TEACHING DIGITAL REMOTE SENSING WITH A SPECIALLY FABRICATED IMAGE PROCESSING WORKSTATION

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ABSTRACT:

An image processing workstation can be a very advantageous instructional tool for teaching, at the undergraduate level, digital remote sensing techniques related to satellite based imagery. In comparison to the conventional methods for displaying and analyzing such digital images, a workstation provides students the opportunity to test quickly and effectively concepts and ideas introduced in class, detect and identify readily the various spatial patterns associated with an image, and explore and analyze thoroughly different research avenues related to their particular environmental interests. A workstation also allows an instructor to cover more topics in a one semester course. However, with beginning prices of image processing workstations ranging anywhere from $15,000 to $50,000 per unit, many small undergraduate programs do not have the financial resources needed to acquire and maintain such stations. This paper examines how, with strong financial assistance from the Student Computing Access Program (SCAP), the undergraduate geography program at SUNY at Oneonta, designed and fabricated its own workstations for less than $5500 each. Methods discussed can be employed also in establishing workstations for other geography instructional areas such as automated cartography and geographic information systems and for other disciplines which need advanced graphics to teach various topics.

The earth is presently the home for over 5.0 billion people; by the year 2000, only 11 years away, another 1.0 billion people will become residents of the earth's surface and by 2010 yet another 1.5 billion will be added for a total of 7.5 billion people. Students now in college will face, by the time they are forty, a world struggling to handle these 2.5 billion new neighbors plus the existing 5 billion. The earth's resources and living space are finite; thus, to accommodate the growing number of people and their life styles, better management and planning of these resources and space become imperative. Geographers along with other scientists are constantly seeking ways to address this issue, and in recent years through combining earth surveying satellites and computer processing systems, they have developed means to detect and measure quickly and accurately land cover changes occurring on the earth's surface and to record these changes on maps which can be used to show how our planet - our home - is surviving. This new field which combines satellite and computer technologies is called remote sensing-digital image processing, and with it, geographers and others are helping decision makers and managers to plan better the use of our physical and cultural environments. Many government and private organizations are moving rapidly toward establishing remote sensing systems in conjunction with other geographic information systems to deal with various earth resources and living space problems. These organizations need well-trained individuals with both technical and liberal arts backgrounds to use these systems effectively.

The Geography Department at SUNY Oneonta has developed one of the best undergraduate programs related to remote sensing, and its allied field of cartography, in the United States. The geography major program at Oneonta is built around three tracks, one of which is entitled "Cartography and Remote Sensing." This track provides students

with a strong liberal arts background as well as a solid exposure to geographic techniques. Below are listed the technique courses offered in this program. Each of these courses is taught either on a one or two-year rotation. Four of these courses relate directly to remote sensing and four are computer based courses. The course named "Remote Sensing: Digital Image Processing" is the topic of this paper.

Geog 145 Remote Sensing: Principles and Applications
Geog 245 Remote Sensing: Aerial Photo Interpretation
Geog 246 Airborne Remote Sensing Systems
Geog 345 Remote Sensing: Digital Image Processing

Geog 240 Cartography
Geog 249 Geographic Information Systems
Geog 340 Advanced Cartography
Geog 341 Computer Mapping and Geo-Information Systems
Geog 343 Quantitative Geographic and Planning Models

A second program track, entitled "Urban and Regional Planning," prepares students to deal with the planning and management of the earth's resources and living space. Students studying under this track are exposed to remote sensing and other geographic techniques in order to understand how these methods can be best employed to address planning problems. The Geography Department also offers three minors, one of which deals with geographic techniques and another with planning. Thus, a student majoring in the "Cartography and Remote Sensing" track can get a minor in planning and a student in the "Urban and Regional Planning" track can receive a minor in geographic techniques. This well-integrated program allows students the opportunity to enter both the technical and applied areas of remote sensing.

Most satellite images are obtained in digital form and represent different portions of the electromagnetic spectrum. No single photographic-like image can display the wide range of information embedded in the data of one satellite scene. Consequently, various quantitative and computer techniques are required to seek out and record information within a scene relevant to different earth conditions. The course, "Remote Sensing: Digital Image Processing," introduces students to these various techniques in a hands-on learning environment. Students in the course are placed into three-member teams. Each team is given two satellite data sets of a particular geographic area to use throughout the course. The data sets provided cover different areas within New York State ranging from the suburban/marshland zones of Long Island to the agricultural and forest lands of the Finger Lakes. Each team must initially define a particular environmental problem that it wishes to address. Obviously, the problem must relate to the geographic area being studied. Throughout the course the student teams use various quantitative and computer techniques in conjunction with their data sets to determine if and how remote sensing-digital image processing can address the environmental problems that they have defined.

