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INVITED ARTICLE

Volunteered and crowdsourced geographic information: the OpenStreetMap project

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Abstract: Advancements in technology over the last two decades have changed how spatial data are created and used. In particular, in the last decade, volunteered geographic information (VGI), i.e., the crowdsourcing of geographic information, has revolutionized the spatial domain by shifting the map-making process from the hands of experts to those of any willing contributor. Started in 2004, OpenStreetMap (OSM) is the pinnacle of VGI due to the large number of volunteers involved and the volume of spatial data generated. While the original objective of OSM was to create a free map of the world, its uses have shown how the potential of such an initiative goes well beyond map-making: ranging from projects such as the Humanitarian OpenStreetMap (HOT) project, that understands itself as a bridge between the OSM community and humanitarian responders, to collaborative projects such as Mapillary, where citizens take street-level images and the system aims to automate mapping. A common trend among these projects using OSM is the fact that the community dynamic tends to create spin-off projects. Currently, we see a drive towards projects that support sustainability goals using OSM. We discuss some such applications and highlight challenges posed by this new paradigm. We also explore the most promising future uses of this increasingly popular participatory phenomenon.

Keywords: volunteered geographic information, crowdsourcing, OpenStreetMap, VGI, OSM

Advancement in technology during the last two decades has brought a shift in how spatial data are created, viewed, and used. For example, improvements in computer graphics facilitated the embedding of interactive maps in web pages and virtual globes. Remote sensing has impacted on how spatial data are collected and digitized. But it was a rapid move towards user-generated content on the Internet which has truly revolutionized the spatial domain over the last decade. Volunteered geographic information (VGI), a term introduced by Goodchild in 2007 [10], refers to the creation and sharing of geographic information by private citizens. The process has also been captured by other terms such as cyber cartography [8], neogeography [12] and wikication of GIS [29], or crowdsourced maps and geographic information [22]. In all cases, individuals and groups who may not possess cartographic skills can collect and disseminate geographic information about a location, often making it freely available for others to use via the Internet.

OSM is widely considered the pinnacle of VGI. In part this is due to the large number of volunteers involved in the project (over 6 million as of May 2020), the volume of spatial data generated, the frequency of updates, the variety of data formats, the favourable licence, and the breadth of projects which utilize OSM data. Initially, OSM was regarded as a mapping tool. The underlying spatial data was used for visualisation, map generation, route finding, and points of interest extraction. However, over the last decade, the use of OSM has increasingly expanded and it is now common to find OSM projects used in humanitarian, environmental, social science, and political projects and research. As such the impact of OSM in the last decade has been extensive in many domains.

One such example is the use of OSM as a tool for crisis response and planning activities. The impact of VGI and OSM, in particular, was seen in large-scale natural disasters such as the 2010 Haiti earthquake [28], the Tibetan earthquake in 2015 [24] as well as supporting humanitarian efforts after tsunamis, violence, and forest fires [19]. OSM has also been used in small-scale crisis situations such as local building fires to assist rescue personnel [16].

The dynamic nature of VGI has allowed for rapid updates of not just the data itself but also the type and granularity of data collected. Therefore, OSM has adapted to different requirements and can be exploited in support of emerging challenges, addressed, among others, by the UN Sustainable Development Goals [1]. For example, mapping deeper levels of information on features captured in OSM data has enabled many projects to support a more sustainable environment. Environmental OSM is a project that aims to map energy, waste management, food, and transport systems as well as habitat use and green space [23]. To respond to new requirements, OSM contributors adopted new environmental tags which can be added to any spatial feature. For example, a recycling waste management facility may be tagged by adding `amenity=recycling` to the feature. Similarly, a tree mapping exercise can be facilitated by adding the tag `natural=tree` to the relevant OSM map feature. In 2018, a worldwide OSM "mapathon" was organized for World Earth Day with the goal of mapping ecosystems and environments of interest [6]. The problems tackled included the spotting of any signs of protected areas being encroached on, monitoring sea levels of island communities, and understanding land use of indigenous people. Many smaller communities at risk are not represented on any maps [9]. OSM Earth has been developed to coordinate these types of collaborative mapping projects [18]. Similarly, the Humanitarian OpenStreetMap Team (HOT) is an international consortium. Their aim is to support humanitarian efforts through open mapping in order to drive sustainability goals as well as contribute towards disaster management [2]. Several projects have spun off from HOT. For example, a HOT community project is OpenAerialMap [1], which provides a platform to search, share, and use open satellite and UAV imagery.

