CURRICULUM DESIGN FOR A UNIVERSITY GRADUATE COURSE ON ADVANCED TOPICS IN GIS FOR NATURAL RESOURCES MANAGEMENT

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ABSTRACT

Geographic Information Science or what is so called GIScience is an applied science, which involves spatial or geo data collection and analysis. It consists of three major fields: remote sensing, GIS and GPS. GIS is one of the most important techniques used to analyze spatial data. Designing a course curriculum is not an easy task. However, it would be even more difficult when designing an advanced one. To design a reasonable curriculum for an academic university course: interest, knowledge, experience and motivation are required. Designing a curriculum for a course on advanced GIS topics for natural resources management is the objective of this paper.

1. INTRODUCTION

The main purpose of a GIS is to manage spatial information for decision-making. It can be defined as internally referenced, automated spatial- information systems designed for data management, mapping and analysis. GIS technology is not a "quick fix" to problems in spatial information handling. A GIS has the potential for cost savings and became an extremely important management tool.

The most important characteristic of GIS is the provision of capabilities for spatial analysis. These functions use the spatial and non spatial attributes in the data base to answer question about the queries real world and this become major difference between geographical information system and system for computer-assisted cartography. The development of GIS techniques has provided a constantly growing number of ever or more sophisticated spatial analysis functions.

In these days Geographical Information Systems are used by users from almost all discipline, proved that GIS is crucial to correct, update and maintain cartographic database for long time. GIS can be used to assist decision makers by indicating various alternatives in development and conservation planning and modeling of natural resources such as forests, land use, agriculture, water, etc.

According to NCGIS Core Curriculum the concern and care for education in GIS has been a major factor in allowing the technology to diffuse so rapidly into geography and related sciences as well as into industry and commerce. Therefore, defining and delivering an effective curriculum is the most important professional responsibility for GIS instructors, especially for natural resources management applications. Graduate (e.g. M.Sc. and Ph.D. program) education needs always to be updated with the latest advanced development in GIScience, new techniques, new software, new hardware and new data format.

Applied Sciences (e.g. Remote Sensing, GIS, Geo-information) can be classified as follow:

1. Introductory courses: principle concepts and techniques (lectures and practical)
2. Application courses: techniques (more practical e.g. hands on courses)
3. Advanced topics courses: recent developments in research (much less practical)
4. Specialized seminar courses: mainly guest lectures and students seminars

Advanced topics in GIS are new concepts and ideas in the GIS theory, new GIS methodologies and techniques, newly developed applications, newly developed hardware and software and new types or format of data. Therefore, advanced topics in GIS are very new and state of the art geographic information science and technology system, they are new and recent developments. It is not necessary that all advanced topics are operational and common, but possibly some of these topics just gotten familiar with it.

The objectives of giving such a course are to: strengthen GIS knowledge and expertise, identify GIS latest research developments and enhance the participant's capacity to design and to implement research in GIS.

The objective of this paper was to design a curriculum for a university graduate course on advanced topics in GIS for natural resources management.

2. THE DESIGN OF THE COURSE

In most of the universities world wide, the education system is base on semesters in which courses or classes are taken. A regular semester is usually consist of four months or approximately 16 weeks. A course like the one is suggested (3 credits course) is consist of several contact hours per week. In this case it is 2 hours lectures and 3 hours practical per week. Consequently the timetable of the course will be as follow:

1. One week of background or introductory GIS to refresh the previous knowledge
2. Ten weeks for 10 selected advanced topics in GIS
3. Five weeks for some Guest lecture and a discussion on 5 key selected papers and/or 5 small GIS projects to be done in groups
4. The last week will be used for the final exam and course evaluation

The grades of the course will be distributed as follow: 40% activities on advanced topics, 40% projects-papers seminar, 20% final

The selected GIS advanced topics are:

1. GIScience for NRM
2. GIS Modeling and Simulation
3. Exploratory Spatial Data Analysis
4. Spatial Decision Support System
5. Web GIS
6. Neural Networks for Spatial Data Analysis
7. GIS Multimedia and Virtual Reality
8. Spatio-temporal GIS
9. Uncertainty in GIS
10. Detecting and Evaluating Error in GIS
11. Data Quality Assessment in GIS
12. Visualization in GIS

This course is based largely on the related undergraduate GIS courses, which have been taken by the participants earlier. Graduate students will participate fully in the course and be expected to complete all components although this will be discussed further once the class is assembled. The five (5) weeks project component of the course is highlighted and will make up a more substantial part of the student final grade.

By completing this course the participants will:

1. gain insight into the history and future of GIS,
2. expand their view of GIS as software to an understanding of broader issues associated with its development and use,
3. develop an in-depth understanding of spatial data models including their design, implementation and utility,
4. be able to apply this understanding within the context of GIS analysis,
5. fully comprehend GIS analysis and become proficient in its basic application,
6. gain an appreciation of the diversity in GIS applications and further their abilities to critically assess these applications, and
7. learn the basics of working with certain software package and the develop the capability to move beyond research, plan, design, implement and report on their own application of GIS.

