REMOTE SENSING AND GIS EDUCATION AT THE UNIVERSITY OF THE AEGEAN

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ABSTRACT

Curriculum development and the implementation of Remote Sensing and GIS at the Department of Environmental Studies of the University of the Aegean, Greece are well presented. The use of a microcomputer laboratory to understand and develop software routines for such technologies, as well as, educational aspects involved, are presented and analyzed.

KEY WORDS: Education, Curriculum, Remote Sensing, GIS, Software, Computer.

1. INTRODUCTION

The department of Environmental studies in the University of the Aegean started for the first time at the undergraduate level in the academic year 1987-1988 while the graduate program had began one year earlier in 1986. At the present time there are four major Sections within the department such as Ecosystem Management, Environmental Engineering, Social Environment and Environmental Planing. All these sections operate under a unique four year program of studies. There is a number of courses offered in each section covering related subject areas. Courses however, related to remote sensing and GIS are offered in the Environmental Planing Section. The lab equipment organization, as well as, the development of courses in remote sensing and GIS, in such a program of studies have certain objectives and limitations. The objectives are:

(a) Laboratory support of a GIS system which will do the management of cartographic and environmental information accessible to all interesting faculty and students through individual workstations. The lab will be used for research and instruction in both graduate and undergraduate level.

(b) Generation of course material covering the GIS: principles, development and operation.

(c) Laboratory support of a remote sensing system for extraction of environmental information from analog and digital images. This lab will be interfaced to the GIS system. This lab will also be used for research and instruction in both graduate and undergraduate level.

(d) Generation of course material to cover the remote sensing methods and provide the necessary knowledge on environmental applications.

There is, however, one limitation such as minimisation of the number of courses which cover both remote sensing topics and GIS. This limitation is necessary to keep the total number of courses in the program within reasonable limits for students, in order to obtain a degree in four years.

2. CONSIDERATIONS FROM NEW TECHNOLOGIES

The term new technologies, or, high technology is referred to the hardware and software components necessary to run a system in an area of application.

Remote sensing and GIS are two neighbouring areas and both are using high technology in their applications. Because they are technology dependent, they do change as technology changes. The scientific bases where these fields are based on, do not change as rapidly as the technological components. The algorithms, however, change to be more efficient any time the computing machines are changing. A lot of research in those areas is concentrated into the algorithms and the software. The scientific way to study and analyze those systems in areas of application such as remote sensing and GIS, involves methods and theories, algorithms, hardware and software. The educational aspects of such complicated systems seems to create difficulties and there are publications such as Dahlberg R.E., and Jensen J.R, 1985, which express such conditions for the educator: "at an individual level one feels both challenged and threatened by the explosive growth of knowledge". In this presentation the educator is assumed to be challenged by the high technology and uses the advantages of high-tech to make the tremendous amount of knowledge easier to understand from what it was before the technological revolution (Hashimi Syer R., 1984, Hatzopoulos J.N. 1985).

The proper response to the challenge of new technologies is to use such technology as an education aid. Then all become much simpler and easier to understand. Some strong advantages of high technology include its capacity to provide quick and correct results in very complicated problems and its ability to simulate most lab equipment, lab experiments and processes. Those advantages if properly are exploited by the educator, they could create strong motives to the student who will try to find out how this happens. In this way the learning process as shown in Fig. 1, takes a Bottom-Top-Bottom (BTB)

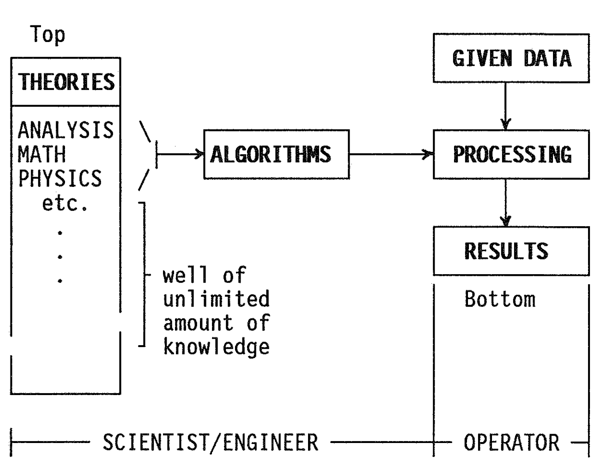

Figure 1. The advantage of the technology to provide quick results creates strong motives to study the scientific bases to a great depth.

