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35 - VGI and Beyond: From Data to Mapping

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This chapter will introduce the concept of Volunteered Geographic Information (VGI) within practices of mapping and cartography. Our aim is to provide an accessible overview of the area, which has grown rapidly in the past decade, but first we need to define what we mean by VGI.

Defining VGI

In a seminal paper published in 2007, Mike Goodchild coined the term Volunteered Geographic Information (VGI) in an effort to describe 'the widespread engagement of large numbers of private citizens, often with little in the way of formal qualifications, in the creation of geographic information' (Goodchild, 2007: 217). At that point, rudimentary crowdsourced Geographic Information (GI) was created and disseminated freely with the help of innovative desktop applications (e.g. Google Earth) or web-based platforms (e.g. Wikimapia, OpenStreetMap). By *crowdsourcing* we refer to the action of multiple participants (sometimes thousands or even millions) in the generation of geographical information, when these participants are external to the organization that manages the information and are not formally employed by it. Since then a lot has changed and VGI now has a deep and broad agenda that ranges from implicitly contributed GI through social networks to rigorously-monitored citizen science projects. However, before we continue the discussion on this subject, it is necessary to shed light onto the key factors that have helped to create this phenomenon.

Background technology and societal aspects

While it may seem that VGI was created suddenly with the birth of OpenStreetMap in 2004, the crowdsourced and collaborative creation of spatial content is not new. The current form of the VGI phenomenon emerged as several enabling factors matured, particularly regarding how people collaborate, with the key paradigms paving the way for similar endeavours coming from the field of software development. Open source software is a prime example of collaboration amongst otherwise unrelated programmers who aim to create software that is freely accessible by anyone. More importantly, the code used to create the software is also shared so that anyone can see, examine, reuse or improve it. This collaborative approach also started to grow in the geomatics domain, but, whereas in software development the purpose was to work together to create an application, here, the mentality was mostly oriented towards collaboration in order to solve a common problem.

VGI and citizen-driven data collection efforts are, however, not entirely new (Elwood *et al.*, 2012). For example, Stamp (1931) describes a group of voluntary teachers and students who participated in land use surveys in Britain and in the United States, Bunge (1971) mentions that city residents carried out local mapping efforts. More recently, examples of such collaboration can be found in what is known as Public Participation GIS (PPGIS) (Obermeyer, 1998) or in the broader area of citizen science (Haklay, 2013). In the former, PPGIS emerged as a means to help researchers and institutions to work with local communities to investigate either controversial issues or to represent local knowledge. The collaboration takes place over a backdrop map where stakeholders or community members provide input in an effort to map and to better understand a phenomenon or a problem and then to find the best solution for all parties involved. In the latter, citizens are involved in scientific research activities where, often with the help of scientists, they collect, manage and analyse observations and data, and disseminate their results. Another enabling factor comes from the technology front. The removal of Selective Availability from the Global Positioning System (GPS) in 2000 (Clinton, 2000) signalled the proliferation of accurate and low-cost GPS-enabled devices. In turn, this enabled individuals to easily capture geographic data from their everyday activities (i.e. commuting, leisure activities etc.) turning them into 'neo-geographers' (Turner, 2006) and citizen-sensors (Goodchild, 2007). It did not take long for this kind of crowdsourced GI to find its way to the World Wide Web. The turn towards a bi-directional Web, where the lines between content users and content producers were constantly blurring leading to what is known 'produsers' or 'prosumers' (Bruns, 2006: 2; Coleman *et al.*, 2009); the novel web-software techniques (e.g. AJAX and APIs) that gave to the Web a programmable façade; and the investment of technology giants (e.g. Google, Microsoft, Yahoo!) to spatial applications with the creation of global wide satellite imagery maps, provided a fertile ground for VGI to flourish. These factors enabled the crowd to instantly upload and consequently have access to spatial information on the Web. At the other end of the spectrum, National Mapping Agencies (NMAs) responsible for the creation and maintenance of Spatial Data Infrastructures (SDI) have continued to treat their geospatial data as valuable sources of income, with the effect of depriving access to these data by the general public. All these factors contributed to the appearance of the VGI phenomenon that was incarnated through the development of numerous web-based and mobile applications.

