# Geographic Information Systems: Real World Applications for Computer Science

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***Abstract****:* This paper discusses the development and delivery of an upper level computer science elective course in geographic information systems (GIS). GIS applications span numerous and diverse fields, but it is computer science that holds the key to the understanding and development of the underlying spatial database and programming for custom applications. Here the authors discuss the benefits and challenges of a GIS course for students, faculty, and researchers.

*Categories and Subject Descriptions:* K.3.2[Computer and information Science Education]: Computer Science education; H.2.8[Database Applications]: Spatial database and GIS
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*Keywords*: geographic information systems, student research, computer science education

## 1. INTRODUCTION

Spatial databases and qualitative reasoning about spatial data are active topics of research encompassing areas such as artificial intelligence, databases and information systems, data mining, and computational geometry. Results from work on spatial data and reasoning are especially useful in geographic information systems (GIS), spatial databases containing data that is geo-referenced to specific locations on the earth, along with mechanisms for reasoning about this spatial data [3, 6, 8].

Several researchers have attempted to formally define a geographic information system [1, 2, 4, 10]. Basically a geographic information system is a spatial database application with a good user interface and numerous built-in data processing, analysis, and display functions. A spatial database contains descriptive and quantitative data like ordinary databases. However, there is also positional information associated with the data. Everything is positioned in some reference space and is related topologically to other data items based on the position. For GIS, the positions are relative to actual positions on the earth's surface, and may correspond to latitude/longitude, map coordinates, or other measurements.

## 2. GIS COURSE CHALLENGES

Because GIS applications are so diverse, many areas of study can benefit from the use of them. Foresters and land use managers, urban planners, geologists, sociologists, political analysts, and disaster planning experts can all benefit from using such systems in their research and in their day to day working operations. It is natural, therefore, for some disciplines like geography, sociology, forestry, and others to want to offer GIS courses as part of their curricula. These disciplines, however, are users of the GIS. For them it is a tool to help them with their jobs. If a GIS course is taught in such an environment, it will be similar to courses taught for learning how to use word processing software, for example. Students can learn the functionality of the software, but they seldom understand the underlying nature and complexity of the software they are using.

When GIS is taught as a computer science course, emphasis must be placed on the spatial database, the customization of functionality, and the integration of such systems with other databases and applications, in addition to learning about the software and developing applications that use this software. Students should also be exposed to more than one GIS package if possible in order to be able to make decisions about things that are inherent in a geographic information system versus things that are simply part of a specific GIS package.

An interesting challenge is to attract students who already have some experience in databases and software development to a GIS course. Often in upper level courses prerequisites are required, and by the time seniors have completed all the prerequisites they are ready to graduate. Upper level elective courses often compete with each other in attracting qualified students for enrollment. In considering all such factors, we chose to cross list our GIS course as both a senior level elective and as a graduate level computer science course for our integrated science

and technology program (ISAT), an interdisciplinary master's program combining math, computer science, industrial technology, chemistry, and physics. The course is named "Spatial Database and Applications". Topics include introduction to GIS, map projections and coordinate systems, spatial data structures, data entry, spatial database management, spatial analysis, remote sensing, global positioning systems (GPS) used with GIS, internet GIS, and GIS scientific applications.

## 3. GIS COURSE METHODOLOGY AND ACTIVITIES

This GIS course was taught differently from other regular courses. Emphasis was placed on creativity, hands-on learning, extended coverage of spatial databases and applications, establishing the research project, and improving oral presentation skills. Students were evaluated by essay tests, course projects, GIS assignments, academic activities, and presentations.

Each student was required to develop and write a formal project or research proposal near the beginning of the semester after the introduction of geographic information systems. Throughout the semester as the various GIS techniques were introduced, students applied their knowledge using ArcGIS software. These assignments helped reinforce basic GIS skills and enhance the knowledge necessary for developing their term projects.

