Utilization of Computer Technology Relating to Geomatics and Geographic Information Systems Towards Fulfilling ABET 2000 Criteria

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Abstract

The need for Civil Engineering Departments to instruct students in the discipline of spatial location has not diminished as the 20th century draws to a close. Today's job market finds new demands being placed on engineers to deal with a vast amounts of data related to traditional survey methods, data base geocoding, digital mapping and real time location. The Citadel is in the process of implementing a plan to upgrade their traditional surveying course instruction to effectively incorporate new technology in the fields of geomatics and geographic information systems into the curriculum. The implementation plan is currently being administered with respect to ABET 2000 criteria.

Criteria for accrediting engineering programs in the United States places the responsibility on an institution to demonstrate that it meets eight criteria consistent with its mission and goals. Consistent with the Criterion, Geomatics and Geographic Information Systems can have an impact on global and societal issues. These fields rely heavily on computer technology for data collection, adjustment, plotting, searching, analysis, and reporting. The Citadel's Department of Civil and Environmental Engineering has expended considerable resources in establishing and improving a curriculum of computer based technology relating to Geomatics and Geographic Information Systems. A flexible plan was formulated to incorporate this evolving technology as part of the curriculum.

Faced with limited resources, technology acquisitions by the Department have been slower than the rate at which new products and services emerge in the market place. To address this important issue the Department has made use of invested funds and acquisitions from outside donors. Several years of the process technology procurement and curriculum transition have been accomplished. However, on-going assessment and improvement efforts are vital to insure a currency in this area of professional practice.

Introduction

Criteria for accrediting engineering programs in the United States places the responsibility for an institution to demonstrate that it meets eight criteria consistent with its mission and goals. Of these, Criterion 3, requires the student to "*have a broad education necessary to understand the impact of engineering solutions in a global and societal context*", "*a knowledge of contemporary issues*", as well as "*an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*". Criterion 6 requires appropriate facilities, to include computing and information infrastructures, where opportunities for students exist to learn the use of modern engineering tools. Geomatics and Geographic Information Systems (GIS) are both modern engineering tools that impact global and societal issues.

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Geomatics can be defined as measurement, representation, analysis, management, retrieval and display of spatial data concerning both the earth's physical features and the constructed environment. The principle disciplines embraced through the field of geomatics include mapping sciences, land management, environmental analysis, goedesy, remote sensing and traditional surveying. Geomatics has its roots in land surveying but has grown to incorporate the much wider fields of measurement science and spatial information systems.

Geographic Information Systems (GIS) can be defined as a spatial computer based system where location, attribute, and/or thematic data are co-registered. Co-registration allows relational data searches to be conducted. Applications can include (but are certainly not confined to) environmental analysis, infrastructure management or city planning, and engineering studies. The framework upon which the entire GIS database is built is an accurate portrayal of the earth's surface. A GIS database is most often created through application of traditional land surveying techniques, photogrammetric methods, Global Positioning Systems (GPS) and remote sensing techniques.

Today GIS is finding its way into many facets of everyday life. Automobiles, for example, are equipped with GIS and GPS to aid driver navigation. GIS initiatives resonate in most county and state governments. Some systems are under construction; some are just coming into operation, while many others have been in existence for a number of years. Practicing civil engineers often are involved in creation, operation, maintenance and use of these systems. To satisfy ABET 2000 Criteria, consideration should be given to include instruction on these topics.

The Department of Civil and Environmental Engineering at The Citadel includes a course in traditional land surveying and a separate course in Geomatics as part of the required undergraduate curriculum. The land surveying course covers topics focused on horizontal control, vertical control, state plane coordinates, and mapping. The Geomatics Course focuses on topographic mapping, GPS, photogrammetry, remote sensing, and GIS. Laboratory experiences are offered students where the mapping products produced in conjunction with the land surveying course are referenced to state plane horizontal control format where they can be imported later into the student created GIS of the campus. Both the land surveying course and the course in Geomatics rely on the use of digital computers for data reduction, analysis, mapping, and database management. The presence of constantly emerging new technology has placed a great burden on the instructors of these courses to constantly review and evaluate new hardware, software, and associated instrumentation as it might apply to the curriculum.

