Open Geospatial Data, Software and Standards

EDITORIAL

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Open-source geospatial tools and technologies for urban and environmental studies

Amin Mobasheri[1*], Francesco Pirotti[2] and Giorgio Agugiaro[3]

Abstract

Open geospatial data and tools are an increasingly important paradigm offering the opportunity to promote the democratization of geographical information, the transparency of governments and institutions, as well as social, economic and environmental opportunities. During the past decade, developments in the area of open geospatial data and open-source geospatial software have greatly improved. Many parts of the research community believe that combining free and open software, open data, as well as open standards, leads to the creation of a sustainable ecosystem to accelerate new discoveries to help solve global cross-disciplinary societal challenges, from climate change mitigation to sustainable cities. The consistent prevalence of open source GIS studies motivated this thematic collection. The contributions are divided into two main categories. In the first category, seven concrete studies on open-source tools and technologies for urban and environmental studies are briefly presented. Each one has been implemented for and applied to a certain use case, and at the same time it may be applied to other use cases due to the reproducibility nature of open source software. The second category presents and discusses the usability of open source geospatial solutions for laser scanning technology and its applications.

Keywords: Open source GIS, OSGIS, Open data, Open standards, VGI, Laser scanning

Introduction

Open-source GIS has consistently and effectively improved during the past decade [1]. Governments and stakeholders from academia and industry actively participate in open geospatial data, software and standards initiatives and support related organizations such as the Open Source Geospatial foundation (OSGeo). Furthermore, Open Geospatial Consortium (OGC) consistently design and test open standards which are at the core of major infrastructures such as the European Union's INSPIRE Spatial Data Infrastructure (SDI). The amount of national and international projects that employ open geospatial data and develop open-source GIS software by implementing open-source GIS standards is extensive and it is expected to grow even further in the near future. As a result, research and practices in the open-source GIS domain with its broad range of applications has become a timely topic of interest to the geospatial community [1–3].

Concrete projects based on open geospatial data and software now have significant and measurable impact on communities, including their economy, political life, environment, health, transportation, and many other areas [4]. While such projects provide their own benefits, the data and software developed by these projects are often reused beyond the original plans, reflecting the real potential of Open Source GIS and its value.

The contributions of this collection are divided into two main categories. In the first, seven concrete studies on open-source tools and technologies for urban and environmental studies are briefly presented, each of which has been implemented for and applied to a certain use

* Correspondence: a.mobasheri@uni-heidelberg.de
[1]GIScience Research Group, Heidelberg University, INF 348, Heidelberg, Germany
Full list of author information is available at the end of the article

case, and at the same time may be applied to other use cases due to the reproducibility nature of open source software. The second category presents and discusses the usability of open-source geospatial solutions for Earth Remote Sensing applications.

Open source tools and technologies for urban and environmental studies

Open geospatial tools and standards for 3D GIS

Three-dimensional GIS datasets are being increasingly used as input in different applications [5]. Nowadays, the 3D GIS community is strongly focused on semantic 3D city modelling (e.g. based on international standards such as CityGML [6] and IndoorGML [7]), but, as highlighted by Biljecki et al. [5], in practice the quality of available 3D datasets is often sub-par since they may contain geometric and topological errors. However, the validity of 3D primitives in 3D GIS datasets is often a prerequisite for using them in simulation and decision-making software. In order to address this concern, Ledoux has developed *val3dity*, an open-source software to validate 3D primitives according to the international definitions of ISO 19107 [8]. Practitioners can use it directly, without limitations: its code is freely available under the GPLv3 license, both binaries and a web-application are publicly available. It takes as input several formats (including the international standard CityGML), and outputs a report that helps users identify and understand the errors. Ledoux' paper describes some of the engineering decisions supporting *val3dity*, and show that it can be used to validate real-world datasets [8].

The next open-source implementation of this thematic collection is *VI-Suite*: a set of environmental analysis tools with geospatial data applications. *VI-Suite* combines the functionality of 3D design software with performance simulation. In their paper, Southall and Biljecki present the history of *VI-Suite* development along with a review of its capabilities of relevance to geospatial analysis [9]. Furthermore, some of the benefits of this tool are discussed including aspects that make it suitable for the processing and analysis of potentially large geospatial datasets. As an example use case, a 3D city model of The Hague is used to demonstrate some of the geospatial workflows possible and some of its visualisation functionalities.

In the same context, an open-source, platform-independent 3D geo-database solution for CityGML-based 3D city models called *3D City Database* (3DCityDB) is developed and presented by Yao et al. [10]. The 3DCityDB software package consists of a database schema for spatially enhanced relational database management systems (both for ORACLE Spatial and PostgreSQL/PostGIS) with a set of database procedures and software tools allowing to import, manage, analyse, visualize, and export virtual 3D city models according to the CityGML standard. Within this paper, the authors illustrate the software suite and explain the related technical implementations and the underlying conceptual software design in detail. Moreover, the utilization of 3DCityDB in different projects and practical application fields are also presented.