[1]https://www.un.org/sustainabledevelopment/sustainable-development-goals/

With the decreasing prevalence of the expert cartographer and authoritative maps, we simultaneously witness the constituting of the citizen as consumer and producer of map products and spatial data through initiatives such as OSM. While widespread and global participation in "mapathon" projects is rewarding for volunteers, there is a deeper level of empowerment and democratisation that can be seen especially in traditionally closed societies, such as China [17] and North Korea [27] where OSM contributors are active. At the same time, we are also witnessing marginality in contested spaces through VGI which opens the data for social science research. An example can be found in OSM data for Jerusalem, where there is an imbalance between the contributions to Jewish and Palestinian territories and, although the reasoning is unclear, it demonstrates some of the social structures of place [5].

It is evident that the increased popularity of VGI, and OSM, in particular, has generated new opportunities, including the possibility to exploit local knowledge and expertise of people (for example, of the area in which they live or grew up) and a reduction in spatial data production costs. In particular, as previously mentioned, OSM provides a platform in which individuals are able to contribute their in-depth knowledge of the environment and make data freely available for the development of citizen science projects where people are given an opportunity to participate in decision making, as well as to contribute to sustainability and humanitarian projects.

However, the emergence of VGI has also posed new challenges and aggravated issues that were minimized by the high level of control used in the production of authoritative data. Both the new exciting applications and challenges have given rise to the proliferation of research on VGI, including various special issues, workshops, reviews, and edited books that have been organized in the past 10 years (see, for example, [7, 21, 25, 32]). Several of these publications report on the use that has been made of OSM data in multiple domains. They also list the challenges and the most promising directions for future research. The exploitation of OSM to produce added-value information and integration with other sources is an area that has not been fully investigated and one that has a high potential impact to support sustainability.

From reading these publications it is evident that the issues and concerns highlighted by authors such as Goodchild [10], at the end of the previous decade, persist in 2020. It is likely that finding solutions to the problems of data trust and veracity, security, privacy, and ethics will be challenging for some time. Of note are the particular challenges related to crowdsourced indoor mapping efforts (facilitated by pervasive mobile devices, social media platforms, and emerging technology such as simultaneous localization and mapping). In 2015, a new data scheme for generating indoor maps based on OSM was described in order to provide a more intuitive workflow for map generation [11]. More recently, such crowdsourced data has been investigated for use in indoor navigation [13]. These efforts make privacy and ethics problems even more pressing. Of course, all of these issues are interrelated and cannot be studied in isolation. For example, to overcome issues related to privacy, anonymization techniques can be applied. However, anonymization complicates the identification of malicious users and, consequently, efforts in data quality and trust management.

While vandalism and malicious attacks in the context of OSM projects might so far have been a limited phenomenon [15], we are now living in an era of fake news and internet bots in which individuals and institutions may seek gain (politically, financially, or personally) by producing inaccurate or false data. Therefore, the more people and institutions continue to use and rely on VGI and OSM, the more we can expect to discover attempts to undermine them. It is thus ever more important that spatial data researchers and professional users continue to monitor and analyse the data, and to devote efforts to find automated solutions to the ever-increasing problems related to veracity, security, and ethical data use. Spatial information science has a role to play here. For example, spatial information science can be used for measuring and improving the completeness, logical consistency, positional, temporal, and thematic accuracy of OSM data. Techniques such as spatial-temporal trajectory mining [4], convolutional neural networks [31], spatial semantic inference [14], spatial reasoning [20], the co-occurrence of spatial features [26], and spatial context indicators [30] have all been proposed to assess and improve the accuracy of OSM. OSM has also become a widely used data source within the spatial information science community. This is seen by a plethora of projects which utilize OSM data as a testbed for spatial theories and experiments [3].

Finally, in light of the COVID-19 pandemic we are experiencing at the time of writing this piece, the importance of free open source initiatives and platforms such as OSM that can bring together truly global and interdisciplinary efforts and expertise becomes more and more relevant. It is in the context of supporting efforts for sustainability (including sustainable agriculture to combat poverty and emergency response) and the prevention of disease spreading (including contact tracing) that we see the biggest potential of volunteered geographic information initiatives such as OSM. To ensure its longevity and utility in the field, it is therefore essential to continue to attract new contributors and encourage the wider use of this type of crowdsourced information.

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