
AC 2011-2559: MOBILE GIS IN A MULTIDISCIPLINARY ACADEMIC CENTER

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Mobile GIS in a Multidisciplinary Academic Center

Introduction and rationale for the Mobile GIS course

The evolution of mobile Geographic Information Systems (GIS), utilizing Global Positioning Systems (GPS), remote sensing, and location based computing, is leading to new and exciting approaches for problem solving in STEM careers. The National Aeronautics and Space Administration (NASA) has documented these activities with a growing list of the use of GPS applications in 32 academic and industry fields at their GPS Application Exchange web site.¹ Additional case studies² in multiple career fields have been published by Environmental Systems Research Institute, Inc. (ESRI), a major commercial provider of GIS systems.

Recognizing the opportunity to enhance the capability of students to carry out research projects, the Center for Multidisciplinary Studies at the Rochester Institute of Technology has developed six graduate and undergraduate courses in Geospatial Technologies. These courses are available to all students across the Institute. The related courses titled Introduction to GIS, Geospatial Data Analysis, and Geodatabase Development establish the context for the Mobile GIS course described in this paper. For students who wish to accomplish a more complete concentration, there are additional courses in Geospatial Science and Geospatial Modeling and Visualization. This set of courses and their motivation are incorporated into a previous paper on a Geospatial Technology degree proposal by Johnson and Tomaszewski.³

Global networking and microelectronic data sensing devices have led to an abundance of raw data with location specific measurements of interest at both local and global scales. Recreational use of geospatial technology has familiarized students with experience in the potential uses of the field technology.⁴ Integration of these technologies with existing GIS systems is an accomplished fact.⁵ Researchers and their students in many scientific and engineering disciplines are using these technologies but need to further develop the ability to synthesize knowledge from their measurements and understand their limitations. MacEachren⁶ discusses the role that the creation of maps plays in the development of new knowledge and modern GIS systems with spatial database and visualization capabilities provide this capability.

GIS systems enhance field work by providing the capability to analyze measurements gathered in the field based on their value and location and to carry the results of processing this information back to the field later in a visual form for both further data acquisition and data maintenance. The capability to effectively summarize and draw inferences in transforming this raw data into useful knowledge is critical to students in many graduate and undergraduate curricula. This paper will describe the topics covered in the Mobile GIS course, the expected learning objectives, and a variety of student project experiences when working in a multidisciplinary environment.

Mobile GIS: Course Outline and Syllabus

This university credit-bearing course introduces students to concepts in Mobile GIS technology, GPS theory, and the integration of GPS and GIS data. Students learn how to use hand-held GPS units, hand held personal computers, and Mobile GIS and GPS software. Additionally, this

course provides students with the opportunity to plan and implement field surveys in a team environment, as well as perform laboratory-based geospatial data analysis on information collected in the field. The course emphasizes the integration of geospatial technologies for field surveys. Topics include:

- Principles of Global Positioning Systems (40%)
- Data accuracy requirements (10%)
- Mobile GIS software (10%)
- Field mapping planning and implementation (20%)
- Location-based services and asset tracking (20%)

Educational and career outcomes

- Students will be able to describe the principles of Global Positioning Systems (GPS) location measurement
- Students will be able to plan and implement a field mapping exercise in a team environment
- Students will be able to determine field data accuracy requirements
- Students will be able to operate hand held GPS and computer units
- Students will be able to use mobile GIS software
- Students will be able to use GIS in the field to collect features and GPS data directly to a Geodatabase
- Students will be able to integrate field based geographic data with remotely sensed imagery data

Educational/Instructional Methodologies and/or Strategies

The objectives are achieved through a combination of lectures, readings and applied projects focused on the use of geographic data in the field with portable personal computers and hand-held Global Positioning System devices. Projects are reviewed with feedback given to the student and revisions accepted.

Resources and Technologies

The course is offered in a Microsoft PC computer lab with all required software installed. At the same time the ESRI ArcGIS software was given to students through a grant program from ESRI which enabled these students to install that software on their personal computers with a one year educational license. Students could download the required DNR software for use in transferring data to and from the Garmin Etrex Legend devices without charge from the University of Minnesota. Trimble's Terrasync software was licensed to the Institute and available in the computer laboratory.