One of the major challenges facing faculty pertains to deciding how to upgrade equipment such as replacing older levels, transits, chains, and photogrammetric devices with state-of-the-art equipment. Total stations and data collectors are now commonplace, as well as the use of digitized aerial photographs and GPS units. The need to upgrade and keep equipment current is self-evident. However, developing an optimal approach to accomplish a realistic and effective transition plan was not clear in the beginning of the process.

Technology Review Process

Gaining knowledge of new developments in GIS and Geomatics is an on-going process. New developments in equipment and application software continue to occur at a rapid pace. Reliable sources of information to stay informed of new developments include professional journals, conference proceedings, Internet sites and trade magazines. These sources often contain information pertaining to new applications and current research efforts. In addition, manufacturers and suppliers of new technology often target professional magazines and conferences.

Reference materials pertaining to Geomatics and GIS systems were accumulated beginning on a wide scale basis. Although financial constraints made acquisition of needed equipment prohibitive, it did allow time for in-depth study of operational characteristics of various systems, and in some cases allowed for the incorporation of refinements that enhanced utilization in the classroom. A refined strategic plan was developed to address and prioritize the most important laboratory and computing needs using a selection process.

Technology Selection Process

In concert with former ABET accreditation guidelines, and now those contained in the ABET 2000 Criteria, the Department of Civil and Environmental Engineering has diligently pursued an implementation plan to offer students an integrated computer experience beginning in their freshman year. These programs include computer aided drafting (CAD), engineering analysis, project scheduling and an introduction to MathCad. Sophomore year offers students experience in working in-depth with MathCad, while the junior and senior years provide students opportunities to use various types of software tailored to engineering analysis and design. Specific needs and experiences are constantly being reviewed by faculty and evaluated. The evaluation process for computing needs involves course instructors, students, the Department's Computer Committee and the Department Chair. Individual course needs are brought forth to the Committee and discussed.

Because the Department settled on AUTOCAD as the computer based drafting platform for student instruction in the middle 1980's, many of AUTOCAD's by-products were available for further computer applications. For example, DWG and DXF file formats became standards for informational exchanges between various related software applications. Evolving software producers offered demonstration programs and technical data that allowed faculty to see firsthand how the software performed, as well as how difficult it was to use. Specific interest was always focused on efficient transfer of software data through input/output file formats. Some programs rely on keyboard entry, while others use files or a database. The ability of a student to create the necessary file, or have access to the required database then became an evaluation factor. Hardware and software system requirements could be determined and upgrades could be factored into the evaluation equation.

Equipment Acquisition Process

Initial support from the institution came in the form of a special computer laboratory that included a drum plotter and eight PC workstations with AUTOCAD and DOS C&G software. Although modest, the creation of this special lab facility was a positive step towards modernizing course offerings relating to surveying and mapping. A list summarizing equipment and software acquired for Geomatics and GIS applications is summarized in Table 1. Information presented in the following paragraphs describe how the equipment/software was acquired and how it is utilized for classroom instruction.

Table 1 - Summary of Equipment/Software for Geomatics and GIS

Quantity	Itemized Description	Manufacturer	Date Acquired
3	4000 ST Survey Grade GPS Units	Trimble	1996
2	Geo Explorer II, Mapping Grade GPS Units	Trimble	1998
2	Pathfinder Office –software for differential correction	Trimble	1998
2	GP Survey – software for data reduction	Trimble	1996
10	STARNET – software for least squares adjustment	Starplus	1998
8	ARCVIEW GIS (3.0) – mapping software	ESRI	1996

8	AUTOCAD (12.0) – drawing software	Autodesk	1999
5	Data Collectors – HP 48 modules	SMI	1998
2	Plot Program – mapping software	SMI	1998
3	GTS-2 Total Stations	Topcon	1998

A major upgrade development occurred when the Civil and Environmental Engineering Department was able to acquire three Trimble 4000 ST survey grade GPS receivers and related computer software in 1996. This acquisition has provided a sound foundation from which the Department has been able to obtain other more modern equipment. For example, another benefactor donated three Topcon GTS-2 Total Stations to the Department in the spring of 1998. This facilitated replacement of three 30-second transits previously utilized in laboratory exercises. In spite of this beneficial and extremely helpful acquisition, other antiquated field equipment currently remains in service.

