Collaborative mapping response to disasters through OpenStreetMap: the case of the 2016 Italian earthquake

Digital humanitarians represent the current generation of volunteers, providing timely contributions in the form of digital map data in the aftermath of natural disasters. Starting from the tragic 2010 earthquake in Haiti and thanks to the success of the OpenStreetMap (OSM) project, the presence and coordination of these volunteers have grown incredibly over the past years. This work investigates the dynamics of the mapping process and the nature of the OSM volunteers who contributed map data after the 2016 earthquake in Central Italy. The analyses show that existing OSM users were the majority of those contributing to the mapping activity, with less edits performed by new users. The collaborative mapping process was efficiently coordinated through a dedicated platform and the area hit by the earthquake was significantly edited in OSM after the disaster.

Keywords: collaborative mapping, disaster management, earthquake, OpenStreetMap

1. Introduction

Natural disasters have always marked the history of humankind. Recent years have witnessed an increase in both their frequency and magnitude at a global level, often with tragic consequences when events strike in developing or underdeveloped countries where authoritative geographic information is either not available or not accurate and up-to-date (Poiani et al., 2016). However, in contrast to the past, the activities falling under the umbrella of disaster management (Hodgkinson and Stewart, 1991) can currently benefit from the flourishing of collaborative mapping practices based on citizens’ provision of geospatial datasets, which have been described with a variety of terms including crowdsourcing, Volunteered Geographic Information (VGI), Participatory Sensing and Citizen Science (See et al., 2016). In the specific context of disaster management, these practices have seen a new player entering the scene: the so-called digital humanitarians, i.e. the networks of technology volunteers crowdsourcing timely information during crises response (Meier, 2015).

The main platform around which humanitarian efforts revolve before and after disasters is OpenStreetMap (OSM, http://www.openstreetmap.org), the world’s openly-licensed geospatial database created by volunteers, which is nowadays used by a myriad of actors and applications (Mooney and Minghini, 2017). The open nature of OSM makes it highly suitable for disaster mapping, as shown by the response after the earthquakes in Haiti in 2010 and Nepal in 2015 (see e.g. Soden and Palen, 2014; Poiani et al., 2016). However, OSM mapping in countries prone to many natural hazards is challenged, among other reasons, by limited broadband connection, lack of GPS devices, technical skills and support from organizations, governments and academia (Latif et al., 2011). In the context of natural disasters, the coordination of volunteers’ mapping efforts is operated by the Humanitarian OpenStreetMap Team (HOT, https://www.hotosm.org), which was formed right after the Haiti earthquake. The HOT’s...
Tasking Manager (TM, http://tasks.hotosm.org) is the software platform used everyday by hundreds of volunteers to perform remote mapping by digitizing geospatial objects (mainly roads and buildings) on top of satellite imagery. This remote work clearly complements the local knowledge of people who are physically present in the disaster area. With these premises, the purpose of this study is to investigate the OSM collaborative mapping process that took place after the earthquake occurred in Central Italy in August 2016. This is done by analysing the number, nature, provenance and amount of contributions of the active OSM volunteers.

The remainder of the paper is structured as follows. Section 2 examines related work in the field of OSM collaborative disaster mapping. Section 3 introduces the Italian case study and describes the experimental work performed through the analysis of the OSM database history and the related results. Section 4 concludes the paper and provides recommendations on how contributors’ response can be facilitated and increased.

2. Related work

Started after the Gaza crises in 2009, the use of OSM for collaborative disaster mapping has raised interest in the academic community since the Haiti earthquake in 2010. In the aftermath of that disaster, the contribution of volunteers’ mapping was shown to be pivotal to deliver relief efforts in a place where data - synthesizes related work in the field of OSM collaborative disaster mapping. The first task (Project 13) in the OSM database history and the related results. Section 4 concludes the paper and provides recommendations on how contributors’ response can be facilitated and increased.