approach instead of a top to bottom which is the conventional way of teaching process. The course material, however, is organized as usual into individual modules or sections and each section dealing with a specific problem, then the BTB approach is applied to that section as follows: The instructor introduces in each section or chapter a group of routines which deal with representative problems within the chapter. Those problems become individual lab exercises which require the development of an algorithm and the writing of a computer program. The algorithm and the running program have already been prepared by the instructor. First the instructor demonstrates the way the program works as an operator (Fig. 1) and allows the students to work with it so that to create strong motives to them to study the scientific bases. At the same time it is given a lab exercise which requires the development of an algorithm and the creation of a running program. Parallel to the lab assignment the scientific bases are analysed in the lecture and the corresponding algorithms are developed. During the lecture there are many questions from the students because they are working on the lab assignment and they need to completely understand all the scientific bases to finish the program.

The instructor, for each lab exercise, may provide the source code of several routines or may provide, with certain restrictions, the source code listing of the entire program, so that the average student will finish the assignment within the expected time limits. The lecture does not have to enter into a great depth of the theory leaving that option to the interest of those who want to study further from provided references. In this way a great amount of course material is covered and there is an integrated learning process of all components involved: theory (at any depth), algorithm, software, hardware plus that the student is confident of knowing the content of the study section. This learning process was applied first during my nine year career at the Surveying Engineering Program of the California State University, Fresno and provided excellent results (Hatzopoulos J.N. 1985).

In the Department of Environmental Studies, of the University of the Aegean, the same process is also applied for remote sensing and GIS courses. There is a microcomputer laboratory with PC compatible microcomputers having CGA and Hercules graphics cards. This lab is used for both remote sensing lab assignments and GIS lab assignments. Two examples one in remote sensing and one in GIS of lab assignments are given bellow:

Remote Sensing Lab # 11. RADIOMETRIC ENHANCEMENT
A part of Landsat image of channel 4 composed of 512 lines by 512 columns is available in the file M4.DAT. Write a computer program to do the following:

1. Generate 13 gray scale shades by making a hyperpixel composed of 3x4 = 12 single pixels of the PC-CGA graphics card which will be worked in monochrome high resolution graphics mode.

2. Read the available file M4.DAT one line at a time and hold in memory those values needed to create the regular histogram of the digital image and the equalized histogram.

3. Create a menu within the program which allows the following operations for radiometric enhancement and image display:
(a) Display regular histogram.
(b) Display equalized histogram.
(c) Display stretched histogram.
(d) Display regular image.
(e) Display equalized image.
(f) Display stretched image.
(g) Change image stretch values.
(h) Define upper left corner coordinates of image display window 60x150.

Notices
The following files are provided to you in the microcomputer lab:
IMPRO1.BAS: contains the source code of a program which solves the given problem.
IMPRO1.EXE: binary version of IMPRO1.BAS.
M4.DAT: The channel 4 of Landsat-TM data from the area of Mytilene.

Wanted (a) The program list with source code which will have different variable names from those in the IMPRO1.BAS and from other students.
(b) A copy of the regular, equalized and stretched histogram in a dot matrix printer using PrtSc command.
(c) A copy of the regular, equalized and stretched image in a dot matrix printer using PrtSc command.
(d) A written report on the impact of the radiometric enhancement (equalization, stretch) to identify: sea water, buildings, the soccer fields, the airport, rangeland, agriculture and forest land.

The graphic outputs of this assignment are shown in Figures 2, 3, 4, 5, 6, and 7.

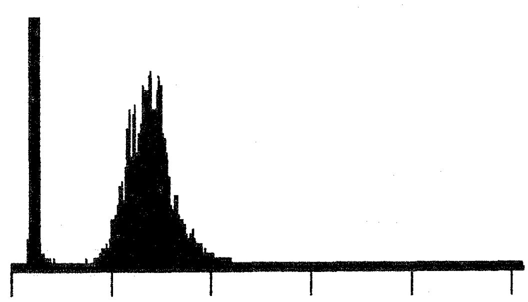

Figure 2. Regular histogram of M4.DAT image.

