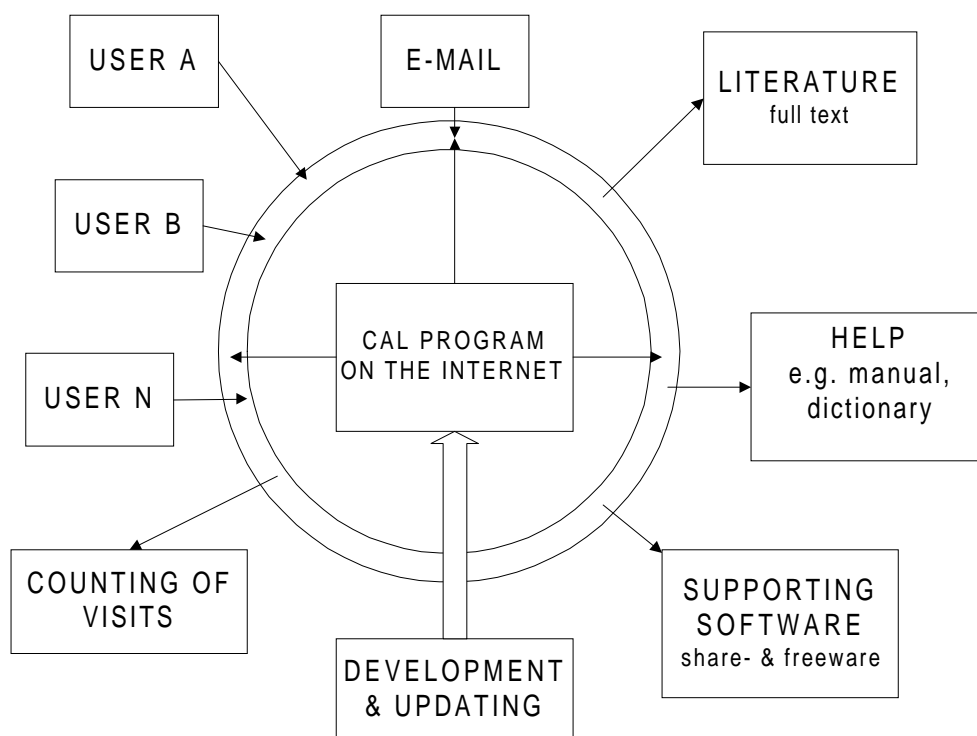
Figure 4: A CAL program at the Internet gives access to many other resources and allows for communication. The latest version of the program is available for all users right away. There are no installation problems for different computers and operating systems if a JAVA compatible browser is used.

## 6  THE LDIPINTER PROGRAM

By the example of the program "**L**earning about **DI**gital **P**hotogrammetry on the **Inter**net" ("LDIPInter") the contents, the use and the development of an Internet-based learning program will be explained in the following.

### 6.1  Contents

The contents of "LDIPInter" comprises the theory and practice of automatic measurements in digital images. The presented methods  are based on the correlation between a target matrix and a search matrix. It is first demonstrated for an image profile and with one pixel accuracy, and subsequently with subpixel accuracy which includes adjustment. The handling of the two-dimensional problem is  next in the contents of LDIPInter. Furthermore,  the application of the theory within practical problems is attached.  These are the interior and the exterior orientation of images which are derived by automatic measurements of crosses (or fiducial marks) and the measurement of control structures in corresponding images, respectively.  The explanation of the theory is supported by animations, sequences of text lines, and hypertexts (compare figure 5). Also links to literature are made. Several exercises are attached to the presented knowledge. They are either calculations with different data sets or experiments. The solutions to the given tasks are checked by the program and an answer ('correct' or 'wrong-try again') is given right away.



Figure 5: Screen image for theme 5 in the learning program "LDIPInter".

### 6.2  Development

The development of the program "Learning about digital photogrammetry" was started in the PASCAL language and for Macintosh computers. Quick progress could be achieved thanks to the many available toolboxes. With the upcoming of the World Wide Web (WWW) and the Java Virtual Machine (JVM),  the  "online updating" and the "platform-independence" of a CAL program could be achieved. Furthermore, the development tools, the "Java Development Kit" (JDK), are shareware and therefore available for everyone. Also powerful integrated development environments exist for the Java language, for example, KAWA of Tech-Tools Inc, which is used in the development of LDIPInter. The environment offers easy structuring of source files, compiling and debugging facilities and is also shareware. The communication programs at the WWW, the so-called  browsers, became new parts in the use of the Internet-based program LDIPInter. Differences in the implementation of the JVM at the different browsers, however, create some problems to run the program as an applet universally (Höhle et al., 1999). Browser and the JDK change continuously and  the development of the program and the browser should be based on the same version of the development tools (JDK). LDIPInter is based on JDK1.1.x. Presently, the program runs on the browser "Netscape Communicator", version

4.7, without problems. With the other major browser, "Internet Explorer", version 5.0, difficulties are experienced in some parts of the program. Also some changes at Greek letters and mathematical symbols were observed when that browser was used. One of the reasons for incompatibility of the two browsers is different implementations in the JVM for the handling of the "Thread"-class which is used in some parts of LDIPInter. Thus the program must detect which browser is running and then establish the relevant "Thread" model. This scheme is planned to be implemented in future versions of LDIPInter to guarantee a universal use of the program.

