Building open source geospatial education at research universities: where we are and what is holding us back

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Introduction

In spite of a growing government and industry support for open source software only few university Geospatial Information Science curricula include open source approach, and most programs focus on use of proprietary software. At the same time, many science and engineering disciplines require flexibility and portability provided by the Free and Open Source Software (FOSS) to support coupling of complex computational tools with geospatial data processing. Some of the largest technology companies, such as IBM and Google, contribute to FOSS development and many U.S. government agencies now require open source as a condition for grants and contracts. FOSS also provides a viable alternative for agencies in regions with limited resources. Moreno-Sanchez [1], in his editorial for special issue of Transactions in GIS devoted to FOSS4G 2011 conference, highlights FOSS4G as a mature alternative in the field of geospatial technologies.

Overview of existing efforts

FOSS4G is used in academia in a variety of settings. The most widespread but hard to track are applications and development in university research laboratories. Related work has been presented annually at FOSS4G conference academic sessions and selected papers were published in special issues of refereed scientific journals [1], [2], [3], [4]. Short courses, workshops, and summer schools is another area with numerous successful efforts and extensive material available through ELOGeo [5] and OSGeo Edu [6] inventories and on the annually updated OSGeo Live DVD. Special topics courses focused on FOSS4G are commonly offered as electives at research universities and colleges all over the world, but there are only few continuously updated, established courses [7]. Academic communities most active in FOSS4G are still geographically concentrated in Europe (especially in Italy and Spain), North America, and Japan although there are increasing efforts to support adaptation of FOSS/FOSS4G in other regions, especially in the developing world (FOSS4G 2008 in South Africa is a good example).

FOSS4G at North Carolina State University (NCSU)

NCSU is located in a region with thriving FOSS industry lead by RedHat, the first FOSS company to reach 1 billion in annual revenues in 2011, validating the viability of the FOSS business model. NCSU has a rapidly growing Geospatial Information Science and Technology (GIST) program. It includes Graduate Certificate, Professional Masters of Science in GIST, and several PhD programs that incorporate GIST-focused research. Major expansion of the program into Geospatial Analytics is under way. The program focus is on general GIST concepts and hands-on practice in both open source and proprietary systems. Advanced technology for in-class courses and for Internet-based delivery is used to support and enhance the instructor work and student experience, both in the classroom and through distance education. The GIST program is interdisciplinary (there is no Geography or Geomatics department at NCSU), managed by the Center for Earth Observation at College of Natural Resources, with faculty coming from 20 Departments and 8 Colleges. The program covers FOSS4G in one core geospatial analysis course that includes GRASS GIS and a number of elective courses that include python, PostGIS and WebGIS applications from the OpenGeo software stack. Easy to install FOSS4G binaries were key for introduction of open source into the curriculum.

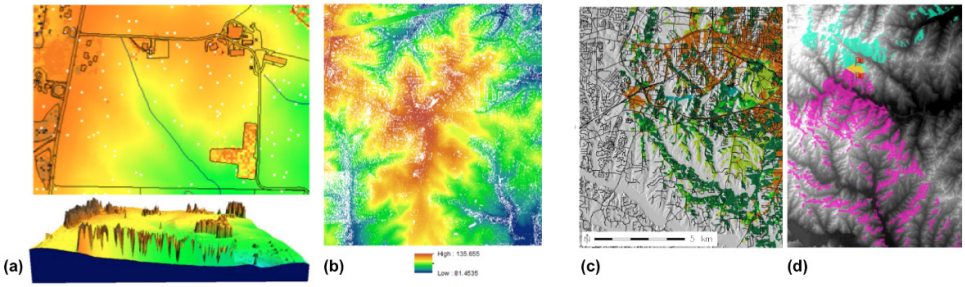

FIGURE 1

Assignment on lidar data processing. Binning point cloud to raster in (a) GRASS and (b) ArcGIS. GRASS output includes cross-section of bare ground and first return surfaces. Analyzing viewsheds: (c) land use composition in the visible area with GRASS, (d) visibility between two points displayed in ArcGIS

To illustrate the integrated approach, specific examples from the graduate course on Geospatial Modeling and Analysis are provided. In this course, the lectures, focused on concepts and methods, are software independent. The related assignments are simultaneously performed in GRASS GIS and ArcGIS, with slight differences in tasks to make the results more interesting, as illustrated by several examples (Figure 1). The course material, with design © by NCSU, and content under CC license, is available free online and updated annually to reflect changes in new software releases. Takehome midterm exam allows students to chose software to accomplish the tasks, leading to interesting and often creative results (Figure 2).