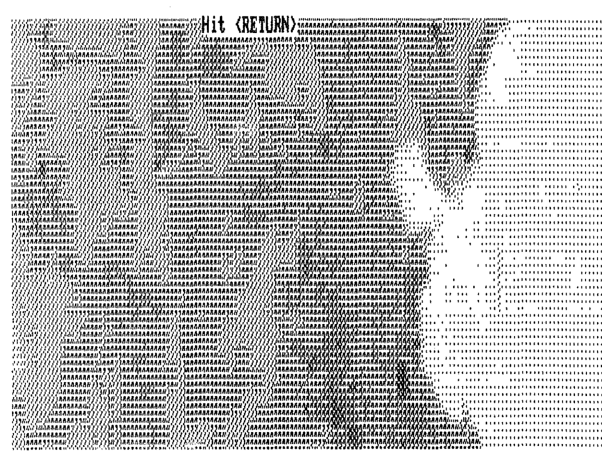

Figure 3. Display of M4.DAT regular image.

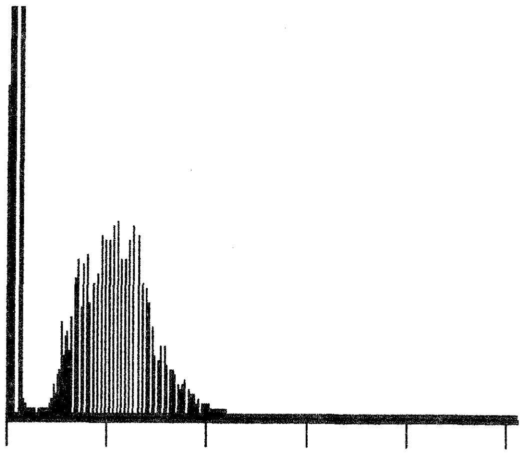

Figure 4. Equalized histogram of M4.DAT image.

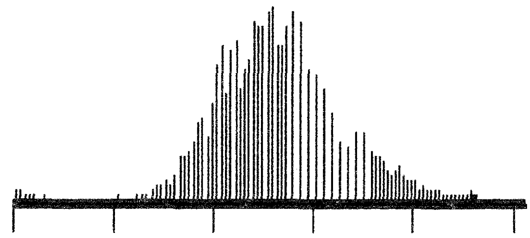

Figure 6. Stretched histogram of M4.DAT image.

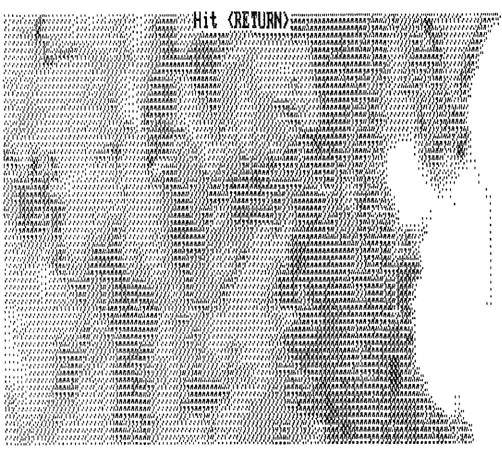

Figure 5. Display of M4.DAT equalized image.

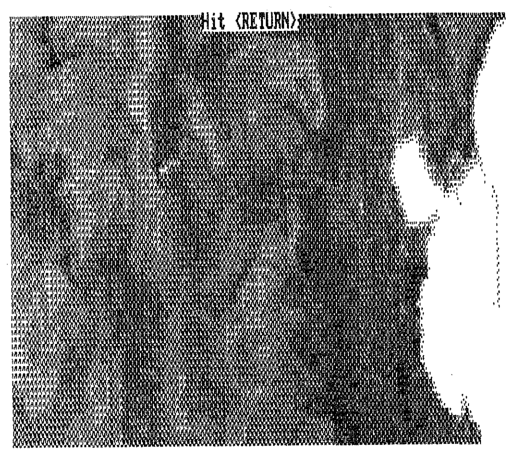

Figure 7. Display of M4.DAT stretched image.

GIS Lab # 8. PERSPECTIVE DRAWING

Write a computer program and make a perspective presentation of the given digital terrain data which are in a matrix form 21-rows by 27 columns and reside in the file LAB8.DAT. Those data have been obtained from a solid waste disposal site in the area of Lemonou. The perspective form will be obtained by assuming that a camera with focal length equal to one is taking a picture of the terrain.