Redefining VGI

Against this backdrop of the technological and social factors that played a role in the birth and development of VGI, it is necessary to re-define it in a broader context. First and foremost, we need to understand that this area is highly interdisciplinary in that intertwines the advances of many domains. VGI is at the centre of a wide scientific community that focuses on the harnessing of new sources of geographic information and in satisfying the spatial turn fueled by the neogeography revolution; a revolution which has put mapping within the grasp of almost anybody (Turner, 2006). VGI is the grafting of the underlying social, economic and technological situation with the geospatial domain. Especially from a cartographer's point of view, VGI can be viewed as a precious, yet so far elusive, map element: the user's perspective. Now, for the first time, the user's perception of space is tangible through the volunteered recording of spatial features or phenomena they consider important to have on a map. This presents a major change in cartography and has been made possible due to the factors explained earlier. Timely crowdsourced spatial content can fuel maps with constantly changing thematic layers which were impossible to have in the previous generation of paper or even online maps. The advantages of VGI, and what this phenomenon can bring to the cartographic domain, will be further discussed later.

Sources of VGI and user participation

Today, VGI comes in many flavours and from various sources: toponyms, GPS tracks, geo-tagged photos, synchronous micro-blogging, social networking sites such as Facebook, blogs, gaming spaces, sensor measurements, complete topographic maps, and so on.

