COMPUTER AIDED TEACHING IN PHOTOGRAMMETRY, REMOTE SENSING AND GIS – A STATUS REVIEW

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ABSTRACT:

This paper will review the status of computer aided teaching advances during the last decade, with a particular emphasis on photogrammetry, remote sensing and GIS. A range of examples will be presented, many of which will be drawn from the Computer Aided Teaching Contests (CATCON), sponsored by ISPRS Commission VI, Working Group 2, during 1996-2006. Consideration of these resources will include a commentary on trends in e-learning and future prospects for further development.

1. INTRODUCTION

During the last two decades a number of factors have combined to encourage, and indeed force, the adoption of new teaching and learning methods in tertiary education. Not least of these has been the Internet-driven increase in the volume and complexity of the available information in any discipline. Simultaneously, there has been a rapid increase in the demand by employers and professional accreditation authorities for graduates with high levels of design, problem solving, team work and communication skills. A total catalogue of such information and other skills cannot be fully embraced within undergraduate degree courses, nor in postgraduate programs at Masters level.

In many universities an added problem has been that courses in the scientific disciplines have been considered to be "over-teaching", particularly in comparison to courses in commerce, law and arts. As a consequence, many courses have been completely re-designed with substantially fewer contact hours. A further rationale for these changes is the generally adopted uniformity of subject load and increased flexibility across universities, allowing greater scope for students to enjoy a broad tertiary level education through elective subjects or other mechanisms. This has reduced the overall contact time available to "core" teaching, and placed a greater emphasis on individual study by students outside of their class time.

The third significant factor has been a climbing student to staff ratio, as universities attempt to maximise the diminishing incomes from government sources and simultaneously accept more fee paying students. For example, the Faculty of Engineering at the University of Melbourne increased the number of students in engineering and geomatics courses from 1600 in 1990, to 3300 in 2000 accompanied by little if any increase in the number of teaching staff. Total enrolments across Australia increased from 49,000 in 1996 to 66,000 in 2006 with an increase from 15% to 34% in the proportion of international students. A similar situation exists for most universities in Europe, including TU Berlin. The additional income generated from the growth in student numbers and increasing numbers of fee paying students has more often been directed to deal with the physical limits of the infrastructure available for teaching, such as computer laboratory space, and research facilities that have only an indirect impact on teaching. The natural response is to make efficiency gains wherever possible in teaching, in order to sustain consistent levels of teaching resources whilst teaching ever larger classes.

The reactions of tertiary educators to these issues have been mixed, with many opting for streamed or specialised degree programs to reduce the amount of information delivered to large student cohorts. Universities with a reputation for a particular emphasis in a degree program have stressed this, for reasons of both specialisation and marketing. However, this response has typically been used in concert with computer based teaching remedies which take full advantage of recent developments in computer technology and the rapid spread of the Internet (Shortis, 2003). University academics are embracing techniques such as curriculum transformation to improve the learning of skills such as design, the provision of online information resources to compensate for fewer contact hours and the introduction of multimedia delivery to improve the efficiency and effectiveness of teaching. Whilst the change in approach is often subtle, the most visible manifestation of the adaptation of tertiary courses is the expanding catalogue of computer aided teaching resources. The use of these resources is absolutely dependent on an increasing expectation of student individual study to take advantage of these flexible, on demand computer aided teaching resources.

Universities are of course not the only providers of computer aided teaching resources. Commercial organisations are increasingly turning to computer based training for staff and computer based presentations for customers. Community colleges and similar organisations providing life-long learning are also making extensive use of Internet, CD/DVD and laboratory based teaching and learning. The catalogue of resources is many and varied, but at a high level of categorisation, includes:

- multimedia tutorials;
- simulations and virtual environments;

- information packages or data sets; and
- application software.

The pace of production and the quality of the resources varies dramatically between these different categories, but it is clear that the total catalogue of material is significantly increasing in response to better development tools, and increasing demand. This paper will review the status of computer aided teaching, computer based training and e-learning resources (hereinafter simply referred to as e-learning) for photogrammetry, remote sensing and GIS.

2. TEACHING AND LEARNING IMPERATIVES

The introduction of e-learning material must be constrained by the primary aim of the effectiveness of student learning and the efficiency of teaching by the academic or learning facilitator. There are a number of factors that must be considered to ensure that e-learning resources do not dilute learning or impact negatively on the student experience.

