An overview about Geographic free and open-source software

Paolo Dabove*

* Politecnico di Torino, Environment, Land and Infrastructure Department (DIATI), Turin (Italy)

Since the last decade, numerous free and open-source software (FOSS) has been developed: this new approach, thanks to its quick update and its affordability, has guaranteed the employment of FOSS both by public and private bodies. In the field of open tools, the development of geographic software (GFOSS) became particularly relevant, whose distribution increased enormously and whose innovations are constantly increasing. This work aims to show the main innovations in the field of GFOSS in order to highlight, by macro themes, what could be the future developments in the field of open source.
Keywords: *Open source programs, GFOSS, GIS, GNSS.*

Una panoramica sui software geografici liberi e open-source. *A partire dall'ultimo decennio, sono stati sviluppati numerosi software liberi e open-source (FOSS) che hanno avuto uno sviluppo rilevante nell'utilizzo sia da parte di enti pubblici che di privati, grazie alla loro rapida possibilità di aggiornamento e convenienza. Nell'ambito degli strumenti open, particolare rilevanza ha avuto lo sviluppo nel campo del software geografico (GFOSS), la cui distribuzione è aumentata enormemente e le cui innovazioni sono in costante aumento. Tale lavoro vuole mostrare le principali innovazioni nell'ambito dei software GFOSS al fine di evidenziare, per macro tematiche, quali potrebbero essere gli sviluppi futuri nel campo dell'open source.*
Parole chiave: *Programmi Open source, GFOSS, GIS, GNSS.*

1. Introduction

The family of open source software is divided into three main categories: COSS, OSS (Riehle, 2007) and FOSS (Lakhani *et al.*, 2005; Lessig *et al.*, 2005). COSS compared to OSS is characterized in a way that a single legal entity owns and controls it, carries out most coding by in-house developers, decides on it, and directly makes money from it (Riehle, 2012). As stated in https://en. wikipedia. org/wiki/Free_and_open-source_software, free and open-source software (FOSS) is software that can be classified as both free software and open-source software. That is, anyone is freely licensed to use (Hancock, 2016), copy, study, and change the software in any way, and the source code is openly shared so that people are encouraged to voluntarily improve the design of the software (source: What is free software? The Free Software Definition. The GNU Project – GNU. org). This is in contrast to proprietary software, where the software is under restrictive copyright licensing and the source code is usually hidden from the users.

Although there is almost a complete overlap between free-software licenses and open-source-software licenses, there is a strong philosophical disagreement between the lawyers of these two positions. The terminology of FOSS or "Free and Open-source software" has been created to be a neutral on these philosophical disagreements between the FSF and OSI in order to have a single unified term that could refer to both concepts (Stallman, 2018).

Richard Stallman's Free Software Definition, adopted by the Free Software Foundation (FSF), defines free software as a matter of liberty not priced, and it upholds the Four Essential Freedoms (Stallman, 2018). The earliest-known publication of the definition of his free-software idea was in the February 1986 edition (GNU. org) of the FSF's now-discontinued GNU's Bulletin publication. The canonical source for the document is in the philosophy section of the GNU Project website. As of August 2017, it is published there in 40 languages. In https://en. wikipedia. org/wiki/List_of_free_and_open-source_software_packages it is possible to find a list of free and open-source software packages, computer software licensed under free software licenses and open-source licenses. Among these, particularly interesting are the Geographic Free and Open Source Software (GFOSS) that will be deeply described in the next section.

2. GFOSS and their applications

Also in the geographic research field, open source software is considered as an innovative process: a new and revolutionary process for producing software based on unconstrained access to source code as opposed to the traditional closed and proprietary approach used by most of commercial world (Steiniger and Hunter, 2012; Steiniger and Hunter, 2013). Open source geospatial software recently evolved to include a variety of components and capabilities that encompasses the entire life cycle of geospatial information, from spatial data collection, spatial database management and geospatial servers, to a variety of geospatial analysis and solutions for web, mobile, and desktop management (Brovelli *et al.*, 2016). In this context, thanks to the rapid evolution of open source software, it is now possible to establish an SDI (Spatial Data Infrastructure) using only open source geospatial software. The United Nations (UN) is trying to introduce open source geospatial solutions to complement, and in some cases replace, proprietary geospatial software (Eom *et al.*, 2017).

Some tools have been developed also for education activities to accept other people, such as migrants, and for raising the awareness of the citizens on this topic. The enormous migratory flows in the European Union and in the Mediterranean area are influencing the lives of people residing in the hosting countries. Nevertheless, the real magnitude of this phenomenon often remains unknown to citizens and can generate erroneous perceptions. For this reason, the MIGRation pATterns in Europe (MIGRATE) was born: this is probably the first attempt to apply, in a modern way, the methods and tools of Geomatics to migration-related themes through a Web Mapping application whose goal is to educate and raise the awareness of citizens on this topic (Aiello *et al.*, 2016).