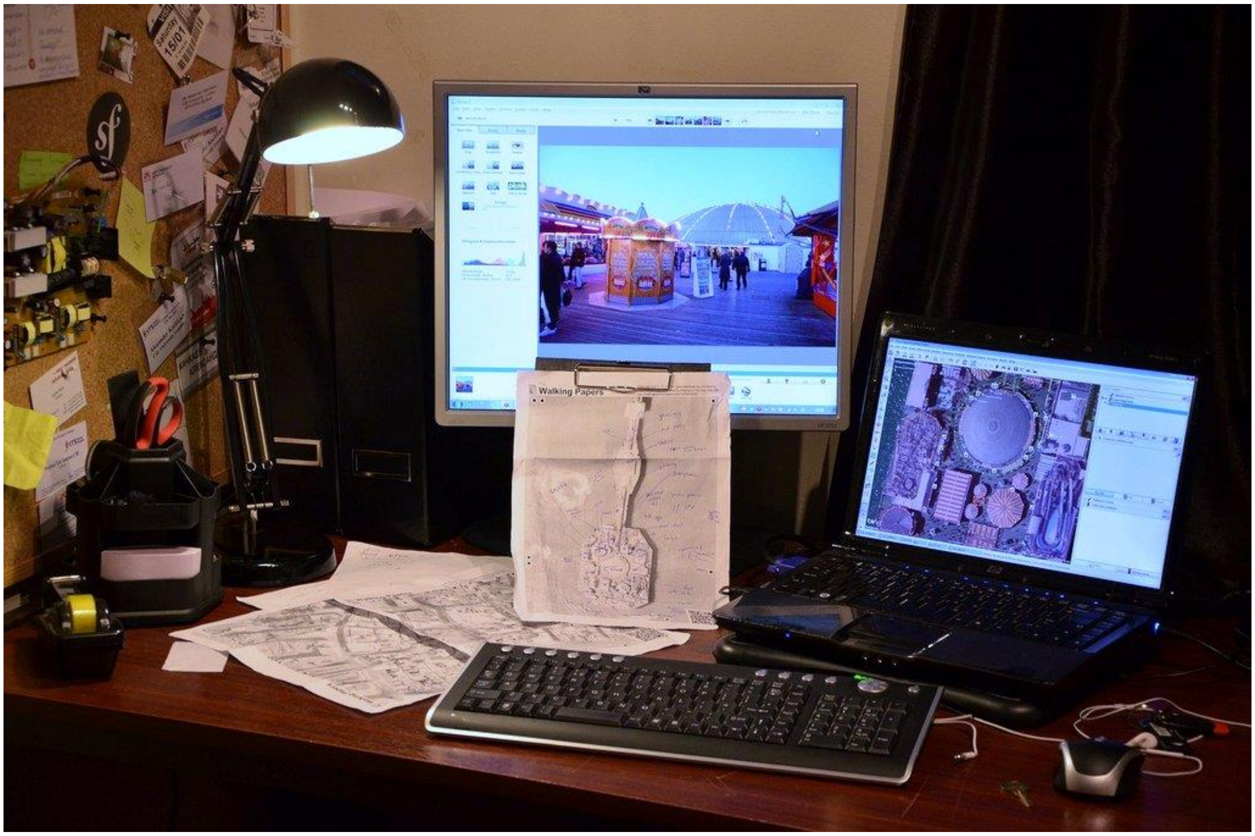

Figure 1 Adding data to OSM after mapping Brighton Pier[1]

The creation of VGI is a process which involves (more or less) the voluntary participation of *produsers*. Indeed, VGI can be either voluntary/explicit or involuntary/implicit. The first type consists in all digital georeferenced footprints that are created by users who consciously interact with Web technologies of different kinds to locate events or to record elements (from animal species to artifacts) or experiences and perceptions. The second type of VGI is produced by users who interact with technologies but who are not aware of the fact that their interaction/activity will leave a digital footprint in cyberspace, such as most users of Twitter, Flickr, Foursquare (and similar social networking websites), who perform regular activities on the Web (e.g., talking to friends, booking a room) (Capineri and Rondinone, 2011: 561).

However, the voluntary element, in both cases, is a subject of debate in VGI research since it can affect the quality and the fitness for use of VGI data since they are often collected publicly, without strict standardization, and every user inserts data according to his/her personal background and point of view (Coleman *et al.*, 2009; Haklay, 2010). In particular, end users who carry out *geographic volunteer work* (Priedhorsky *et al.*, 2008: 267–268) perform an active role when the volunteered information production is regulated by shared rules concerning geocoding (i.e. the process of transforming a description of a location to real-world coordinates), tagging (assigning a key attribute), and annotating the data. In this sense, VGI becomes part of citizen science, which has emerged from ecology, biology and nature conservation, whose projects are based on volunteering and contributing information for the benefit of human knowledge and science (Haklay, 2013). Citizen science reconsiders the separation between scientist and the public and scientists need to adjust to this new character of the scientist as both mediator of knowledge and citizen and

[1] Alexander Kachkaev - https://secure.flickr.com/photos/kachkaev/6448160479 - CC BY 2.0

not as the sole repository of scientific truth: 'This might end up being the most important outcome of citizen science as a whole as it might eventually catalyse the education of scientists to engage more fully with society' (Haklay, 2013: 14). In this context, VGI may represent either the implicit or the explicit relationship of the individual with the whole; this relationship has long been a critical part both of the individual's motivation to act in some larger interest and of the group's ability to exhort the individual to take action and to participate (Curry 1997: 685–686).

Advantages and disadvantages of VGI

From the early days of VGI, there was skepticism towards its value. First it was the validity of the term 'Volunteered'. Scholars challenged this term as misleading regarding the true intentions and motivation of the contributors (Elwood 2008). Then, at a more substantial level, the criticism focused on the long term sustainability of VGI and the trust, credibility and quality of the GI produced (Flanagin and Metzer 2008). For the former, there were concerns that VGI was overhyped and it would share the fate of many new trends that disappear after a viral, yet short, life. For the latter, it was obvious that as VGI has deep social roots; the profile, motivation and the digital divide as well as the educational background of the contributors could severely affect the overall data quality. There were many issues that fuelled this discussion, ranging from the lack of any cartographic background or skills that professional geographers and surveyors have to the appearance of malicious contributions – like those that are very common and largely anticipated – to the rest of the Web today.