Given data will be (see also Fig. 1): (a) The digital terrain data in a matrix form (b) The XL, YL, ZL coordinates of the camera station (c) The angle s of the camera axis and a horizontal plane (d) The azimuth Az of the principal plane. The photo-coordinates x, y of all grid nodes will be calculated from the following projective equations.

$$DX = X-XL, \quad DY = Y-YL, \quad DZ = Z-ZL$$

$$x = \frac{DX.\cos(Az) - DY.\sin(Az)}{DX.\sin(Az)\cos(s) + DY.\cos(Az)\cos(s) - DZ.\sin(s)}$$

$$y = \frac{DX.\sin(Az)\sin(s) + DY.\cos(Az)\sin(s) + DZ.\cos(s)}{DX.\sin(Az)\cos(s) + DY.\cos(Az)\cos(s) - DZ.\sin(s)}$$

Note that the equations above are derived from the tilt, swing, Azimuth collinearity equations of photogrammetry (swing = 180, s = 90 - tilt) as shown in Fig. 8.

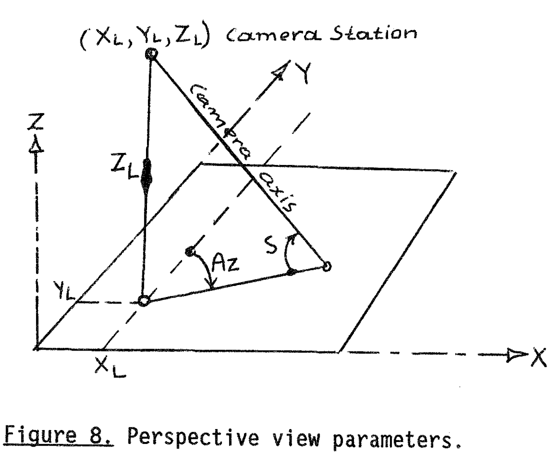

Figure 8. Perspective view parameters.

Wanted: (a) The program listing (the program will read data from the file LAB8.DAT and it will compute the image coordinates of the grid nodes then it will display the perspective view of the terrain in a PC-Graphics Monitor, see Fig. 8).
(b) A copy of the perspective drawing in a dot matrix printer using the command PrtSc, for each one of three views of the area so that to clearly display good quality relief and the drainage features.

Notice.
A list of a program doing the same work will be available to you with the restriction to look at it and keep hand written notes. You are not allowed to copy that program or use exactly the same code. The same program is available for execution only, it is located in the file LAB8.EXE

The graphic results of this assignment are given in Figures 9, 10, and 11.

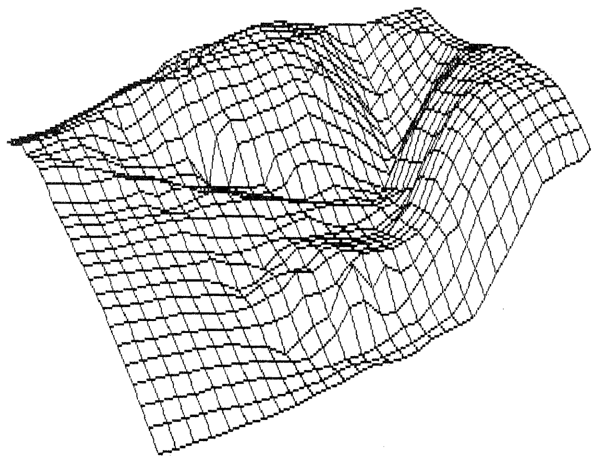

Figure 9. Perspective view of the left drainage.

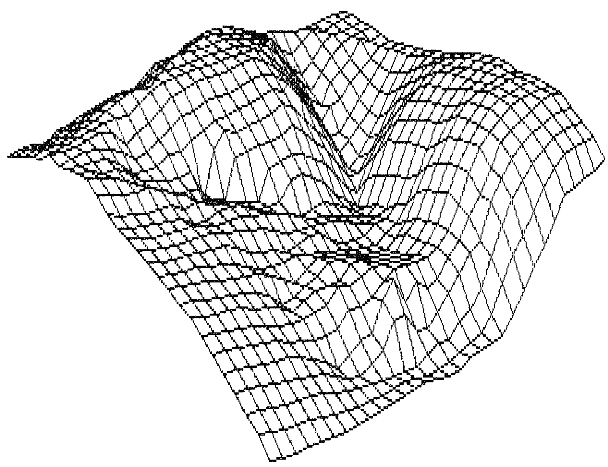

Figure 10. Perspective view of the center drainage.