During the semester two graduate students attended a national workshop at Delaware State University supported by the USDA Capacity Building Teaching Program. The students learned a great deal about Global Position Systems (GPS), and they participated in hands-on exercises for collecting waypoints and mapping them using GIS software. Students also learned how to use a handheld spectroradiometer to collect spectra from various plants. In addition, students were exposed to hyperspectral imaging, remote sensing and mapping of invasive species, precision farming, real-time traffic systems using GIS, and GIS in ocean and forest research. This was the first time our students attended this national workshop. They enjoyed presenting their research posters and sharing their experiences with other students from different universities. When they returned, the two graduate students taught the other students in the class about the GPS and let them collect the sample data they needed in their project. It was a great experience for our students to learn not only from their instructor, but also from the faculty of other universities having expertise in different research areas, and also from fellow students.

Near the end of the semester, the two graduate students attended the 2007 ESRI User Conference Recap. There they learned about productivity tools and user enhancements in ArcGIS 9.2 from presentations and technical demonstrations. They later used some of these enhancements in their term projects.

To improve the self learning and oral presentation abilities of students, each student was assigned a topic from the textbook [5] that was related to his/her background to teach the class. Each student studied the assigned subject, integrated the knowledge learned from other courses with this subject, and developed a PowerPoint presentation to teach this subject to the rest of the class. The instructor and other students asked questions, discussed the subject, and gave evaluations as feedback to the presenter. The students learned a great deal from each other in this activity, in addition to becoming well versed in the area presented by themselves. As a result, the class did extremely well on the final exam on those topics taught by their fellow students.

## 4. GIS COURSE PROJECTS

The course project is an important component of this GIS course. All students in this course were required to do a project on a topic of their own choosing. The project was evaluated by the following categories: proposal, product, final report, and presentation. All students successfully finished their projects and submitted completed packages with all required materials.

One computer science major senior chose the topic "Analysis of the Effects of Hurricane Katrina on Louisiana's Gulf Coast". This project analyzed the damage done on Louisiana's gulf coast by Hurricane Katrina. The primary data source of this project was the Louisiana's Coast Web site [11]. In this project, the student extracted the information pertaining to the Louisiana coast and inserted the information into Microsoft Excel spreadsheets. Using the spreadsheet function properties the student calculated the total land loss and water gained and saved that new inclusive information into separate spreadsheets. Figure 1 shows the outline of the entire gulf coast region where the thin buffer represents possible land loss. This process was achieved by first digitizing and sketching a plotline that fit the coast line and using the analysis tools to add the buffer. Hyperlinks were added in the mapping documents to show areas such as the Chandeleur Islands, which were completely decimated by some of the storm surges.