However, most of the initial concerns have been dispersed by the evolution of VGI. Today the term is well defined and the evolution and possibilities of VGI in the geospatial domain have attracted the interest of academics and professionals alike with thousands of scientific papers published on the topic and a growing number of governments and corporations leveraging this kind of GI knowledge. Notwithstanding the acceptance of VGI, the truth is that VGI comes with a number of caveats, mainly concerning the quality of the data collected. First, there are social and spatial biases. As VGI is technology driven, the digital divide directly affects the datasets compiled and thus we need to be very careful about the coverage and representativeness of the data that are being collected (Graham *et al.*, 2014). Second, is the GI itself. Lack of metadata, heterogeneity, patch work and fragmented contributions should be expected when handling such data. Moreover, in academic and professional discourse, spatial data quality is a mixture of tangible factors like thematic, positional and temporal accuracy, completeness, logical consistency and usability, but not all VGI sources can stand such scrutiny. However, existing spatial data quality measures can be adopted and new quality indicators have been devised to better describe the quality of VGI (Antoniou and Skopeliti, 2015).

A relevant aspect of VGI is the acquisition of local knowledge. People's contributions in VGI tend to be more accurate in places the contributor knows best and is nearer to, according to Tobler's Law which states that 'everything is related to everything else but near things are more related than distant things' (Tobler, 1970: 234). As such, some of the scientific literature associated with VGI hypothesizes that (a) contributors write about nearby places more often than distant ones, and that (b) this likelihood follows an exponential distance decay function (Hardy *et al.*, 2012). However, according to recent research, about 50 per cent of Flickr users contribute local information on average, and over 45 per cent of Flickr photos are local to the photographer (Hecht and Gergle, 2010). Remarkably, local knowledge derived from VGI has been used in vernacular geography which 'encapsulates the spatial knowledge that we use to conceptualize and communicate about space on a day-to-day basis. Importantly, it deals with regions which are typically not represented in formal administrative gazetteers and which are often considered to be vague' (Purves and

Hollenstein, 2010: 22). Also, it is worth mentioning that longstanding authoritative spatial products like gazetteers were traditionally based on knowledge that originated from local people (Kerfoot, 2006). Moreover, in some cases, especially when VGI is derived from social networks such as Twitter or Facebook, data are mostly produced in urban areas due to better Internet connections and population concentration. A recent analysis (Hecht and Stephens, 2014) shows that in the US there are 3.5 times more Twitter users *per capita* in core urban counties than in rural counties; the same authors have revealed also that urban users tweet more than their rural counterparts.

Another major contribution of VGI is that it sparked the creation of a virtuous circle having in its center the linkage between society and spatial information. Indeed, technological advances have facilitated spatial data collection and online diffusion, and this has made people familiar with spatial content, cartographic products and location-based services. This, in turn, created the need for more spatial content that is both high quality and freely available and thus VGI contributors were better placed to address this need, resulting in more sources of VGI becoming available on the Web. This positive feedback loop was also fuelled by the intrinsic characteristics of VGI data. First, the open and free access to VGI data was a major factor. VGI can provide a reliable alternative for many spatial and cartographic projects without the need to bear the high costs and restrictions that come with proprietary data. We should also consider the extended field of scope that VGI can cover. While VGI became known mainly from a handful of champion projects such as OpenStreetMap, Wikimapia and Geonames, examples also include data gathering for air pollution, urban noise, traffic and congestion maps, cycle maps, gpx-trail maps or soil mapping. Most of these topics were usually under the radar or the NMAs as their focus was on few well-defined mapping products.

Another comparative advantage of VGI over proprietary data is the fact that accessibility seems quite easy and fast, thanks to computing architectures which enable data collection in a timely manner and to geoweb applications that foster citizen access and participation (Crampton, 2009). This reveals another important VGI feature: real-time recording and the proactive approach of the user. Timeliness in capturing and communicating an event (e.g. floods, fires), a problem (e.g. a traffic jam), an opinion, a feeling, and so on, enables the user to contribute to his/her environment in a participatory and collaborative way; these contributions help decision-making and problem-solving processes to be undertaken in a faster way than in the past (Bertot *et al*., 2012). Moreover, ubiquitous sensor devices shorten the time horizons of the updating of geographical data as the time gap between data capture and data consumption is minimal. For example, a study by Antoniou *et al.* (2010) shows that more than 60 per cent of the photographs submitted to Flickr were actually taken in under 7 days while fewer than 9 per cent have longer than a one year gap between time of capture and time of upload. This creates a new environment for all cartographers in the sense that there is now an increased responsibility for delivering up-to-date spatial/mapping products. This is even more so in time-critical situations. Thus, it is unsurprising that the real value of VGI has surfaced after severe natural disasters such as wildfires in Santa Barbara (Goodchild and Glennon 2010) and the Haiti Earthquake (Kent, 2010; Zook *et al*., 2010).