Mobile Devices:

- Garmin Etrex Legend GPS devices – recreational GPS devices.

- Trimble GPS devices – Juno, GPM – professional GPS accuracy and capabilities

Computer Packages:

- ArcGIS 10.0 or current version.
- Trimble Pathfinder Office GPS software for uploading and downloading information.
- Garmin DNR GPS software for uploading and downloading information.⁷

General Evaluation Criteria:

Student learning objectives are evaluated through a midterm exam covering reading and lecture material, three assigned projects described below, and a final project. All students are required to submit a final project of their own choosing at the end of the course. This project should illustrate the accomplishment of the course objectives and is graded on the following criteria:

- Effective communication of overall project
- Effective design and layout
- Effective use of symbology and text
- Effective use of color
- Originality
- Accuracy/detail
- Output quality
- Overall impact
- Spatial analysis component
- Complexity of GIS processes used

Final project deliverables include:

- A geodatabase for organizing feature classes
- Image files for all maps (.PDF or .JPG.)
- A brief Word document that includes text describing the project.
- Detailed description of the source for all of your data.
- Description of GIS processes used with step by step explanations of complex geoprocessing procedures or graphical descriptions of your GIS methods.

Students earning graduate credit for this course are also required to submit a research paper on the topic selected for the final project. This paper should be approximately 20 pages in length including figures (such as map inserts), results from the literature in their field, determination of the current state of affairs, conclusions, and proposals for future work that would advance the state of the art. This paper should justify the project submitted and include bibliography and web references.

Assigned Mapping Projects:

These mapping activities include the use of GPS devices and software to incorporate location-based data acquired on the university campus. Many objects located on campus (artwork,

benches, emergency telephones, recycling containers, building entry doors, etc.) are not fully documented on existing campus maps. No printed map can include everything, but in many cases these are needed for visitors or even students in an emergency situation.

Directions for Mapping Project 1

Goal: Use the GPS to gather data points and import into a map.

Summary: Using a GPS device (e.g. the Garmin eTrex Legends), capture 20 thematic waypoints on campus and create a map using ArcGIS with these points imported and displayed on a basemap of your own choosing. Use available basemaps from the ESRI resource web pages. Keep a written log of the displayed accuracy for the GPS unit when you are logging a point. Use the DNR Garmin software to download the waypoint data as a .csv file and use ArcGIS tools menu choice to add the x,y data. When you display the points, compare the location on your map with your personal knowledge of the spot where you were standing and estimate the accuracy of the data collection process.

Turn in a copy of your map in two forms:

1. A .jpg image (export from ArcGIS)
2. A compressed folder containing the mxd file and a data folder that contains the data file of points you acquired as well as any data needed for your basemap.
3. A document with a brief paragraph describing the accuracy of the location data that you gathered.

Directions for Mapping Assignment 2

Goal: Collect location-based data and integrate into existing layers in a map.

In assignment 1 the goal was to collect locations and then create a map layer to overlay an existing basemap, allowing a map reader to visualize and locate the points. In this assignment, measurement data should be collected into a log from the same locations (using the Garmins again to find them) and joined to the existing point layer in the map. The information can then be symbolized as appropriate to show the state of the location.

Note: The ESRI resource basemaps cannot be used in this manner since their layers may not be modified. Use other shapefiles that you collected.

Identify locations on the map layer that will be visited and gather information at the site – e.g. condition of blue light phones on campus – working, accessible, etc., garbage cans – full, empty, etc., POI on campus and description. Make sure to collect both quantitative and categorical data for each location. Currently, from Assignment 1 above, the latitude and longitude of the location is known, but there is no additional data or information about the location. Create a spreadsheet from the data that can be linked to the geographic layer in the map. Then use the Add Data tool to create a new entry in the table of

contents. Use the GIS join operations to integrate the data and symbolize the points to create an informative map.

Turn in a compressed folder with

- a) your map (mxd file)
- b) data folder containing
 - i. your point data (txt or shp files)
 - ii. spreadsheet with your data log.
 - iii. Any other layers you have included
- c) Jpeg file with the exported image of your map.
- d) A short paragraph describing the accuracy of the measurements you have included.