2.1 Effectiveness of Presentation

Clearly, e-learning resources must be designed and implemented to facilitate learning by students that have a variety of information technology skill levels. An intuitive and consistent interface style within e-learning resources is important to allow students to navigate within and make efficient use of multimedia material, irrespective of their IT skills. Web page design for educational materials is now a more mature science and there are many resources available to inform the web page designer (Abbey, 2000). Similarly, application software tends to have very consistent menu structures, largely replicating widely used software such as the Microsoft range of products.

Consistent structures and interfaces are more difficult to maintain if online material and teaching resources are based on different presentation styles. Further, the use of a variety of delivery platforms and learning frameworks can exacerbate inconsistencies in style and navigation. Use of a single learning framework, such as commercial systems like Blackboard, enables and encourages a uniform design. However, the primary intent of the e-learning material may necessitate a very different approach to the style of the material and the interface design. For example, a design for a web delivered multimedia tutorial is unlikely to be similar in style to a stand-alone simulated environment used within a computer laboratory.

2.2 Engagement and Interactivity

Whereas there is an acceptable need for different approaches to style and design that are in context with the teaching and learning aims, there is one operational imperative that all presentation styles universally attempt to achieve. Engagement of the student or user by the multimedia product is absolutely essential for the material to be effective and have the potential to realise the teaching and learning aims.

E-learning material universally incorporates text, images and graphics, as these are the staples of multimedia products that are sometimes known as an “electronic text”. Instances of e-learning approaches that rely primarily on communications systems or user interaction rarely stand in isolation and depend on background or contextual information that includes at least some of the three staples. However, use of text, static images and graphics alone is a change in delivery medium only. Whilst perhaps taking advantage of the convenience of distribution via CD-ROM, a PC application or the Internet, a change in medium only does not constitute the transformation of a curriculum and could be considered to be no better than a paper text book.

The quantum leap from an electronic text to an engaging multimedia delivery is enabled by audio, video, animations and virtual environments, all of which cannot be provided by text alone. Further, engagement of the user is enhanced by interactive components such as animations, simulations, virtual environments and requirements for feedback. Other than more flexible access, a passive user clicking through the pages of an electronic text is unlikely to derive any more benefit beyond turning the pages of a paper text. An active user that must manipulate a simulation to demonstrate a particular concept is much more likely to be engaged and gain a clearer and more comprehensive understanding of the issues presented.

2.3 Online Assessment

Engagement of students by multimedia products is further enhanced by the inclusion of an assessment component. The strong compulsion of a linkage between e-learning material and self-paced testing or feedback for the relevant subject can overcome the reluctance of students to become more active learners. Online assessment not only encourages frequent and regular use of multimedia and computers in general, but has also been shown to have a positive impact on student performance (Amoroso, 2005).

There are many factors to be considered for the inclusion of online assessment, particularly the security of delivery systems, the authentication of users, the efficiency of the analysis process and the proportion of assessment to be derived. On the latter issue, retaining a component of independent, individual testing will always be advisable and there is increasing use of computer laboratories under examination conditions, primarily to achieve greater automation and therefore efficiencies for marking. Notwithstanding this, even a small percentage of online assessment is advantageous to encourage use of multimedia material. The assessment of self-paced testing and computer based examinations can also be very efficient for large student cohorts if the analysis of the responses is automated.

2.4 Integration into the Curriculum

The last major imperative for the use of multimedia delivery is integration with the curriculum. Integration is very important if electronic delivery is used as an enhancement of learning by a university that emphasizes the student experience of learning within the campus environment. Online information must be relevant, current and a valuable enhancement to a subject or course. Students must be able to progress through the online information and multimedia material in concert with progress through the curriculum. Although not always an ideal solution, components of a web site, for example, may be released during a teaching semester to coincide with classes and control progress. Finally, the online information is most effective if it is integrated with all aspects of a subject or course, including lectures, tutorials, laboratory/practical classes and, as noted above, assessment. A consistently inclusive environment of online information is the strongest encouragement for students to embrace a change in the culture of learning.