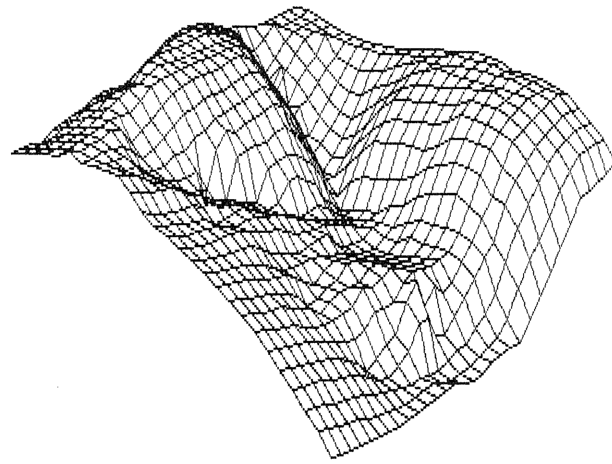

Figure 11. Perspective view of the right drainage.

3. THE COURSE MATERIAL AND LAB ORGANIZATION

As stated in the introduction remote sensing and GIS have to provide a limited number of courses to support the Environmental Studies program. Such courses has been found out to be organized in two levels for each field as follows:

1. A basic course covering Remote Sensing and Photogrammetry which is a required course in the curriculum and provides the basic principles for obtaining desirable quality images and extracting metric and non metric information of the environment from images.

2. An advanced course covering selected environmental applications of remote sensing. This is an elective course and its material is still in the preparation stage.

3. A basic course in GIS which covers GIS basic principles and components such as: cartographic data collection (in the field using compass, in the office using digitizer) and entrance in the system, basic operations in data organization (raster/vector data forms) and processing, concepts of relational data bases, decision making functions of the GIS for the environment, data presentation (display and printer/plotter forms).

4. An advanced course covering selected environmental applications of GIS. This is an elective course and its material is still in the preparation stage.

The analytical outline of the two basic courses which are now offered is given bellow:

OUTLINE OF BASIC REMOTE SENSING COURSE
(4th semester)

Units: 3 (2-hour lecture, 2-hour lab per week)
Prerequisites: Math I, Computer Programming I
Grading: Lab assignments 30%, Written exams 70%.

Photographic and non photographic systems for: aquisition, formation, processing and display of images. Mathematical principles and geometry of images. Photointerpretation methods for extraction of reliable information from images. Algorithms for image enhancement, image processing, and classification of digital images. Review of existing technology.

COURSE OUTLINE

WEEK	LECTURE (2-hours/week)	LABORATORY (2-hour/wk.)
1	Introduction to Photogrammetry and Remote Sensing	Photointerpretation. Geometry of photographs.
2	Nature and properties of the electromagnetic radiation.	Extraction of qualitative information.
3	Optical systems, conventional photography.	Extraction of metric information.
4	Photointerpretation.	Image coordinate transformation.
5	Mathematical bases to interrelate image - object.	Depth of field, characteristic curve.
6	Collinearity and coplanarity conditions.	Internal, relative and absolute orientation.
7	Design of an analytical photogrammetric instrument.	Design simulation of a photogrammetric instrum.
8	Satellite multispectral and radar images.	Digital image processing.
9	Radiometric enhancement of digital images.	Regular, equalized and stretched histogram.
10	Geometric corrections of digital images.	Histograms.
11	Multispectral classification.	Multispectral classification.
12	Density slicing and edge enhancement.	Density slicing.
13	Principal components, filters, convolutions, Fourier transf.	Filters.

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OUTLINE OF BASIC G.I.S. COURSE
(3rd semester)

Units: 3 (2-hour lecture, 2-hour lab per week)
Prerequisites: Math I, Computer Programming I, or concurrent.
Grading: Lab assignments 30%, Written exams 70%.