All these comparative advantages gained ground for VGI, a fact that was further amplified by studies regarding the quality of the datasets produced, such as Haklay *et al.* (2010); Girres and Touya (2010); Antoniou (2011); and Neis and Zipf (2012), usually using OSM as a proxy for VGI sources. Moreover, new Geographic Information Retrieval (GIR) techniques have been developed that focus on the use of implicitly generated GI to existing spatial processes such as the validation of land use/land cover (LU/LC) maps (Antoniou *et al*., 2016). In this context, it is clear that while, at least in the near future, VGI cannot replace proprietary data, it can play a crucial role in correcting, enriching and updating existing datasets (Craglia, 2007) or provide the basic information layer for new products. This change is crucial in many ways, but for the first time in the geomatics domain, a grassroots process has such an impact on well-established processes. The impact of VGI on NMAs, on society, and on new mapping products is further discussed in the next section.

The Impact of VGI

VGI and NMAs

The open data policies adopted in many countries around the world inevitably lead to the free usage of spatial data. While this can severely affect the economic resources of NMAs, their mission to provide up-to-date datasets nationwide has not changed. On the contrary, they have to step up their efforts and keep up with the technological advances and demands for more data. In a sense, today, NMAs need to do more with less. Moreover, as Goodchild (2007) notes, the arguments made by Estes and Mooneyhan (1994), about a mistaken popular notion of a well-mapped world, are still true and thus NMAs are facing some pressing challenges.

Cartographers in NMAs should be prepared to change their conceptual apparatuses used so far in the front of data management and organizational structure alike. In many NMAs today, the focus is on developing new and agile in-house processes and organizational structures that can foster the creation of VGI data and then can easily incorporate such input with spatial data derived from traditional sources (Antoniou, 2011). Indeed, a growing number of NMAs (including Ordnance Survey in the UK, the Institut national de l'information géographique et forestière in France, Dienst voor het Kadaster en de openbare registers in the Netherlands, and so on) have started to explore the potential use of VGI in map production and evaluation activities. The intertwining of NMAs and VGI can take place in many levels. Examples include the collaboration of the Natural Resources Canada with the OpenStreetMap community to facilitate data updates (Bégin, 2012) or the development of an efficient alert reporting system like the one developed by IGN France. Similarly, the National Land Survey of Finland provides its entire topographic database freely to the public and also provides a Web and mobile application to collect feedback from citizens. Moreover, the Netherlands cadastral agency has developed an in-house system to collect feedback from its users and also provides a change-detection mechanism for the 1:10,000 dataset (TOP10NL) based on local administration datasets and OSM (Olteanu-Raimond *et al.*, 2016). In another case, vernacular place names are mixed with authoritative toponymic datasets to provide a detailed gazetteer to support search-and-rescue missions from the UK Maritime and Coastguard Agency (Haklay *et al.*, 2014). However, the conflation of VGI datasets with authoritative data should utilize the best of both worlds: the rigorous quality and standardization processes applied in NMAs and the overwhelming flow of timely spatial content that is generated by volunteers.

VGI and citizens

The spread of sensor networks, the growing availability of Internet connections, and the creation of wireless connections, have all enabled information and services to be reached virtually from any place. These technological innovations have also affected the mode of communication on the Internet by creating communities of interest who are potentially free from the bond of physical proximity and are bound together by mutual interests, practices and passions. The community-building process has also been described as 'communities of crickets' (Buchanan, 2002: 49) and 'members of a food web' (Buchanan, 2002: 17). This process has been reinforced by the emergence of the Geoweb, which is characterized by a high level of interaction between the Web and the users; their activity is the footprint of daily routines, movements, ideas and values which reveal new forms of sociability, social activism and engagement. Moreover, daily life is local by its nature: daily issues ranging from health to entertainment, to education, to the supply and security of goods and services, relate largely to the local scale. Traditional types of data and information (i.e. census data, on the spot surveys) are not good at managing and dealing with knowledge at this local scale or asking timely questions. Most of the data and information have a geospatial component and are converging with other digital tools to help institutions manage services such as transportation, water supply, sanitation, public safety, public health, and energy, to improve the quality of life. This pro-active ability has attracted the interest not only of citizens but also of institutions and enterprises. In particular, public institutions are called upon to reinvent the governance of public affairs and to update the means for interacting with their communities; at the same time they become protagonists in a complex scenario that requires new professional skills (e.g. Internet capability, willingness to collaborate) and new abilities to accommodate and 'exploit' the 'collective intelligence' of Web 2.0.