After lengthy consideration, the Department decided to acquire licenses to operate ARCVIEW GIS, Version 3.0 during the summer of 1996 in the previously discussed special laboratory for surveying and mapping. A critical enabling factor was a new feature on selected software version that would allow DWG files to be imported as part of the project. This allows students to directly import mapping products developed from surveying exercises into a GIS environment. Other software features made it an attractive choice from the perspective of teaching and learning.

Although the Trimble 4000 ST GPS units opened a new era in surveying experiences on the Citadel's campus where centimeter accuracy could be obtained in the stationary mode, these units were not suitable for mapping purposes. During the spring of 1998, the Department purchased two Trimble GeoExplorer II units and the necessary Pathfinder Office software for data reduction and adjustment. These portable units can be carried in the palm of the hand, and have the ability of tracking lines of delineation, such as streets, paths, or woods lines. They can also be used in the "high precision" mode to locate points. Collected data can be easily corrected using differential techniques built into the software. Differential correction requires simultaneous base station data that is often available via modem bulletin board download. Differentially corrected data can be exported in the form of shape files or DWG files for further use in either ARCVIEW or AUTOCAD, thus data can be utilized for multiple applications.

Other initiatives include the recent departmental acquisition of STARNET least squares surveying adjustment software. This software can utilize both conventional surveying field data as well as GPS vector data in an adjustment session. This feature is attractive from the standpoint that simultaneous adjustment of all data can be achieved through use of this program. STARNET also has the ability to export files in DWG format where a plot of the resulting network can be obtained. A demonstration version of STARNET is available at no cost to students and allows user input from as many as ten positions and one hundred side-shots. These limitations do not hinder use within classroom exercises.

Most recently, the Department was able to gain access to Surveyor's Module International (SMI) HP 48 modules for Data Collection and Construction Layout. Plans are currently underway to incorporate the use of these data collectors in the laboratory classes. SMI also produces mapping software called "SMI Plot" that will utilize downloaded data collected using their module and produce a completed plat. SMI Plot is compatible with AUTOCAD so interchange integrity is preserved.

Assessment Process

The Department's decision to adopt AUTOCAD as the mainstream computer aided drafting instructional package has proved beneficial in two major ways. First, and foremost, graduates and industry have indicated that CAD literacy is necessary in today's workplace. Secondly, AUTOCAD has also evolved into an industry standard, recognized worldwide where built-in interfaces allow users a number of input/output options. Although DOS version 12 of AUTOCAD was available on the Department's CAD workstations as late as December 1998, it was replaced in January 1999 by AUTOCAD version 14 in conjunction with AutoDesk's Land Development Package, thus meeting one of the long-term goals of the Department. This upgrade allows students the ability to take advantage of multi-tasking, cut/paste operations, and integration with other windows based application programs.

Currently students are required to prepare during their sophomore year, finished plats as well as topographic maps that are generated in straight AUTOCAD. The arrival of the Trimble 4000 ST GPS units has allowed students an opportunity to gather position data on survey control points, and then adjust their plats and maps to the South Carolina State Plane Coordinate System, using as a basis the single zone SCSPCS 3900 criteria. These mapping products can be directly imported into ARCVIEW as part of the basemap and spatial data inventory.

Students have been required to create with ARCVIEW, a small GIS of the campus using as a basemap rectified orthophotos that have been registered to the South Carolina State Plane System. These orthophotos have been made available for our students to use strictly on an educational basis. Student generated maps and plats that are imported and superimposed over the orthophotos allow students to create relational spatial data upon which the attribute database can be constructed. Because GIS construction was just adopted last year as part of the curriculum, it was unclear what capabilities the students had to produce a final GIS product. Associated databases tended to include data identifying campus features, historical information, and users. With the ability to use "HOT LINKS" (a means to relate a geographic location to amplifying information), future GIS projects can possibly be expanded to include scanned images, as well as other forms of electronic information.