3. COMPUTER AIDED TEACHING CONTEST

3.1 Contest Rationale

The Computer Assisted Teaching CONtest (CATCON) is organised by ISPRS WG VI/2 (Cho, 1997; König and Shortis, 2008). The primary objective of the contest is to promote the development and dissemination of multimedia products, educational information and simulation packages for computer assisted teaching. In general, material submitted by contestants is required to be non-commercial and provided free of charge for not-for-profit use. The assessment of the submissions by the contestants for each CATCON is based on peer review by the working group VI/2 Chair(s) and various ISPRS office bearers. Certificates and monetary prizes are awarded to the three submissions judged to be the most innovative and address the following criteria:

- Ease and clarity of use
- Sophistication of material
- Relevance to education and training
- Free availability
- Free of hardware and software restrictions

CATCONs have been held at the last three ISPRS Congresses, organised by the current WG VI/2 Chairs in each case. CATCON 1 was held at the Vienna congress in 1996, CATCON 2 at Amsterdam in 2000 and CATCON 3 at the ISPRS Congress in Istanbul in 2004. To address the increasing catalogue of e-learning resources, CATCON 4 was held in Tokyo in 2006 in conjunction with the ISPRS Commission VI inter-congress symposium. It is expected that CATCONs will be held at all future inter-congress symposia, as well as the quadrennial congresses to provide more frequent opportunities for individuals and organisations to demonstrate their e-learning resources.

The accumulated catalogue of submissions generated by the CATCONs is a limited and tightly focussed sample of e-learning resources, but it does provide a basis for some analysis of trends in categorisation, delivery modes and learning emphasis. Further, the CATCON submissions represent a longitudinal sequence that demonstrates the changes and evolution of e-learning resources.

3.2 Analysis of Submissions

An analysis of the submissions to the last four CATCONs is shown in table 1. The table identifies the overall number of submissions, the category of the each submission and the delivery mechanism for each submission. In some cases the categorisation is unclear and the submission could be delivered in more than one mode, so analysis is limited to general trends. Two clear trends in the delivery of e-learning material are evident in the table. First, distribution on CD-ROM is no longer common and delivery via a web page or as a PC application is predominant. Second, delivery via an Internet web page is clearly increasing. The trends for the category of the e-learning material are less clear, although the number of multimedia tutorials and simulated environments, as compared with data sets or application software, is increasing.

Whilst the teaching and learning imperatives described in section 2 were not directly part of the judging criteria, many of the CATCON submissions were certainly framed in a context of education at tertiary level. One aspect of the categorisation which is not evident from the table is that it has been increasingly common for multimedia tutorials and simulated environments to incorporate engaging, interactive student-centred environments that guide learning. This is reinforced by increases in the number and sophistication of simulated environments over the decade. In contrast, most application software is more straightforward and either provides little guidance at all, or includes a help system or case studies that are not well integrated into the e-learning material.

Very few of the CATCON submissions have contained a component of assessment as part of the e-learning material. There have been instances of practice examples that provide formative assessment, especially within multimedia tutorials, but in general the e-learning material has concentrated on the delivery of learning rather than the assessment of the acquired capabilities of the learner. The engagement and assessment aspects of the CATCON submissions have not been systematically documented, although the judging panels have very often remarked on these issues. This aspect of CATCON submissions is unexpected considering the tertiary education background of the majority of the applicants.

CATCON Year	Number of Submissions	**Category**				**Delivery**		
		Multimedia tutorial	Simulated environment	Information or data set	Application software	Web	PC application	CD or other
1996	11	2	-	2	7	1	8	2
2000	9	1	1	2	5	3	3	3
2004	10	5	2	1	2	5	5	-
2006	14	2	5	1	6	9	6	-

Table 1. Summary of CATCON submissions 1996-2006

4. BROAD TRENDS IN E-LEARNING

As noted previously, CATCON information is a limited sample, so a more general analysis of trends in e-learning in photogrammetry, remote sensing and GIS is needed to provide a broader view.