Directions for Mapping Assignment 3

This project is similar to the preceding two mapping assignments but will involve a change in technology and the development of a workflow for the project. Use the Trimble GPS devices running the TeraSync software. Document the location and properties of 6 pieces of outdoor artwork on the RIT campus and export this data to a campus map prepared using ArcGIS.

Project Steps:

- 1) Create a data dictionary (a .ddf file) using Pathfinder Office software in the lab to be used in gathering your data. Submit the .ddf file to dropbox for this lab. Upload this file to the Trimble device using the Pathfinder Office software. Connect the Trimble to the PC computer using Microsoft ActiveSync installed on both devices. That should happen automatically when you do the following:
 - a. Turn on the Trimble GPS unit.
 - b. Plug in the usb cord to the computer.
 - c. Put the Trimble in the cradle to connect.
- 2) Uncradle the Trimble device and take it outside to collect locations and data.
- 3) Return to the lab, cradle the Trimble, and download the data gathered using the Pathfinder office software utility to create a .ssf file. Submit this file also.
- 4) Carry out the differential correction process on the data using Pathfinder Office. This will create a .cor file that you should submit to the dropbox.
- 5) Now export the corrected point file to as an ESRI shape file. You will use this to build the map that you submit for this lab. Pick your own basemap to add context to the collected points. Submit the .mxd file and a data folder for your map as before.

The final course project requires students to create a GIS based map that synthesizes what they learned in the course in spatially organizing information of interest in their field of study. They must pick a topic that includes spatial information and then find and create data that can be displayed and visualized using GIS.

Assessment Data

This course was offered in Spring 20010 concurrently to 5 undergraduate and 5 graduate students. This multidisciplinary group (students from colleges of science, applied science and technology, and liberal arts) was asked to assess the instructor and course using the ongoing RIT online student evaluation procedures near the end of the course. This was most appropriate since all course administrative processes had used an online course management tool for dissemination of course materials and submission of student project work. Grades were generally good as expected in a project based course with unlimited feedback and revision.

Five of the ten students responded to the questionnaire (2 graduate, 3 undergraduate) which included 23 multiple choice questions as well as 3 questions allowing free-format comments regarding the instructor and the course itself. Questions related to the course objectives and to the material in this paper are summarized below with responses listed:

1. Clarity of the course objectives and how well were they met? (2 very good, 2 good, 1 adequate).
2. Value of course assignments?(1 very good, 3 good, 1 poor)
3. Use of teaching techniques and styles that encouraged your learning? (1 very good, 3 good, 1 adequate)
4. Satisfaction with how much you learned in this course? (4 good, 1 poor)
5. Your background preparation for this course? (3 very good, 2 good)
6. The course overall? (1 very good, 3 good, 1 adequate)
7. How well do you expect to do for the final course grade? (3 very good, 2 good)
8. How would this course be improved?
 - a. More time in the field with mobile equipment
 - b. Very little information was new to me – not challenging. Too much introductory information.
9. Other comments?
 - a. Not enough assignments.

This feedback and other items are being used in the preparation for the second course offering. In general the laboratory resources and field equipment were effective for the course objectives and will be used again.

Conclusions

This course has focused on a particular activity of mobile computing using GIS/GPS technology to perform outdoor fieldwork requiring precise location-based data. For many students this is the first opportunity to formulate a research question, gather data with an emphasis on minimizing measurement uncertainty, and building visual displays, static and interactive maps, for incorporation into a written research report.

Concepts and design of project workflow are central to the activities of the course as well as skills and knowledge of GIS/GPS technology. Students from diverse academic disciplines added interest to the class projects and enabled students to integrate different viewpoints and research issues that would not have surfaced within a single discipline. This course will be offered and

evaluated again in Spring, 2011. Project based assignments will continue to be the primary instructional method with an emphasis on problem solving and written communication of results.

The future applications of developing mobile technologies⁸ and location-based services⁹ provide fascinating learning opportunities that could well define the nature of scientific discovery and communication in the next century. Certainly, the data rich environments that are currently overwhelming us will require much different methods.

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