The collection of field topographic data using a compass and the collection of cartographic data from existing maps to create a data base with information about location of points, lines and polygons are emphasized in this course. The association of other type of information such as topology and thematic data to specified locations and the formation of a Geographic Information System utilizing a relational data base are also well covered. Algorithms for data processing within the GIS such as Coordinate Geometry and digital surface/terrain modeling are presented. The functions of the GIS such as polygon overlay and query analysis to support environmental studies and applications are given in a great depth.

This course is composed of three parts: (a) aquisition and processing of field surveying data using compass, (b) cartographic principles and digital cartography, (c) Geographic Information Systems (GIS). Most parts of the instruction material is accompanied by laboratory exercises in the form of algorithm development and computer programming.

COURSE OUTLINE

WEEK	LECTURE (2-hours/week)	LABS (2-hours/week)
1	Introduction to surveying	Field surveying data aqu-
2	Cordinate geometry	sition, processing, plot-
3	" "	ting, contours, profiles,
4	Cartography	Bathymetric map
5	Thematic map design	Design of thematic map
6	Color theory	Manuscript preparation
7	Digital cartography	Display of thematic data
8	Digital terrain models (DTM)	Thematic map
9	Operations on DTM	Digital map
10	Introduction to GIS	Generation of DTM
11	Boolean algaibra	DTM contour interpolation
12	Polygone overlays & buffering	DTM perspective view
13	Design of a GIS	Thematic map from GIS

Bipliography
1. Dent Borden D., 1985, Principles of Thematic Map Design", Addison-Wesley 398 pp.
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The laboratory of Remote Sensing and GIS has to cover multiple levels of education such as: (Barnes G., J.C. Loon 1988)
(a) Undergraduate instruction
(b) Graduate level research
(c) Support to the other sections of the Department

The existing lab in the Department of Environmental Studies includes the following equipment: The ERDAS-PC system for image processing and the PC-ARC/INFO for GIS, both systems are mounted on microcomputer systems, thus covering part of the research needs. Peripherals to those system are an various digitizers and various plotters. There are also equipment such as compasses, stereoscopes which together with the microcomputer laboratory cover the undergraduate needs. The existing equipment provide, at the present, enough support to the other sections of the Department but as demand for more support increases the lab has to grow up more. The future expansion of the lab will include a network of a UNIX based server and workstations with color graphics capabilities which will be distributed to all sections of the department.

4. SOCIAL IMPACT OF NEW TECHNOLOGY IN EDUCATION

It is important to understand that education is being for the moment, in a transition stage and it will take a while until both the instructors and the students are well prepared to efficiently face new technology. The first step in student preparation is the introduction of courses in information science and other high-tech fields at the secondary level of education. A well documented report for such student preparation has been published by Becker T.W. 1989. The student preparation at secondary level of education is being experimented and hopefully it will proceed to take fundamental steps in Greece. The instructor preparation, however, to face new technology is rather difficult to happen particularly in countries like Greece which maintain a tradition of theoretical knowledge. Other countries also face the same problem for instructor preparation by organizing seminars on a regular basis and by providing all possible facilities.

The problem for the educator and for the society in general, due to the intrusion of new technology, is what Dahlberg R.E., and Jensen J.R, 1985 refer : challenge and threat. As analyzed earlier in this paper, the use of new technology to face regular curriculum problems, as well as, problems arising by the intrusion of new technology is highly efficient. This is a real challenge to the educator to turn the threat into success and provide better quality of knowledge. But there is still the problem for the educator who is excellent in the field that covers, but considers new technology as a threat. This is a social problem concerning not only the educator but other people too. This problem eventually will be resolved by the time but meanwhile (the present transition stage) will be there for a while.

5. CONCLUSIONS

Remote sensing and GIS are dependent on new technology developments and as such it is important to develop a curriculum which provides the bases to implement and understand all components of such a system at any depth. The efficient utilization of the microcomputer laboratory helps to create alternatives for the best preparation of course material and lab assignments. New technology provides a big challenge for faculty and students to experiment complicated theories and ideas. It is an ideal tool particularly for courses such as remote sensing and GIS because it permits direct implementation of theoretical developments providing immediate solutions to experimental and real problems. The goal of curriculum development in remote sensing and GIS in the Department of Environmental Studies is to generate quality knowledge through a limited number of courses so that the students will be able to understand and implement such knowledge in their major field and at the same time they will have the potential to be smarter than the machine.

6. REFERENCES

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