Höhle (1997) provides a snapshot of computer assisted teaching for photogrammetry in 1997, at around the time of the first CATCON. Not surprisingly, the delivery methods are similar, with a division between Internet or web delivery and PC based applications plus a brief mention of Unix based workstations. PC based solutions are noted as more prevalent because of the large investment in PC software development, the use of low cost PC laboratories and the latest improvements in the

technology, leading to a more rapid response and the ability to incorporate higher levels of sophistication in the applications. Internet delivery is noted as a relatively recent innovation and the use of Java to provide hardware-independent applets for real time visualisations and simulations is reported. The author also notes the more advanced ability of PCs to display high resolution graphics, and the use of sounds, speech, images and films to present resource-rich multimedia tutorials for either software applications or Internet-based delivery.

The current state of computer assisted teaching is represented by examples, some of which were featured in CATCONs in 1996 and 2000. Two of the examples, LDIP and LDIPInter, were prize winners at CATCON1 and CATCON2 respectively. LDIP is a learning program for automatic measurements, such as image correlation, within digital images. Processes are described in a step by step fashion and include interactive exercises for students that provide feedback on the accuracy of responses. The user interface is very straightforward and has consistent navigation tools. LDIP was written for Macintosh and intended to be used in computer laboratories. LDIPInter is a later development that implemented LDIP into Java for Internet delivery.

Five years later, reference and resource material, multimedia demonstrations and realistic simulations (Shortis and Cartwright, 2002) are noted as common types of e-learning. These identified types align well with the CATCON categories shown in table 1. However, in this report on teaching and learning in spatial science courses, there is a strong emphasis on the use of the Internet for student-to-student and instructor-to-student communications to enhance learning. Computer mediated communications and virtual universities are discussed as the manifestation of an explosion in real time information exchange, encouraged by universal access to high speed Internet links within and between universities.
Discussion forums, threaded discussion, moderated discussion and simple chat rooms all allow students to collaborate on specific projects or general issues, either as a primary tool for distance or online education, or as an enhancement to face to face delivery on the campus. Teaching staff and learning facilitators may be directly involved in discussions, but more often act as moderators to orchestrate the peer to peer learning amongst students. In 2002, the majority of this interchange was text based. This type of interaction has now become an embedded feature of learning management systems used in tertiary education institutions.

In 2002 virtual universities had only recently been introduced as an avatar based method of online, real time communications within a realistic virtual environment. This precursor to Second Life allowed a much richer interchange between students and teaching staff, including virtual classrooms. Second Life is now a legitimate medium for learning and teaching at all levels of education (Livingstone and Kemp, 2006).

Shortis and Cartwright (2002) note that some multimedia material and information resources are distributed using CD-ROMs or computer laboratories, but the majority of e-learning was being delivered via the web at that time. This trend is supported by the increase in Internet based delivery of CAT contestants as shown in table 1, and certainly has continued to dominate the delivery of e-learning during the last few years (König and Schiewe, 2006; Shortis *et al.*, 2004).

5. EXEMPLARS

A few specific examples of each type of e-learning material, drawn from widely used e-learning material and CATCON prize winners, are described in the next few sections. These illustrate the state of the art in e-learning for remote sensing, photogrammetry and GIS.

5.1 CARST and WinASEAN

Computer Assisted Remote Sensing Training (CARST) was developed by GeoInfo Ltd. for hands-on training in remote sensing and GIS (Duong, 2006). CARST is composed of WinASEAN 5.0, Remote Sensing Notes, published by the Japan Association of Remote Sensing, and GIS Work Books of Professor Shunji Murai. The WinASEAN 5.0 Education version provides basic digital image analysis functions that can handle both one-byte and two-byte image data. Each function is explained in on-line help, available in both English and Vietnamese.

The help file is linked to the digital books to provide the user with a deeper understanding of remote sensing and GIS concepts (figure 1). The system is also accompanied by interactive tutorials developed by InstantDemo software that allows beginners to carry out self-paced, step by step training in basic digital image analysis functions. CARST 1.0 is being used for hands-on training in remote sensing courses organized by the company GeoInfo Ltd. in Vietnam.

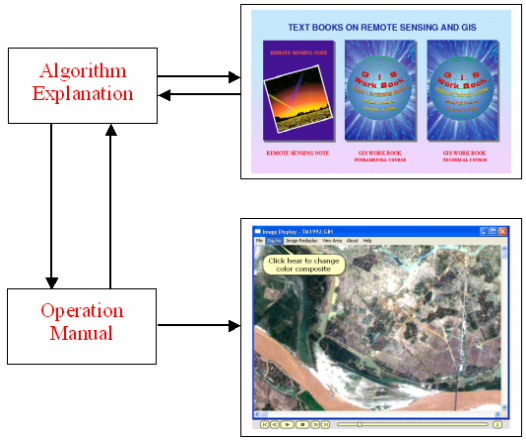

Figure 1. Help system of CARST/WinASEAN (Duong, 2006).