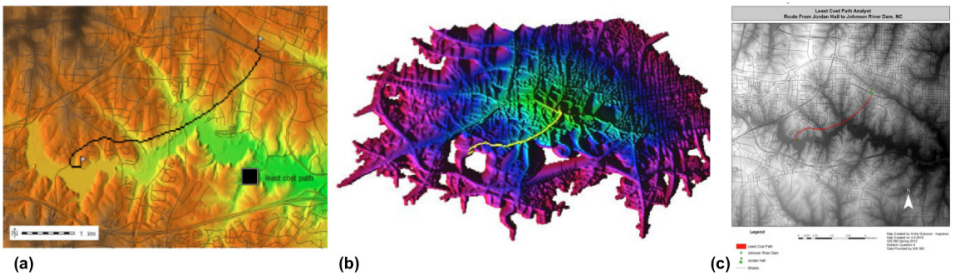

FIGURE 2

Midterm exam: results of the least cost path task performed and visualized in: (a) GRASS GIS with path displayed over shaded relief, (b) GRASS GIS with path draped over the 3D representation of cost surface, (c) ArcGIS displayed over elevation raster

Important component of the course is an independent project: again students chose the software and it is quite common that both ArcGIS and GRASS are used. Several examples of students' projects that use FOSS4G demonstrate the diverse open source geospatial applications (Figure 3), such as creating a DEM by using the mobile phone GPS, analysis of karst topography from lidar data, or study of coastal dynamics and hurricane impacts. Several projects lead to peer reviewed publications [8], [9]. Although the students come into class with at least some experience in ArcGIS, GRASS GIS and open source concept itself have been new for all and many students were eager to gain the unique knowledge and skills that FOSS4G offers. As additional benefit, the students working as research assistants introduced FOSS4G into their research laboratories.

Under the auspices of the Memorandum of Understanding between the

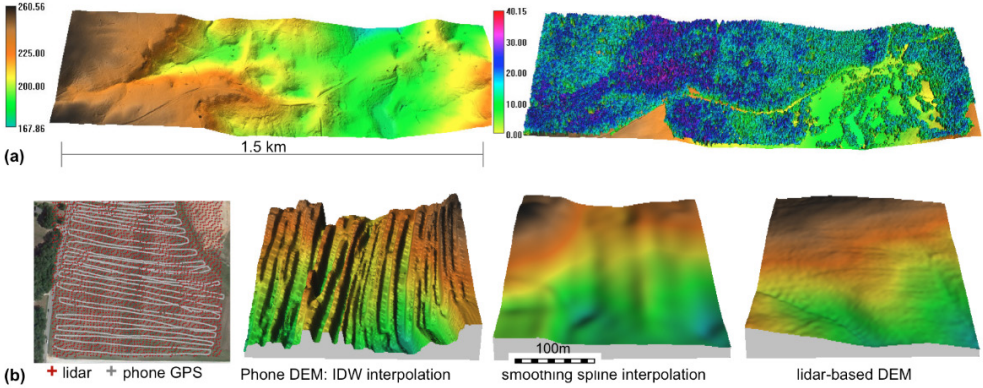

FIGURE 3

Geospatial Modeling and Analysis course projects using GRASS GIS: (a) Using LiDAR to map sinkholes and canopy height in Mammoth Cave National Park; (b) creating a digital elevation model using mobile phone GPS

International Cartographic Association and OSGeo [10], there are plans to establish OSGeo Research and Education Laboratory (OSGeo REL) at NCSU with the goal "to support the development of open-source geospatial software technologies, training and expertise and to provide support for building up the development of open-source GIS teaching and training materials in order

to encourage wider participation globally." The active collaboration with the Geoinformatics program at the Czech Technical University and its planned OSGeo REL will explore effective approaches to international collaboration to achieve these goals that could then be applied on broader scale.