This course, being the follow up to few undergraduate and/or graduate one will engage the student in more advanced topics in the theory and applications of Geographic Information Systems. The practical side of the course will involve some software with a vector/raster-based and GIS system. The course will focus on a more in-depth treatment of the basics that participants received in earlier GIS courses, as well as the exploration of more complex issues concerning data structures, spatial analysis, visualization, uncertainty, and application issues in GIS.

During the practical periods of the 10 weeks of advanced topics, participants will undertake a series of self directed laboratory assignments designed to expand their understanding of basic GIS operations (vector and raster) and analysis. The participants will also complete a major project during the five weeks follow the 1st 10 weeks. The participants should understand that they will not become experts in specific software, but they will be exposed to broad range of functionality contained within the major packages available. The goal is not simply to learn software, but to expand ones knowledge of GIS and to elevate the ability to understand and utilize GIS as natural resources managers.

A practical periods manual will be available and is structured as both an information source and as a step by step guide designed to introduce the participants to work with one of the major GIS software. Participants are responsible for working through the manual in the timeline suggested. The culmination of this effort will be evaluated through a scheduled practical exam. It is in participants interest to make sure that they make use of the scheduled practical period times, and instructor's expertise during these periods.

The second major "hands on" component of the course will be a GIS project, which the participants will undertake during the 5 weeks following the first 10 weeks of the selected advanced topics. A range of datasets will be provided to exploit. It will be the participant's responsibility to select a set that interests them and design, carry out and prepare a report on the GIS analysis they perform. Information on the datasets and important dates will be provided.

As high and advanced topics graduate course, it should not follow the traditional way of teaching. It should mix between the traditional and non-traditional (e.g., new or modern or multimedia technology). However, the mix should be done in some kind of collaborative activities including lecturer, TA's and participants. "The face-to-face lecture event, in which people physically meet, is a momentum to informal interactions: asking questions of instructors and friends in the hallway before class, carrying out discussions with other participants, and developing trust and supportive friendships that start with the companionship resulting from facing common challenges. If participants study from lecture-based learning objects, they will still need these informal interactions." (Kerns, 2002)

3. EXAMPLE OF SOME THE ADVANCED GIS TOPICS

The following are some examples of advanced topics selected for this course.

3.1 GIS Modeling and Simulation

Models are simplified abstractions of reality representing or describing its most important/driving elements and their interactions. Simulations a model runs for certain initial conditions (real or designed). The main reasons to develop models for simulation are: analysis and understand observed phenomena, test hypotheses and theories and prediction of spatio-temporal systems behavior under various conditions and scenarios to support decision making). As far as the types of models is concern, they can be classified according to: Application such as Natural process, Socio-economic, Mixed; Spatial distribution such as Homogeneous, Network, Point, Mixed; Approach such as Process based, Empirical, Combined; Representation such as Static, Dynamic (spatio-temporal). To assess the ability and accuracy of the spatial models the following steps should be followed: validation (comparison with reality), adjustment and optimization and implementation and Operationalization. Some examples of spatial models used in natural resources are: Forest Fire Hazard Model (see Figure 1 as an example of the fire hazard model developed by Sharma and Hussin ,1997), Forest Fire Spread Model, Erosion Model, Deforestation Model, Disease Hazard Model and Reforestation Model.

3.2 Web GIS

which consist of developing GIS functionality in the Internet, Worldwide Web, and private intranets. As far as information collection it can be done in three strategies:
1) server-side strategies, 2) client-side strategies and 3) mixed (See example on Figure 2 by foot and Kirvan 2000).

3.3 Artificial Neural Networks

Classifier that attempts to simulate the working of the brain by composing sets of linkages processing units. The basic element is the processing node.
Each processing node performs two functions. Sum the value of input and apply a threshold function to this value.

3.4 GIS and Multimedia and Virtual Reality

Multimedia: Computer systems, integrated access to a range of data through the means of stimulating human senses using digital technologies.
Virtual Reality: Computer systems, combine a mixture of real world experiences and computer generated material to simulated real world representation.

One of the most important issue is the output which is emphasizing visualization. Visualization has many important and strategic applications such as: natural, tourist, military, etc. Visualization is to make things so realistic to the viewers that they feel they can reach out and touch them. Visualization Should convey a realistic idea of what it actually represents solid models such as carvings perspective in drawings and paintings, stereo-pair photographs, computer images and computer animations.