CARST and the educational version of WinASEAN are distributed on CD-ROM and also available from the web site (GeoInfo, 2008). CARST received the Silver award from the judging panel at CATCON4 in 2006 and WinASEAN received the Silver award at the first CATCON at Vienna in 1996.

5.2 Remote Sensing Core Curriculum

A review of CATCON entries over the ten years indicates that the majority of remote sensing educational resources are provided on CD-ROM, rather than via the web. This trend is primarily due to concerns over limitations of Internet bandwidth, which may restrict the effective use of high resolution images. One of the exceptions is the American Society of Photogrammetry and Remote Sensing Core Curriculum (RSCC), which has been available since 1998. Now the newly-formed International Center for Remote Sensing Education (ICRSEdu, 2008), a non-profit corporation, is now responsible for managing RSCC.

The RSCC program was developed to meet the need for a national-level core curriculum as defined by the American Society for Photogrammetry and Remote Sensing (ASPRS) members in cooperation with the National Center for Geographic Information and Analysis (NCGIA), National Aeronautic and Space Administration (NASA) and Earth Observation Satellite Company (EOSAT). The goal of RSCC has been to provide resources to support a state-of-the-art educational experience for use at national and international academic institutions. This curriculum currently represents a comprehensive collection of high quality resource materials available for use at all educational levels. RSCC was initiated under a NASA grant to form a consortium of experts from academia and industry.

Figure 2. List of modules in RSSC (ICRSEdu, 2008).

The development of RSCC content is distributed among several authors from different institutes. Currently, 5 of 8 volumes are nearing completion (figure 2). The newly reworked website is well designed and consistently presented, but every volume has its own corporate identity. Navigation is straightforward but frequent scrolling is needed to follow the explanations. RSCC gives rich and comprehensive information but is more a textbook with rare animations and low interactivity. Moreover, some updates to the volumes are needed. The educational resources, a collection to relevant links and the direct access to satellite imagery, are very useful for additional study material.

5.3 ARPENTEUR

ARPENTEUR (Architectural PhotogrammEtry Network Tool for EdUcation and Research) is a digital photogrammetry software package delivered directly via the Internet. This Java-based application has been widely documented (Grussenmeyer *et al.*, 2002) and is freely accessible via the internet (ARPENTEUR, 2008). The software is a joint initiative of photogrammetry and architecture laboratories of CNRS at Strasbourg and Marseilles in France.

Different solutions are available for the orientation of digital images. Images from different kinds of cameras (with fiducial marks, réseau cameras, non metric and digital cameras) can be used. The réseau crosses are measured automatically in the interior orientation. The measurements on the images are manual or semi-automatic by area based correlation. The model resulting from the measurement process can be visualized either using the internet-oriented VRML plug-ins, or exported in the Bentley Systems DGN format. Presently various examples from different projects, mainly based on small and medium format images, are accessible via the web on servers located in Marseilles and Strasbourg. Whilst the software contains no overt educational resources, as noted in Grussenmeyer *et al.* (2002), there are a number of examples of ARPENTEUR projects that have been used effectively by students in an educational environment. ARPENTEUR received the Gold award from the judging panel at CATCON2 in 2000.

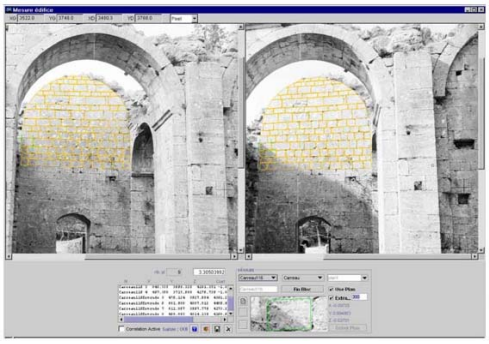

Figure 3. ARPENTEUR web interface (ARPENTEUR, 2008).