LDIPInter is installed on a server of AAU, the address is: http://sunsite.auc.dk/LDIPinter

The program will be updated and extended with new topics. At the time of writing the version 3.0 is installed which includes five themes (Automatic measurements, correlation in the sub-pixel range (1D), correlation in the sub-pixel range (2D), automatic measurement of réseau images, automatic orientation of aerial images).

## 6.3  Use

In order to run "LDIPInter" one has to call the applet within the browser with its URL  address from above. This can be done on different client machines. "LDIPInter" is downloaded from the Web. The loading time depends on the performance of the computer and of the network. Also the "traffic" on the Web plays a role. But under favourable conditions it takes a few seconds only. The loading time is considerably reduced by downloading the bytecode file onto the disk of the client machine and starting from there. (This means, however, that the advantage of automatic updating of the program gets lost.) Experience with LDIPInter in distance learning is still limited. So far it was used in one distance learning course only. No problems were experienced to fetch  and run the program. The interactive use and the possibility of self-assessment contributed to the  progress in the learning. More detailed explanation for the tasks to be solved is wanted by some of the students. In general, much more explanation is necessary in distance learning than in the courses at the university. An intuitive user interface, clear help functions and some conferencing with the teacher or fellow students will contribute to avoid frustrations or uneconomic learning. The professional background and experience with the IT technologies of the students also play a role in the proper use of  CAL/CAT programs.

## 7   EXPERIENCES WITH OTHER CAT/CAL PROGRAMS IN DISTANCE  LEARNING

At the first distance learning course in "Geoinformatics" at Aalborg University the Macintosh version of "LDIP" could be downloaded from the net (Höhle, 1998). Due to the fact that the participants from Denmark and other Scandinavian countries did not have access to Macintosh computers, LDIP was not used very often. Another CAL program of the author, named ORTO, which deals with orthoimages and their use in GIS, is based on the DOS operating system. Special features in this CAL/CAT program include the possibility of exchanging the texts with other languages and to analyse the performance of the student. The use of 'ORTO' in distance learning requires the downloading from the WWW, including decompression. This gave some problems to some of the students, if they were not instructed for that at the weekend seminar. The program requires also some calculations. The feedback to the given solution with "Incorrect - try again!" is not sufficient. A re-calculation with all intermediate steps is more appropriate. Undoubtedly, CAT/CAL programs are very useful for these 'independent learners', provided that the user interface is self-explanatory and the program runs safely.

## 8   OTHER INTERNET-BASED MATERIAL

The distance learning based on the Internet can use many other educational materials. Other CAT/CAL programs, images and other data, tutorials, articles and textbooks  can be found on the homepages of professional organisations, universities, companies or individuals. Some learning programs for themes in remote sensing can also be found at the home page of the ISPRS working group on  CAL/CAT programs and be downloaded (free of charge) from there (www.tric.u-tokai.ac.jp/research/cat/cat.html). A good start is also the WWW Virtual Library which provides references to subject matters like Image Processing and Remote Sensing;  132 000 and 145 000 Web pages, respectively are found in such a search in March 2000. Good search machines and search strategies are necessary in order to find useful information in a short time. Another approach is professional programs which have to be bought and then downloaded for a specifiable platform (e.g. Windows NT) from the Web. Some examples are IMAGINE of ERDAS, IDRISI of the Clark University/U.S.A., Winchips of the University of Copenhagen/Denmark, or Photoshop from Adobe. These programs are rather expensive, have a wealth of functions, and can import and export images in all formats. Teaching and learning of the basics in image processing and remote sensing is not the goal of such programs. They solve practical tasks. It can take a lot of time to become familiar with all the functions. An attached  tutor or a strip-down version can

be favourably acquired. Such freeware or shareware exists on many Web sites; it can be downloaded and used in the teaching and learning as well.

## 9 DEVELOPMENT OF FUTURE CAT/CAL PROGRAMS

The students in distance learning expressed that the interactive learning programs are very useful and in need. The quality of such programs must, however, be good. This can be achieved with efficient tools, pedagogical and technical expertise and in co-operation between teachers and students. Teachers are normally very occupied with many other duties, and the production of such CAT/CAL programs is normally not very much estimated in an academic career. One way to promote the development of good CAT/CAL programs is award winning contests. For example, CATCON2 will take place on the ISPRS Amsterdam Congress. The winning CAT/CAL programs will thereafter be shareware and can be downloaded from the server of the ISPRS working group on CAT/CAL (address see above).

## 10 CONCLUSION

Distance learning will extensively use the Internet in future. Therefore, it will be natural that the participants of distance learning courses, the so-called independent learners, ask for Internet-based learning software which includes text, graphics, sound, animation, simulation, experiments, etc. and requires interactions as well as feedback on the progress of learning. There will be a big demand for such CAL/CAT programs. Also the traditional education at the universities will use these programs with advantage. But the efforts to create good interactive learning software remain great. A joint development of new CAT/CAL software packages could be carried out by staff members and students at the same university or at different universities. Financial support or funding has to be found and seems to be available today. The vision for a virtual university and a virtual electronic classroom is no longer science fiction. The attraction of students across national borders and the world-wide competition between universities will create progress in the development and use of CAT/CAL programs.

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