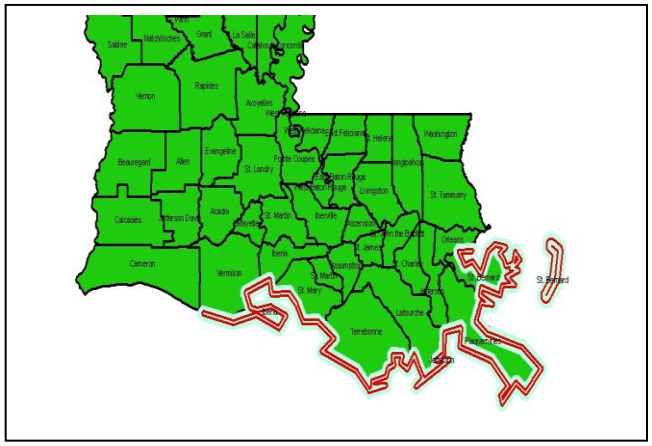


Figure 1 Possible Land Loss Along Gulf Coast Line

A project titled "Geographic Spread of International Students in Southeastern Louisiana University Hammond, Louisiana" was done by an ISAT graduate student. Five goals were achieved in this project: geographically showing the home countries of students, geographically showing how many students come from each continent, analyzing the five-year trends of student population increase/decrease from each country, predicting the future growth of international students from several major foreign countries, and providing political, economical, historical, and cultural information for each country represented. The data for each year concerning international student information was obtained from the university's Office of Institutional Research and Assessment website [9]. Data was transferred into a spreadsheet, sorted descendingly by the student ID number. ArcGIS 9.2 was used to open the country layer of the world map. After joining the attributes table of the world map to the international student table, each country was named and symbolized by colors. Darker colors represented countries from where higher populations of students came, and lighter colors represented countries having fewer students at Southeastern. Figure 2 shows the international students from Europe.

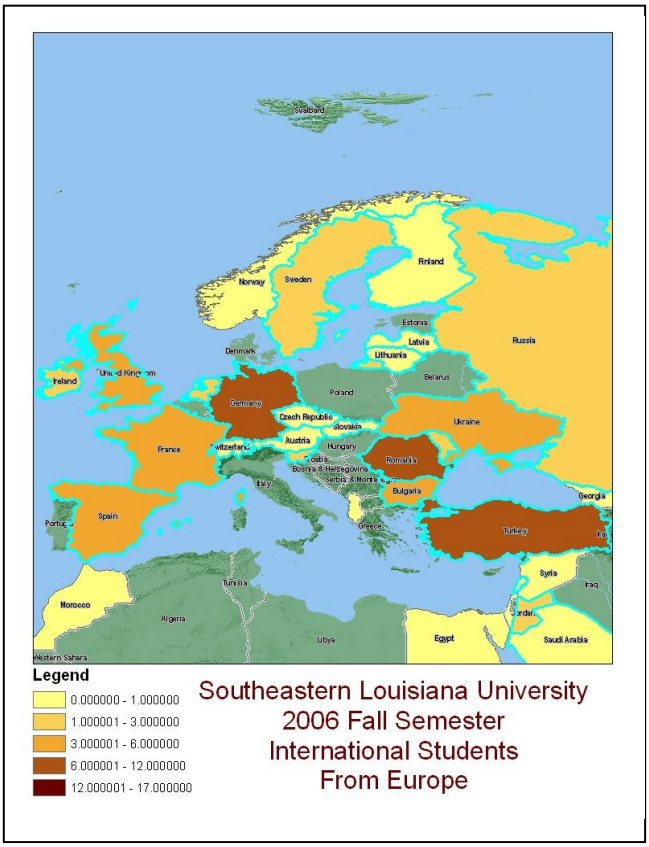


Figure 2 International Students from Europe

The statistical tools learned in a prior Quantitative Analysis for Management course was applied to analyze the five year data for the top twenty-five countries and to forecast their student populations for the next year. A chart was drawn for each country to show its current trend. The "Information" function in ArcGIS was used to link each country's chart of trend and forecasting to its country on the world map. It was also used to link appropriate websites to each country, resulting in a nice tool for university officials studying demographics of international students.

The application of GIS for marketing is well known these days for offering excellent results if applied correctly. Businesses, institutions, and organizations have been using GIS to solve real-world geographic and business problems for some time now, and universities can also benefit from using this technology. Geographic analysis is used to solve various decision problems using mapping software, and by using database variables universities can help identify and target the best prospective students and faculty for recruiting purposes. The use of GIS technology to reorganize marketing initiatives at McHenry County College in Illinois [7] has prompted growth in enrollment and better course schedule distribution.

An ISAT student whose undergraduate study was in business marketing did a project to demonstrate that by using GIS technology our university will be able to identify better students, contact and recruit them, and find better ways to retain them. Creating better marketing opportunities through GIS software, Southeastern will benefit from higher enrollment and better students. Also, with the use of GIS, Southeastern will be able to offer better course schedule distribution and better services for the entire student population. Figure 3 shows the student population from 6 parishes of Louisiana.