HOT’s cooperation with other organizations has led to projects aimed at preventive mapping in countries that are high vulnerable to epidemics, political crises and natural disasters and where maps do not exist. As an example, Médecins Sans Frontières, the British and American Red Cross and HOT have launched a malaria elimination campaign in Southern Africa, Southeast Asia and Central America (https://www.hotosm.org/projects/malaria_elimination_campaign).

3. The Italian case study

On October 30, 2016, at 03:36 AM (local time) a Mw 6.0 earthquake (Mw 6.0) struck a large portion of the Central Apennines between the towns of Norcia and Amatrice (see Figure 1). The epicentre was located near the town of Accumoli. The area was struck by several earthquakes in historical times (1627, 1639, 1672, 1703) (INGV Working Group on Historical Earthquakes). The 2016 earthquake caused 299 victims and almost 400 injured people. Several other shocks occurred during the following weeks and other earthquakes struck adjacent areas in the Central Italy during the following months on October 26 (ML 5.4), October 30 (ML 6.5) and January 18, 2017 (4 main subsequent shocks, Ml 5.1, 5.5, 5.4, 5.0).

The data analysed and discussed in this article refer only to the first event (August 24, 2016). In fact, this was the main driver for the activation of the Italian OSM community’s mapping efforts. The first edit in the map was made at 05:44 AM, while the first message on the Italian OSM mailing list was sent at 06:56 AM (https://lists.openstreetmap.org/pipermail/talk-it/2016-August/054643.html). The collaborative mapping response started with the activation, at 11:02 AM, of the first task (Project 13) in the OSM TM instance managed by Wikime
interaction was activated with the European Commission COPERNICUS Emergency Mapping Service (http://emergency.copernicus.eu/mapping/copernicus-emergency-management-service) with the purpose of adding to OSM the information derived from the remote sensing assessment of damages on buildings and roads published in a specific activity created by COPERNICUS Emergency Mapping Service for the earthquake in Central Italy (http://emergency.copernicus.eu/mapping/list-of-components/EMSR177).

3.1. Methodology

The analyses are primarily based on the OSM full history planet file (http://planet.openstreetmap.org/planet/full-history), which contains the full editing history of the OSM database. Thanks to the Osmium Tool (http://osmcode.org/osmium-tool), the OSM planet file was cut both spatially (on the same geographic area of Project 13 in the OSM TM, which also included the areas of Project 14 and Project 15) and temporally (on the whole year 2016). In other words, the resulting file contained the full history from the beginning to the end of 2016 of all the OSM objects included in the area of interest, i.e. all their versions and changes (in geometry and attributes), the user(s) who made the changes and the timestamp of each change. This file was then imported into a PostgreSQL database (https://www.postgresql.org) enabled with the
PostGIS spatial extension (http://postgis.net), using the osm2pgsql tool (http://wiki.openstreetmap.org/wiki/Osm2pgsql). The analysis was also performed on the OSM tile log (http://planet.openstreetmap.org/tile_logs), a text file containing the number of visits to each map tile (https://en.wikipedia.org/wiki/Tiled_web_map). To run the analysis, an open source Python script named OsmEventAnalyst was created (https://github.com/osmItalia/OsmEventAnalyst). In parallel, user contributions from the TM of Wikimedia Italia were also investigated.

3.2. Results and discussion

Throughout 2016, 506 OSM users have made at least one edit in the study area. These users were divided into five classes according to their OSM history: existing users who modified the area only before the event (EB), existing users who modified the area both before and after the event (EBA), existing users who modified the area only after the event (EA), users registered to OSM after the event who made the first edit outside the study area (AO), and users registered to OSM after the event who made the first edit outside the study area (AI). Results show that the existing users contributing OSM edits in the study area in 2016 were about the 90% of the total: they included EB (40.1%), EBA (11.7%) and EA (38.5%). Among the users registered to OSM after the event, the majority (36 users, corresponding to 7.1% of the total) were AI and only 13 (2.6% of the total) were AO. This shows an overall positive response to the event from the OSM Italian community.