Last but not the least, Agugiaro et al. present the Energy Application Domain Extension (ADE) for CityGML with the aim of enhancing interoperability for urban energy simulations [11]. According to the authors the Energy ADE is meant to offer a unique and standard-based data model to allow for both detailed single-building energy simulation (based on sophisticated models for building physics and occupant behaviour) and city-wide, bottom-up energy assessments, with particular focus on the buildings sector. Their article presents the rationale behind the Energy ADE and describes its main characteristics, the relation to other standards, as well as provides some examples of current applications and case studies [11].

Open source geospatial solutions for urban/environmental spatial analyses

Open-source geospatial solutions have been effectively employed in various geospatial use cases which involve studies of the urban environment. In this regard, this thematic collection includes two further studies focused on spatial analysis and one study on employing volunteered geographic information (VGI), both for urban/environmental applications. A brief overview of the studies is presented below.

GeoJModelBuilder is an open-source geo-processing workflow tool which allows distributed geo-processing algorithms, models, data, and sensors to be chained together to support geospatial data analysis for environmental monitoring, as a use case example [12]. In their article, Zhang et al. present the system architecture as well as the technical implementation details of *GeoJModelBuilder*. Their developed framework leverages open standards, Sensor Web, geoprocessing commands and services, OpenMI-compliant models together [12]. The paper justifies the ability of the proposed workflow tool with discussing three environmental use cases.

In another urban study, Molloy and Moeckel present an iterative algorithm to design optimally sized spatial zones suitable for spatial modelling, while respecting municipal boundaries [13]. The authors argue that the appropriate resolution of a zone system is key to the development of any transport model as well as other spatial analyses, since the number and shape of zones directly impacts the effectiveness of any further modelling steps, with the trade-off between computation time and model accuracy being a particularly important consideration. Their article as well as their source code are openly accessible for detailed investigation and usage in projects [13].

Crowdsourcing geographic information and participatory GIS have been among the most intensively studied topics in geospatial research and industry over the past two decades. Various projects have implemented participatory-sensing concepts within their workflow in order to benefit from the power of volunteers, and improve their product quality and efficiency [14, 15]. The datasets generated or collected by volunteer citizens are referred to as Volunteered Geographic Information (VGI), which has been one of the most interesting and challenging type of open geospatial data in the past years. The next study in this thematic collection employs OpenStreetMap data; the most popular form of VGI data source for producing up-to-date litter maps [16]. *OpenLitterMap* rewards users with Littercoin for doing the work of collecting, mapping, processing and producing open geospatial data on an increasing variety of pre-defined types of litter. This process is currently accomplished through a web-app, which is built with focus on the mobile and generally available also on-line. As described by the developer of the project, in order to ensure data quality, all data goes through a manual verification process, which is being done by a small team of trained volunteers. This verified data is being used to develop machine-learning algorithms that will make manual processing and verification easier [16]. OpenLitterMap is an interesting example of implementing useful open data platforms and infrastructures on top of OpenStreetMap among many other existing platforms such as OpenTopoMap, OpenCycleMap and WheelMap [17], to name a few.

Open geospatial solutions for laser scanning technology

Open Source GIS software and solutions have not only expanded the usual vector GIS data capabilities, but considerable improvements were also implemented in the area of point cloud data. This thematic collection includes two further studies covering related to laser scanning technology and spatial point cloud data analyses.

In the first study, Pirotti et al. present the implementation and assessment of two density-based outlier detection methods over large spatial point clouds [18]. The authors stress that accurate methods for automatic outlier detection is a key step in analysing spatial point clouds for deriving meaningful information. Hence, in their article, they use an open-source workflow to assess two outlier detection methods, statistical outlier removal (SOR) filter and local outlier factor (LOF) filter. Details of their tests and results as well as the source code of their implementation are available as open source [18].

Finally, the last article of this thematic collection provides an overview of the contribution of open-source projects for supporting the use and analysis of laser scanning data [19]. The first part of the article provides an introduction on laser scanning principles, followed by sections respectively reporting on open standards and formats for lidar data, tools and finally web-based solutions for accessing lidar data. One of the aims of this article, as described by the author, is to provide scientists that have not yet worked with lidar data an overview of how this technology works and what open-source tools can be a valid solution for their needs in analysing such data [19].

Conclusion

This thematic collection presents nine studies focused on development and applications of open-source geospatial data, software and standards. It is worth noting that the thematic collection and this editorial paper does not claim to be a complete review of the numerous open-source GIS software and solutions that are available nowadays. The editors of this thematic collection were motivated to provide examples of new developments in open-source geospatial solutions and increase awareness of the diversity of methods, algorithms, data and tools that are developed and applied in spatial analysis and remote sensing.

Authors' contributions

A.M. wrote the article; F.P, and G.A proofread and provided comments that improved the article. All author(s) read and approved the final manuscript.

Competing interests

Authors declare no conflict of interests.

Author details

[1]GIScience Research Group, Heidelberg University, INF 348, Heidelberg, Germany. [2]TESAF Department, Interdepartmental Research Center of Geomatics, University of Padova, Viale dell'Università 16, 35020 Padua, Italy. [3]3D Geoinformation Group, Delft University of Technology, Julianalaan 134, Delft 2628BL, The Netherlands.

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