3.5 Uncertainty in GIS

It is well known that information extracted from remotely sensed data is subjected to error and uncertainty. One of the major sources of error is the nature of the remotely sensed data used. This can be related to the remote sensor system characteristics and quality of the data. As far as sensor system characteristics is concerned, the type of sensor (photographic, optical scanning or radar), radiometric characteristics and resolution (*i.e.*, the recorded wavelengths and the number of radiometric bands used) and, lastly, the spatial resolution, are all important. These sources of error are related to the geometric and radiometric characteristics of the data. A second major source of error and uncertainty is due to the process of data analysis, and in particular to the techniques used to interpret or digitally classify image data. These particularly concern the sampling techniques, sample size and number of samples used. The third source of uncertainty concerns the tropical scene complexity. By their very nature, tropical forests are characterized by their heterogeneous species composition and by the wide biophysical variation among forest cover types.

3.6 Spatio-temporal GIS

Basically the spatio-temporal term is the changes in spatial data through time. "Because environmental processes are, by definition, concerned with time, spatio-temporal data are fundamental to natural resources, and to monitor its condition in particular. Although remote sensing is a valuable source of spatial data for natural resources monitoring, different temporal states are recorded as separate "time slices" or "snapshots". In a conventional geographic information system (GIS), these time slices are held as separate layers" (Weir 1999) (Figure 3).

Temporal behavior of geographical objects can be as: isolated events, continuity, fluctuation and sequential time-series. Conventional GIS data models emphasize static representations of reality. Geographic information for a given area is decomposed into a set of single-theme layers as regular (raster) or irregular (vector) tessellation models (Frank and Mark, 1991). The se layers constrain GIS capabilities to represent dynamic information, such as transitions and motion. (Yuan, 1996).

4. CONCLUSIONS

The aim of the paper was to design a curriculum for advanced topics in GIS for natural resources management. The course was designed for a sixteen weeks study semester. Ten major advanced topics were selected for this course are: GIScience for NRM, GIS Modeling and Simulation, Exploratory Spatial Data Analysis, Spatial Decision Support System, Web GIS, Neural Networks for Spatial Data Analysis, GIS Multimedia and Virtual Reality, Spatio-temporal GIS, Uncertainty in GIS, Detecting and Evaluating Error in GIS, Data Quality Assessment in GIS and Visualization in GIS. A period of five weeks is to be spent on discussion of some selected key GIS papers and/or implementation of a small project. Some guest lectures will be included in this course too.

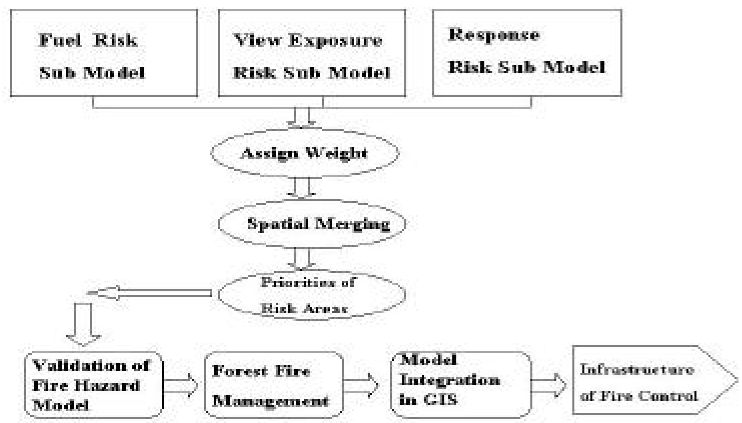

Figure 1. Fire Hazard Model (after Sharma and Hussin 1995)

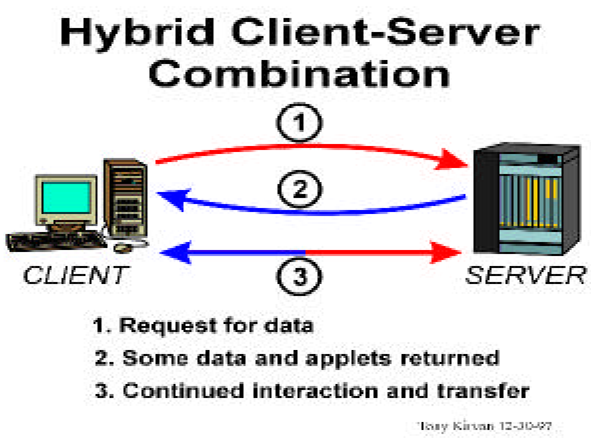

Figure 2. Web GIS of Mixed or Hybrid Client-Server (after Foote and Kirvan 2002).

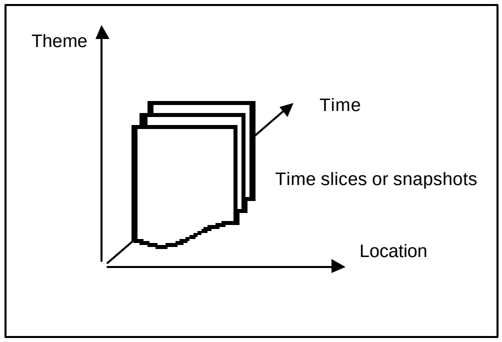

Figure 3. Spatio-temporal GIS (after Weir, 1999).

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