Figure 2 (a) shows the evolution of the daily number of OSM users performing edits in the study area after the earthquake of August 24, 2016. A peak is clearly visible on August 24 and 25, followed by about two weeks of intense OSM mapping. After that, the activity remained almost silent until the second earthquake (October 30) when another peak is visible. Figure 2 (b) shows instead the daily number of OSM edits according to the user categories presented above. Most of the edits were clearly performed by the OSM users already registered before the earthquake (EBA and EA), while little contributions were provided by new users. Interestingly, while for the first earthquake the contributions of users who were already active before the event (EBA) are less than the contributions of users “attracted” after the event (EA), the proportion is inverted (contributions of EBA greater than those of EA) for the second earthquake. A possible reason might be that EA are mostly not local people driven by humanitarian concerns who after the first event were more motivated than EBA in contributing to the mapping activity. Conversely, the second event has attracted a higher number of local contributors.

The results highlight that the collaborative mapping effort was driven by already experienced users. Conversely, new users had probably not enough experience and practice to be able to significantly contribute to the mapping activities. To analyse the mapping performed through the TM of Wikimedia Italia, the lists of OSM contributors available for Projects 13, 14 and 15 were first extracted. These include only the contributors who have marked as complete at least one of the sub-areas of each Project (see http://learnosm.org/en/coodination/tasking-manager for details), i.e. they do not include
all the contributors who have made at least one edit in the study area. The latter are traditionally much more than those who have marked as complete the project sub-areas. Comparing the OSM usernames of the 94 contributors who marked as complete the sub-areas of Projects 13, 14 and 15 with the usernames of the contributors extracted from the OSM full history planet file, results show that the 94 TM users included most of the users active in the aftermath of the first earthquake (to which Projects 13, 14 and 15 were related) and overall they contributed the 63% of the total OSM map edits in the study area during the whole 2016. Taking into account that the contributors active through the TM were more than the 94, this confirms that the TM is a very important driver and aggregator for disaster-related mapping.

The analysis of the OSM data in the study area reveals that most of the objects (~90%) were not modified after the earthquakes and the objects with more changes are linear data, followed by point and polygon data. Almost all the edited objects were created before the first event, which is in line with the fact that they were edited afterwards to reflect the damages or changes caused by the earthquakes. The number of OSM objects with changes in geometry was approximately the double of those with changes in the attributes (or tags). Finally, the analysis of the OSM tile log files in the study area shows an expected peak on August 24, 2016. Visualization of the tiles corresponding to the city centre of Amatrice (WGS84 lon-lat coordinates 13.2891755, 42.6292367) reveals that before the event the area was almost not visited at all in OSM, while it was still visited after months from the event.

The detailed results of this analysis on OSM data, including additional plots and graphs, are available at http://www.geodati.fmach.it/osm_paper_geam.html.

4. Conclusions

Over the recent years, OSM has become a catalyst for the collaborative mapping response after natural disasters. This work has investigated the response of OSM volunteers after the earthquake events occurred in Italy in 2016. The analyses show that these events have mainly stimulated the existing OSM users to improve the quantity and quality of data in the event area, while few new users have contributed to the mapping efforts. In addition, the study has shown that the area hit by the earthquakes has gained a lot of OSM-related interest in terms of both visualization and new data added after the disasters.

A number of lessons were learned from this experience. First, the availability and activation of a TM instance (like the one of Wikimedia Italia in the case study analysed) is crucial to coordinate volunteers’ efforts and especially to prevent the conflicts traditionally generated when many users edit the same area in the aftermath of a disaster. The availability of post-event satellite imagery is crucial as well to increase the accuracy, the up-to-dateness and, in general, the fitness-for-use of the OSM data created/edited by volunteers. After the Italian earthquake, OSM data were used on the field by rescue workers, fire fighters and the Civil Protection. Despite this is a very successful result, in a future outlook the situation might be still improved, e.g. by further strengthening and coordinating the OSM national community; by encouraging institutions to make use of the OSM basemap on their official websites to advertise and promote the project, to adopt policies based on releasing open geospatial data (not only after disasters) and enabling their reuse in OSM; and by enhancing the contacts between the OSM community, the Civil Protection and the Copernicus Emergency Management Service to optimize the channels for data/information exchange.

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