VGI as point of departure for new cartographic activities

From the early days of VGI, it was understood that if this phenomenon managed to last and evolve it could spark shift changes in the geomatics domain and thus there was considerable research interest from the beginning. However, Goodchild (2012) explains that initially research focused on the phenomenon itself: the type and origins of VGI and contributors, data quality, social context, and so on. As VGI evolved the research focused on using VGI in areas such as social and environmental sciences or citizen science. In other words, VGI served as a research apparatus that provided a novel way for approaching existing and new domains. In this context, VGI played a key role into expanding the horizons of cartographic activities introducing new thematic areas and data sources or redefining existing ones.

An indicative example can be found in the field of urban sensing and smart cities. Today, with ubiquitous sensor networks our living environments are being transformed into smart cities where the flow of VGI in terms of volume and currency opens the opportunity to monitor and understand, in an unprecedented way, what exactly takes place in every corner of the urban fabric. In turn, this, in a sense, redefines the scope of urban maps. While static street-level mapping products are still useful, today it is possible to map, analyse and monitor the heartbeat of most urban areas. Another field where VGI can offer a fresh view is emergency mapping. When disasters occur, authoritative geospatial support is not always available and experience has shown that the most effective efforts come from volunteers on the field. Haklay *et al.* (2014) discuss a number of cases where crowdsourcing and VGI provided the needed mapping products. Of special interest are the efforts by the Humanitarian OpenStreetMap Team (HOT), a group of volunteers who provide base maps and cartographic products to relief organizations in emergency cases via the OSM platform. Their projects include emergency mapping for the Haiti earthquake in 2010, the Ebola outbreak in 2014 and the Nepal earthquake in 2015.

Another field that has been stimulated by VGI is the creation of applications for maps and mapping. Today, leveraging the opportunities that low-cost technology is providing, the citizen sensor can capture and thus map any phenomenon at a local or a global level. Thus, novel mapping products and applications have started to emerge. From noise maps around airports[2] and problem-reporting to local authorities[3] up to global environmental monitoring[4], the scope of mapping applications is getting broader with the help of

[2] http://mappingforchange.org.uk/projects/royal-docks-noise-mapping/
[3] https://www.fixmystreet.com/
[4] http://www.geo-wiki.org/

crowdsourced GI and this puts geospatial engineers and cartographers into the driver's seat for the next generation of mapping applications.

Figure 2. Crowdsourced noise mapping around City Airport, London, UK[5]

The art of mapping VGI

Mapping VGI requires art, just as it has always been with any cartographic activity. The maps of VGI fall into the category of thematic mapping and the recent burgeoning literature offers many experimentations of VGI representation on maps where the map is either a tool supporting some other actions (e.g. emergency relief in disaster management) or highlighting a discovery (e.g. the boundaries of vague places). In extreme synthesis, placing VGI on a map implies a process which can be either very simple, such as a basic representation of data through the many intuitive and attractive Web mapping tools, or more sophisticated according to the aim of VGI's use (e.g. distribution areas of a phenomenon). Neo-geography has certainly opened up the black box of maps for a larger public and for much more diversified uses than in the past; moreover, traditional paper maps are being substituted by a new publishing genre which raises the question of the maps' maintenance and storage. But when VGI is employed as raw information to be transferred on a map, either on a piece of paper or on screen, then cartographic principles and methodologies are required just as much as before. Nevertheless, among the many mapping practices, at least four main types of representation seem to emerge, with each type referring to a different interpretation of the data.