Lessons learned clearly focus on the need for improvements to the computing system. The Citadel's Information Technology Service (ITS) has installed a software lock to prevent students from copying or overwriting program files in the CAD laboratory. Data files must either be permanently installed on the hard disk, or supplied by the user on a 3-½ inch disk. Campus orthophotos permanently reside on the hard drive. Because some students are creating files that push the floppy disk to capacity, even when compressed, a move is underway to network the workstations where larger files can be stored locally on a dedicated server. Once installed, this should help ease some of the housekeeping problems.

Use of the roving GeoExplorer II pathfinder units will start in the Spring of 1999 as part of the Geomatics Laboratory experience. It is anticipated that GeoExplorer II data files, once corrected using Pfinder software, can be used to embellish each student's GIS project, and provide a more complete information database.

Initial use of the SMI Data Collector Modules is scheduled for the Fall of 1998. Students will have an opportunity to download their field data and create a finished plat using this new system. AUTOCAD can be used to enhance the final map product. One problem encountered with the SMI system was the difficulty for students to obtain a record of their calculations and raw data without a separate thermal printer for the HP 48. To overcome this barrier, a conversion program was written so that raw data from the collector could be converted into the required STARNET ASCII format. This allows the data to be read-in and adjusted in an efficient manner. Students will have the ability to create a hardcopy using a PC based platform, and can also take advantage of least squares adjustment for all survey measurements, including GPS and conventional data, as well as importing the results into AUTOCAD for plotting.

Summary

As the Department of Civil and Environmental Engineering continues to make a concerted effort to increase the quality of education at The Citadel, the question is asked, " Is the quality education improving?" Considering that today's work environment is greatly influenced by computers, recent graduates must be familiar enough with computers where they can command and control computer utilization with a degree of self-confidence and reliability. Educational experiences offering computer utilization as part of the coursework enhances student familiarity and confidence.

Because new technology is constantly changing the landscape where computers reside, more sophisticated computer applications slowly become commonplace in the work environment. This in turn can create new academic goals and objectives. As a result, meeting these new milestones placed new demands on equipment and software acquisitions. This allows the curriculum to start with simple applications and then increase in complexity with experience. The Department has been able to achieve some acquisitions in the past through the efforts of the Institution, grants, outside donations, and manufacturers. Ongoing efforts are focused to upgrade the CAD capabilities as well as the quality of equipment utilized for field observations.

Conclusions

Computer based technology relating to GIS and Geomatics is constantly evolving where new demands are being placed on educators to upgrade their curriculum. Scarce financial resources often make equipment and software acquisitions difficult, so when an opportunity arises for procurement, a well thought out plan must be in place to achieve the greatest amount of integration and compatibility. The plan, therefore must be reviewed often, and modified whenever newer objectives and goals are set, or refinements in existing technology create a warranted change.

References

Accreditation Board for Engineering and Technology. *Engineering Criteria 2000, Second edition*, Baltimore:ABET, 1996.

Autodesk, INC. AUTOCAD. Sausalito, CA.

Environmental Systems Institute, Inc. *ArcView GIS*. Redlands, CA: ESRI, 1996-1997.

STARPLUS SOFTWARE, INC. *Star*Net—Least Squares Survey Adjustment Program*, Oakland, CA: STARPLUS SOFTWARE,INC, 1995,1997.

Surveyors Module International. *COGO, Data Collection, and Construction Five HP48/GX Modules*,Church Hill, Tennessee:SMI, 1990-1996.

Surveyors Module International. *SMI Plot*, Church Hill, Tennessee:SMI 1998.

Trimble Navigation Limited. *GeoExplorerII*. Sunnyvale, CA: Trimble Navigation Limited, 1996.

Trimble Navigation Limited. *Pathfinder Office Software—GPS Mapping & GIS Processing Tools for GPS Pathfinder Systems*. Sunnyvale, CA: Trimble Navigation Limited, 1997.

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