5.4 E-Tutor for GIS

E-Tutor for GIS is a development by the Centre of Studies in Resources Engineering, Indian Institute of Technology, Bombay (Venkatachalam *et al.*, 2006). The multimedia based tutor was developed with Macromedia Authorware and is available on CD-ROM. For hands-on exercises, GRAM++, an indigenous GIS package, must be installed (IIT, 2008). The E-Tutor was funded by the United Nations Development Programme (UNDP) assisted project on "GIS Based Technologies for Local Level Development Planning". It is expected to be a useful teaching aid for spreading GIS education across different levels of users in developing countries.

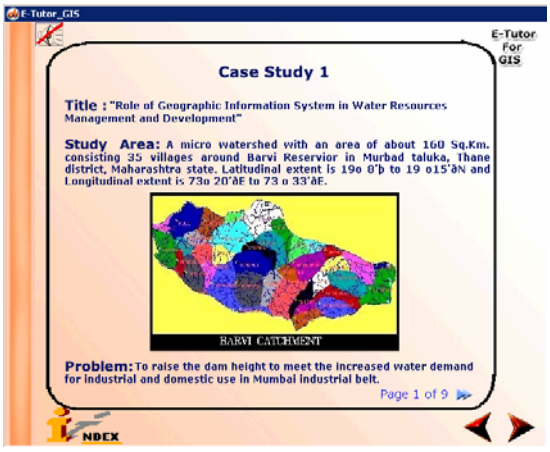

Figure 4. Example tutorial page from E-Tutor for GIS.

E-Tutor for GIS includes technical topics; understanding GIS functionality containing animations; application studies and a small number of case studies; a GIS reference section with links to journals, books, lecture notes, magazines and GIS web-sites; a glossary of terms; a small number of practical exercises; and instructor resources offering a question base and presentation documents. Each topic is explained by text, graphical illustrations, and animations, and the trainee has to complete quizzes and perform hands on exercises. In addition to spatial theory, a few GIS functions such as network analysis and data base queries are explained through graphical animations. The GIS reference section includes an extensive bibliography covering GIS related literature. Context sensitive help is provided on technical words through links to references to the glossary. E-Tutor received the Gold award from the judging panel at CATCON4 in 2006.

6. FUTURE TRENDS

There are several clear trends in the development of e-learning material that are evident from progress made during the last two decades. Internet delivery, of either the material itself or a software installation, is increasing as bandwidth limitations diminish. Curriculum material is becoming richer and more detailed because of improved development tools, more powerful computers and the wider availability of source materials such as high resolution images. E-learning material is becoming more and more interactive to increase engagement with the user and improve the effectiveness and depth of learning. As the new generations of students assimilate the ubiquitous new media and Internet technologies, demand for communication and collaborative work will rapidly increase. Software tools for discussion forums, wikis and blogs are now part of most learning management systems. Students, and not just teachers, will contribute to the learning experience and process. It is also clear that these trends will continue and the use of immersive environments such as Second Life will expand rapidly.

A related aspect of e-learning material that will become increasingly important in the future is the quality of the resources provided. As is the case with all web-based information, access is rarely guided by the quality of the information available on a web site, but more frequently by the popularity of the site or proactive manipulation of search engines by the organisation. A number of different approaches are possible to determine quality indicators, such as the reputation of the site or organisation, the number of citations of the material or an objective evaluation by professional reviewers. However, there is an emerging trend for Internet sites to be reviewed, either anonymously or by invitation.

The expert review approach has been recently extended to e-learning material by providing a consistent framework of comprehensive criteria for evaluation (König *et al*., 2008). The review criteria include content, learning goals, learner orientation, interface ergonomics and several other aspects of quality e-learning material. Each of these criteria receives a rating, which is stored in a database. In the future, prospective users of online e-learning material for remote sensing, photogrammetry and GIS will be able to search the database of reviews to identify resources that best match their requirements.

7. CONCLUSIONS

This paper has reviewed the status of computer aided teaching advances during the last decade, with a particular emphasis on photogrammetry, remote sensing and GIS. E-learning has made, and will continue to make, an extremely valuable contribution to teaching and learning within the discipline at all levels of education and training. Trends toward the predominance of convenient Internet delivery, greater richness of the content, enhanced user-centred learning and the availability of effective quality evaluations will ensure the expanded use of e-learning in the future.

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