This course was established in 1979 with grants from the National Science Foundation (NSF) and the SUNY Faculty Grants for the Improvement of Undergraduate Instruction program. The National Aeronautics and

Space Administration (NASA) also supported the development of the course by providing facilities and contracts to the instructor and making computer software and data obtained from the Landsat satellites available. The Geography Department already had some computer hardware acquired through other grants for its computer cartography course. Although a considerable amount of assistance and facilities were available, the instructor spent a great amount of time converting and developing software, learning the best way to manage the large data files, and integrating the software and hardware to form a relatively friendly "hands-on" instructional environment for undergraduate students, a great many of whom had never worked with a computer before let alone satellite data.

When initially offered, the course was based on computer batch operations with a minimum turnaround time of twenty-four hours. With respect to the large number crunching jobs associated with analyzing images, this arrangement was quite adequate. However, in terms of the image processing tasks, this arrangement was not desirable. Students would run batch programs to create line printer images or maps of their data sets. Generally after reviewing a line printer map, they would want immediately to make some changes on the input parameters to check or refine their work. Each time that they made a change they had to wait twenty-four hours for a new line printer map. This approach did not give them the opportunity to receive immediate feedback and slowed down the instructional process limiting the amount of material that could be presented in the course. Also, on the line printer maps each print character represented one picture element and to cover a reasonable size data set (study area) a large print out was necessary. To use this approach to display one entire scene from the early Landsat satellites, a line printer map of approximately 30 feet by 30 feet would be required and with today's satellites a printout of 120 feet by 120 feet would be needed. A typical student data set would be 5 feet by 5 feet. Needless to say such output would require a great amount of space to display. In addition, to make out features on the maps students would have to stand ten to fifteen feet back from the printouts since the printer characters were too large to detect easily items or patterns when standing close to the output. Thus, turnaround time on processing images and the difficulties with displaying images using line printer map-output made it essential to develop an interactive processing environment designed specifically to handle images. A digital image processing workstation was needed to resolve these problems but such stations start in price at between $15,000 and $50,000, well beyond the resources of the Geography Department at Oneonta. Thus, the Department decided to build a station and with financial support from the Student Computing Access Program (SCAP) purchased the necessary hardware components, namely an IBM-XT microcomputer, a Vectrix PCVX card set, and a high resolution monitor. The total price was $5,317. The VXPC card set alone cost $1,850 but this set permits 512 colors to be displayed simultaneously from a palette of 16.8 million colors, provides a 670 x 480 pixel resolution, zooms an image instantaneously up from between 2 to 16 times its original size, and allows bit plane manipulation of its nine level memory plane. In addition, the card set provides a large firmware library of function commands which can be incorporated easily into any high level computer language and programmed with little difficulty to produce the needed workstation software. A program called "IMAGE" was written in Basic employing the functions provided by the card set. This program which is initialized through a .BAT file provides students with a large array image processing tool to analyze their images in

an interactive environment. In addition, without exiting IMAGE, students can access any DOS command, WordPerfect, and Handshake (a terminal emulator). In other words students can use IMAGE to perform directory checks, file copies, and other DOS operations including the Basic interpreter and EDLIN without disrupting their work. Also, through WordPerfect students can write their course papers and reports while viewing their displayed work on the high resolution monitor or maintain progress notes about their work, again without leaving IMAGE. Students are expected to submit their papers on floppy disks as word processing files and the instructor can review their papers and retrieve their images by using IMAGE. Finally, through Handshake students can convert the workstation into a terminal linked to the mainframe and run programs and other operations on the mainframe. The mainframe programs prepared for the course are designed to start initially in interactive mode to permit parameter input and then they switch to batch mode to handle the bulk of the processing. When running in batch mode, a student can leave Handshake, automatically returning to IMAGE to continue his/her other work. Handshake is also the software used to transfer files between the mainframe and the workstation. All of the above mentioned operations which use the Basic SHELL command are nested within IMAGE and students only need to turn on the microcomputer and start IMAGE in order to have a powerful workstation available to them.

Approximately two years of work was required in order to acquire the various hardware components and develop the program IMAGE. Today, for basically the price of one commercially developed workstation, the Department has four workstations being used in several courses in addition to the Remote Sensing: Digital Image Processing course. An enhanced version of the workstation has been developed using a B&W graphics monitor along with the color monitor. This monitor is used to display graphically ancillary information needed to analyze the land cover conditions being shown on the high resolution color monitor. Putting together these workstations has taken considerable effort but it is very rewarding to see how the students become totally engrossed with their work while using the stations, so much so that they frequently forget to attend their other courses. The workstations have greatly enhanced the learning process in the remote sensing-image processing course. Many students who have taken this course and majored in the cartography-remote sensing portions of the geography program at Oneonta are today actively involved in the development and use of this technology. They are contributing to the essential on-going processess associated with protecting the earth's resources and living space while trying to accommodate the world's growing population.