FOSS4G at Czech Technical University (CTU) in Prague

FOSS4G tools have been used in courses at the Faculty of Civil Engineering, Czech Technical University (CTU) in Prague since 2005. First, the assignments for a Remote Sensing course in the Geoinformatics program were developed with GRASS GIS. A new course called Free Software GIS was introduced later, in 2007. Within this course, the students learn about the FOSS4G environment in general, including a community-driven development, OSGeo role, as well as the desktop and webbased projects. The course is available also in English to make it accessible for international Erasmus students. Thanks to Professor Cepek, FOSS tools have been used in the Geoinformatics and Geodesy and Cartography programs for several years, including PostgreSQL database system in the Introduction into Database Systems course, Qt framework in Programming in C++ course and Introduction into GNU/Linux OS course has also been offered. The students can further enhance their knowledge in database systems in the Introduction into Geospatial Processing course focused on geospatial data handling in database systems using PostGIS. Thanks to these efforts the students get valuable experience with various FOSS4G tools (programming, geospatial database systems, GIS desktop or web-based applications) in addition to the proprietary GIS solutions. Several students became involved in FOSS as translators, power users and developers. Since 2008 several Geoinformatics students from CTU participated in Google Summer of Code (GSoC) program and developed a new GUI for GRASS visualization module wxNviz (in 2008, 2010, and 2011, Figure 4) and for a network analysis module wxVNet in 2012. Other students have been involved in QGIS development as their semester projects or diploma thesis (e.g., recently developed QGIS plugin for Czech cadastral data or Workflow builder for QGIS Sextante project). These activities and the annual Geoinformatics conference along with GRASS GIS community sprint held in Prague provide a sound basis for the planned establishment of a regional OSGeo Research and Education Laboratory at CTU.

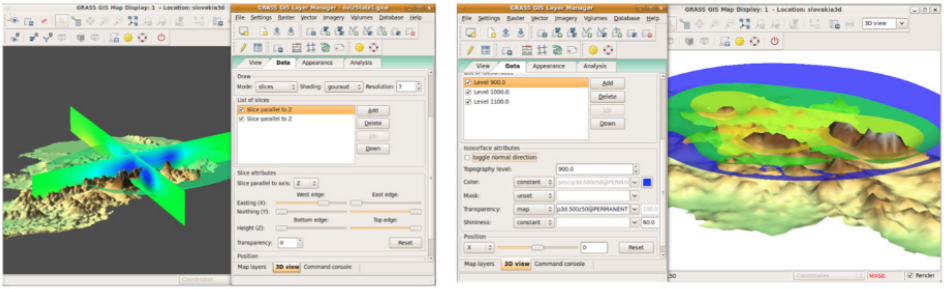

FIGURE 4

GUI for 3D visualization developed as GSoC project

Conclusion and future directions

In spite of several successful programs [7], incorporation of FOSS4G into GIST education remains challenging. Although substantial educational material is available, preparing and maintaining free, up to date, on-line educational material for multiple systems requires substantial resources in time and expertise but the number of faculty directly involved in FOSS4G projects is still rather small. Student contributions to FOSS4G remain limited in spite of positive role of GSoC and university research laboratories. Several initiatives based on experiences from universities with successful programs [7] may bring progress on these issues. The proposed global network of OSGEO Research and Education Laboratories [10], if supported by sufficient funding, has a potential to create a coordinated front for FOSS4G education material development, including electronic textbooks, task oriented software tutorials, lectures and webinars. Direct involvement of university faculty and students in the FOSS4G projects as power users or developers and broader participation in GSoC as mentors and programmers could provide the bridge between the academic world and FOSS4G development community. Testing of new modules, development of add-on tools and contribution to teaching materials can be incorporated into courses as class assignments, helping students to overcome potential barriers to involvement in FOSS4G communities.

As the successful programs demonstrate, FOSS4G provides a cost-effective, portable and highly functional toolset for interdisciplinary research and education that is especially valuable in science and engineering programs. With coordinated effort and collaboration of academic community it can be fully integrated into GIST curricula worldwide and bring a new level of innovation and creativity into geoinformatics and geomatics education.

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