Other tools were developed for risk management: this is the case of ERIKUS and a dedicated approach developed by the authors for the speditive 3D reconstruction of the environment using smartphones or tablets. In the first case that tool was developed by members of Regione Piemonte and Arpa Piemonte for the 2016 earthquake event in Central Italy. This application, based on QGIS open source software, is a tool for managing requests for house survey presented by citizens to Municipal Operations Centers (Coc), in order to give a quick response to the safety of their homes (Mayneri *et al.*, 2017). In the second case, the proposed method is based on the use of tablet devices for rapid close range photogrammetry in post-earthquake scenario. Starting from images acquired by tablets during speditive surveys, the authors showed how is possible to reconstruct the environment starting from data acquired by low cost devices (Dabove and Di Pietra, 2018). Even for this disaster, also members of OpenStreetMap (OSM) community have developed tools for collaborative mapping, that can be exploited everywhere in an easy way (minghini et al, 2017), as already happened in (Latif *et al.*, 2011; Shemak, 2014). Another example of the use of open source software and open data, for the same event occurred in Italy, was developed by Baiocchi *et al.* (2017) for the determination of some parameters useful for assessing the seismic vulnerability of each building potentially exposed.

Considering the aquatic environment, a couple of interesting tools have been developed: the first one is the NARVALO systems that is mainly dedicated for marine environment, while the second one is OAT, specific for groundwater modeling. NARVALO is a collision avoidance system for logistic platform areas that detects possible dangerous situations, which could lead to accidents, and consequently alerts vehicles and people involved (Marzocchi *et al.*, 2017). The other interesting method is the Observation Analysis Tool (OAT): this is a module of the FREEWAT plugin for QGIS, developed to handle time-series data from various sources and formats and to ease the incorporation of environmental monitoring data into GIS applications, specifically water resources management and groundwater modelling (Cannata and Neumann, 2017).

2.1. Some applications in GIS environment

Considering the GFOSS, one of the biggest project is related to GIS environment: QGIS. QGIS is a professional GIS application that is built on top of and proud to be itself FOSS (https://qgis.org/en/site/about/index.html.), licensed under the GNU General Public License. Probably a book would not be enough to describe the world around QGIS and its project: QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities. QGIS is a volunteer driven project and it is so famous because it is used around the world. Most of research activities are now based on hydrogeological applications (Apiratikul *et al.*, 2019; Park *et al.*, 2019; Ollivier *et al.*, 2019; De Rosa *et al.*, 2017) but there also some research activities on remote sensing image analysis (Gilliot *et al.*, 2018), photogrammetry (Oxoli *et al.*, 2017) and geology (De Donatis *et al.*, 2018). It is also used for landslide (Bovolenta *et al.*, 2017; Stralla *et al.* 2017; Costantino and Angelini, 2017) and soil conservation analyses (Dumedah *et al.*, 2019; Massawe *et al.*, 2018).

2.2. Some applications in GNSS

Starting from 2010, the research fields related to Global Positioning System (GPS) or Global Navigation Satellite System (GNSS) started to use FOSS. Probably, the main software in this field is RTKLIB (Takasu and Yasuda, 2009), developed by Takasu from the beginning of 2009(Takasu, 2011). Using this software, many research activities have been developed for many purposes, starting from the evaluation of low-cost GNSS receivers up to cadastral applications (Dabove, 2019), landslide analyses (Bellone *et al.*, 2016) and atmospheric monitoring (Hankansurijat and Andrei, 2018; Astudillo *et al.*, 2018). At the same time, another open-source software for GNSS positioning was developed by researchers at Politecnico di Milano (Italy): goGPS, firstly developed in Matlab (Realini and Reguzzoni, 2013), is now available in Python and it provides comparable results with respect to RTKLIB in terms of positioning performances (Poluzzi *et al.*, 2019).

An interesting application, based on atmosphere monitoring, was provided by the analysis of GNSS signals. Ferrando *et al.* (2017) identified a procedure to monitor in space and time the Precipitable Water Vapor (PWV) content on regionally extended and orographically complex area, using also the GRASS GIS software for interpolating the local estimation of Zenith Total Delay (ZTD) measured by a GNSS Permanent Stations network, to produce PWV maps.

With the advent of the Android N (version 7) Operating System, GNSS receivers installed inside smartphones are able to provide a set of raw GNSS measurements, in addition to the user position, which open the way to more advanced and customizable positioning algorithms. Many studies have done in relation of the quality of the measurements (Navarro-Gallardo *et al.*, 2017) as well as the quality of positioning, in terms of accuracy and precision.

3. Conclusions and future steps

As shown before, FOSS is widely spread around the world and is used for many purposes. One of the main subject category is represented by software used for geographic purposes (GFOSS). In this context, most of possible applications have been shown in this paper, especially considering Italian and European research activity. In Italy, there is a specific association named GFOSS. it (http://www.gfoss.it/) which promotes the development, dissemination and protection of exclusively free and open source software for geographic information. Every year, this association organizes a national meeting where researchers coming from all parts of Italy are presenting their works. This year the conference was held in Padova while in 2020 it will be hosted at Politecnico di Torino, from February 18 to February 22. This association is the local (Italian) chapter of the Open Source Geospatial Foundation (OSGeo – https://www.osgeo.org/) that is a not-for-profit organization whose mission is to foster global adoption of open geospatial technology by being an inclusive software foundation devoted to an open philosophy and participatory community driven development.

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