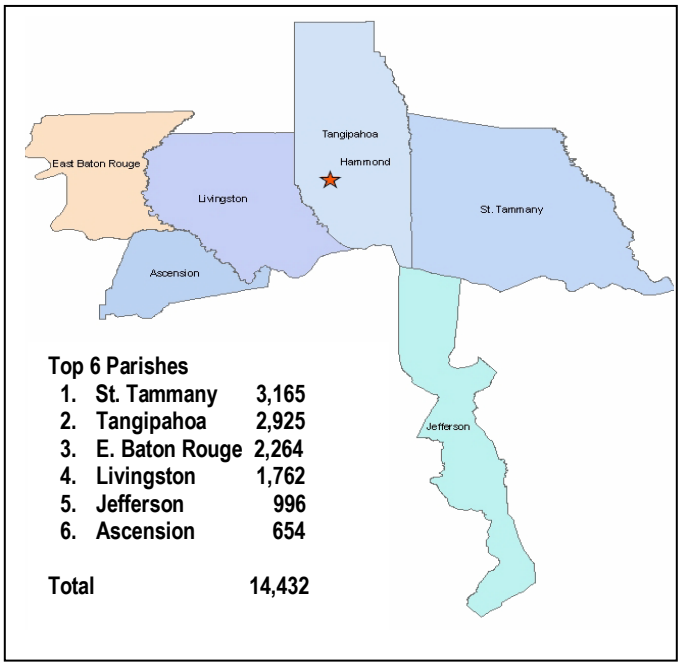


Figure 3 Number of Students from Louisiana Parishes

Overall, the projects in this GIS course were very successful. Students learned a great deal about spatial databases and applications, and they performed research and solved real world problems using GIS.

## 5. GIS RESEARCH OPPORTUNITIES

There are numerous research opportunities in the area of geographic information systems, so students and faculty can easily find topics for research and venues for presenting their results. During a semester course in GIS, students gain sufficient knowledge to be able to identify some area of study, and as they become more and more familiar with GIS software, they can easily develop applications for research problems in numerous fields.

The GIS course proved to be very rewarding for students. One undergraduate student submitted his project proposal for funding through our Science and Technology Awards for Research (STAR) program, which enhances undergraduate education by providing funding for students engaged in research projects or creative work designed in collaboration with Science and Technology faculty members. Proposals were reviewed and funded by the STAR Review Committee and awards were determined on a competitive basis. The student's proposal was awarded, and he went on to submit a paper based on his research to the 2008 IEEE International Geoscience & Remote Sensing Symposium (IGARSS08).

Graduate students also gained valuable research experience through this course. One graduate student began a collaborative research project with a chemist titled "Long Term Impact of Katrina on Environmental Contaminant Exposure to Lead (Pb)". This student is using a GPS unit to find the accurate position where each sample of data is collected. A spatial database will be generated, and the sample data and results will be integrated into a GIS, producing a map that will provide our community and researchers with readily available information about the distribution of traced metals in the area.

Another graduate student decided to continue his research on GIS and marketing, and has expanded his GIS term project on marketing Southeastern Louisiana University through GIS as his final research project for his master's degree.

## 6. CONCLUSION

A GIS course is a challenging, but rewarding opportunity for both faculty and students. This paper discussed the development of an upper level computer science elective course in geographic information systems and described many of the activities in which students were involved.

Several interesting real world projects were developed during this course, resulting in students becoming more interested in related research. The projects accomplished by students incorporated knowledge from other disciplines to produce solutions for a variety of problems. The research ideas and applications that came about through the student projects and presentations also benefited faculty. New contacts were made with faculty in other disciplines and topics for future collaboration and research were discussed.

The GIS course proved to be an excellent course for a computer science elective. Students were able to expand on knowledge and skills learned throughout their academic careers and incorporate those skills with new knowledge about spatial databases and their applications presented in the course. They learned to apply their problem solving skills to real world spatial database problems, to use research techniques, and to formally present their results.

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