GIS learning with GRASS

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Abstract

Since 1996 GRASS is used in GIS classes at the Dipartimento di Ingegneria Civile ed Ambientale of the Università di Trento. This paper describes the potential of this GIS, with freely available code, in Geographical Information Systems education, both for university courses and professional training.
The use of GRASS offers several advantages: the software is accessible without licensing worries, the system can be freely distributed to students, the source code is available for the analysis of the algorithms and a large free collection of documentation exists on the Internet.
Educational experiences gathered in several years of teaching using multimedia devices have been applied to specific courses on GIS and in land planning and management, where GIS is used as a tool. Different approaches in GIS training are presented: lectures, tutorials and full GRASS applications.

1. Introduction

Geographic Information Systems are currently fundamental tools in all processes involving spatially referenced information, such as land management and planning (usually carried out by public administration) and cadastral applications (usually performed by professionals).
The insufficient education in GIS significantly slows the organization public or professional in adopting these new tools. A better education in GIS would offer several advantages: a more efficient use, a better knowledge of geographical information system potential and the possibility of a proper choice of the suitable GIS.
Education in GISs in the Italian universities has just recently begun. Some short courses (three years) on GISs have started, while GISs are used as tools in courses on land survey, management and planning.
There exist a significant delay in GIS teaching/learning with respect to other European countries such as the United Kingdom or France, where specific courses on GIS started years ago.
Open source GISs, and GRASS in particular, can give a significant push to the GIS diffusion and education. These systems are based on a co-operative development model so that each user can take advantage of the software freely and pass it over to others, with the only obligation of redistributing every modification free of charge. Such a development model, which has been successfully used for operative systems and application software, makes available an effective and skilled geographic information system outside traditional distribution channels. The availability of such programs is becoming always more meaningful in every research field for the possibility of directly influencing the system development, in particular by creating new software modules solving problems peculiar

of the specific research field. Even in the educational field this class of software can lead to new methods in teaching geographic information systems theory and applications.

2. Education levels

The proposed educational path is structured on three levels, optionally followed by a fourth step involving the development of new applications within the GIS framework.
The first level implies a series of lectures introducing the basic concepts of numerical cartography and geographical information systems. In this stage the working design of the system and the data organization are presented. The system description is carried out together with the real time display of a working GIS. An extensive documentation and the availability of the source code make possible an accurate and deep description of the system. Students usually prefer working with an open and modifiable system, rather than with a close one.
The second level consists in a tutorial, which guides each student through the basic operations with the system. This whole step is carried out using the system directly. The tutorial starts with the system's access procedures and introduces simple operations to get the student accustomed with the interface and the general system usage. Afterwards some complete applications, which have been discussed before by the class, are carried out. The tutorial shows both the logical steps and the GIS procedures of each application. These applications acquaint the students to the translation of logical models into geographic information systems' procedures. During the classroom exercises one or more instructor are present.
The use of a GIS working in multi-user operative systems and the client-server architecture allows a centralized management of the data and the accounts. The operative system on the client side is meaningless as long as an X server is available for the graphical output.
The third level requires to the students the development of a complete application, solving a land planning problem or implementing a model for a spatially distributed phenomenon. This application is planned by each student with the teacher for the application's details and procedures as well as for the data needed and their format. The operations for data format conversion are left to the students.
The use of an open source GIS allows the distribution of the software to the students both for its normal use (in binary form) and its analysis (as source code). This means that the students are allowed to freely use the software after the end of the lessons, re experiencing the classroom exercise and developing new applications.
Conventional GIS software does not allow the redistribution to the students, some software houses offer free software for the visualization and map printing but no data elaboration is allowed.
An optional fourth level would require the development of full-featured new procedures, exploring more deeply the GIS programming aspects and data structures.

Approach	**Knowledge**
lectures	basic concepts in GISs, system functional design, data structure
tutorial	main commands, interface use, data referencing, map algebra syntax
complete application	data import/export, specific commands
procedure development	data structure, algorithm

Table 1 – Approach-knowledge scheme.

The tutorial consists of several lessons with an hypertext structure: each GRASS command or GIS term carries a link to a manual page or a glossary, each procedure has a dedicated page explaining the logic beneath and input/output data. The first lesson simply introduces the operations for

accessing GRASS and the use of its two user interfaces, graphical and command line. Some basic concepts such as GRASS "region" and data management are explained.
The second lesson shows the raster data management in GRASS and the use of several modules working on such data. The third lesson explain the use of digital terrain models, their creation, manipulation and generation of 3D images.
The next lessons consist in complete applications of GRASS, such as mining analysis.
Further complete applications will be added.

3. Education experiences

The scheme above has been successfully applied for several courses in GIS, in university classes for undergraduate as well as graduate students. After only ten lesson hours each student is able to use a powerful geographic information system such as GRASS. The full applications are carried out in cooperation with the tutors of other classes in land planning and management, where geographic information systems are used as tools.
This educational method has also been used in training for professional users and public administrations' operators.
It is possible to distribute the system to the students, so that they can test it for their own applications.
The possibility of client-server architecture simplifies the organization of the classroom exercises, since it is possible to manage on a single server all the students accounts and the data. It is feasible to employ a single server for about 6-8 clients (i.e. students or groups of students) even using a standard hardware system, for example a standard Pentium system with a 450 Mhz CPU and 128 Mb RAM.

4. Benefits for using an open source GIS

The benefits for students and instructors coming from the use of an open source GIS as GRASS are meaningful.
For teachers:

1. the availability of the source code allows a detailed analysis and control of algorithms and data structure;
2. the availability of free software simplify the set up and management of laboratories, with savings on the budget and less organization efforts;
3. the availability of abundant and detailed documentation makes the planning of the lessons easy;
4. the availability of free datasets and on line tutorials in different languages, which can be used for the training.

For the students:

1. the possibility of freely install the software on his/her own computer;
2. the possibility of exploring the system procedures by inspecting the source code;
3. the possibility of free access to a large documentation about the use and the development of the system;
4. the possibility of merging new programs into the system.

An important feature of GRASS for its use in GIS education is the possibility of using both the graphical and the command line interface. This fact allows a progressive learning of the GRASS commands and their syntax: novices usually prefers the graphical interface, since there is no need to learn commands by heart and the options choice is simple, while experienced users frequently use

the line commands because of their speed and better flexibility. It is possible to force the use of one interface when the feature of the interface is important: while the graphical user interface simplifies initial operations, the command line allows a better insight of the procedures.

5. Conclusions

The use of open source software allows a new and innovative approach in geographic information systems education.
Past experiences "on the field" for university classes and professional training have confirmed the effectiveness of the educational method. GRASS has proved to be suitable as a system for comprehensive geographic information systems teaching. It is effective for students approaching a GIS for the first time as well as for experienced users willing to improve their skills.

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