[5] Source: Mapping for Change, 2008

The first type is the neutral or locational representation. If the map is simply carrying positional information (i.e. an address) of the VGI data by using the georeference attribute (e.g. coordinates, geo-name), this kind of representation satisfies the need to know where contributors or the recorded items are located (Fig.3).

The second is the representation of spatial hot spots which aims to identify areas with unusual high data densities by means of clustering techniques; this allows the discovery of areas of interest/activity independently of given boundaries (Fig. 4).

The third type is a hybrid representation where VGI data are grouped according to existing boundaries. Figure 5 shows the concentration of tweets in Florence's enumeration districts weighted according to the resident population. In this case, VGI data may augment existing information if they are integrated with other authoritative sources.

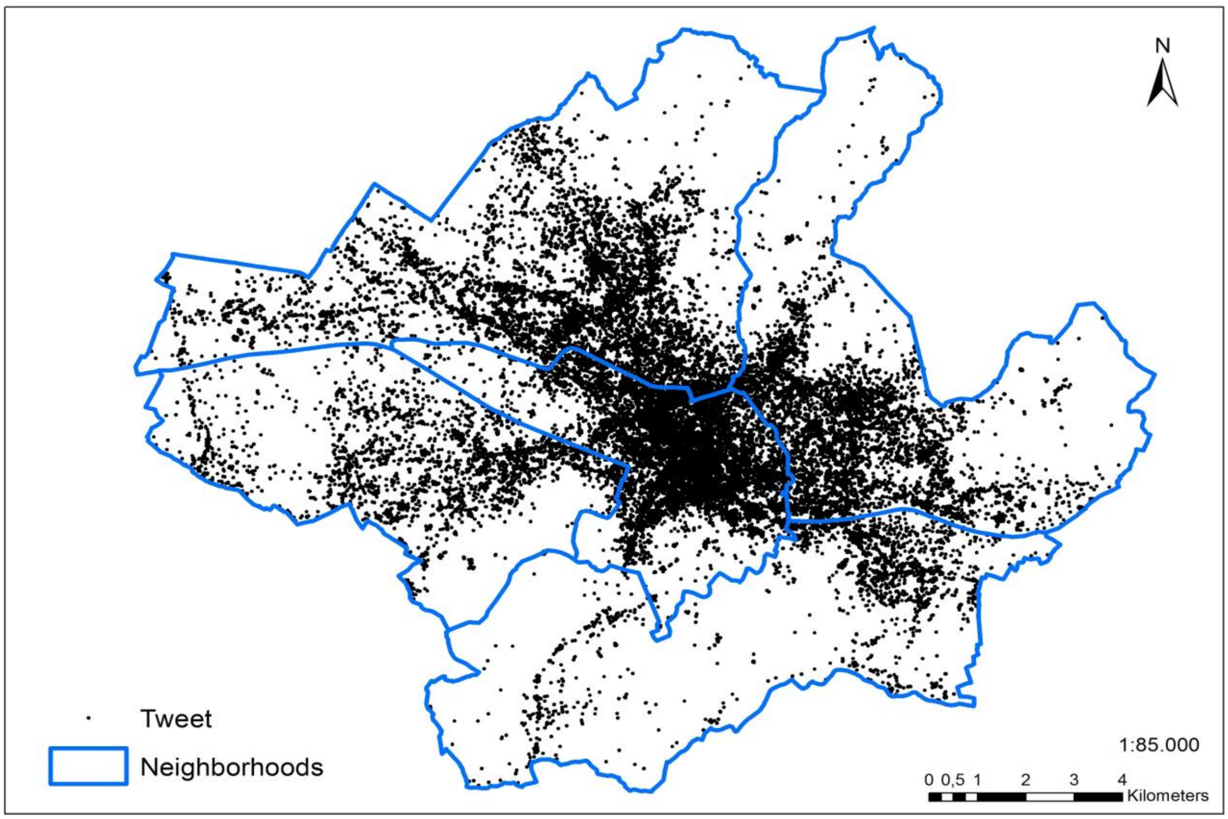

Figure 3. Distribution of georeferenced tweets in the urban area of Florence, Italy

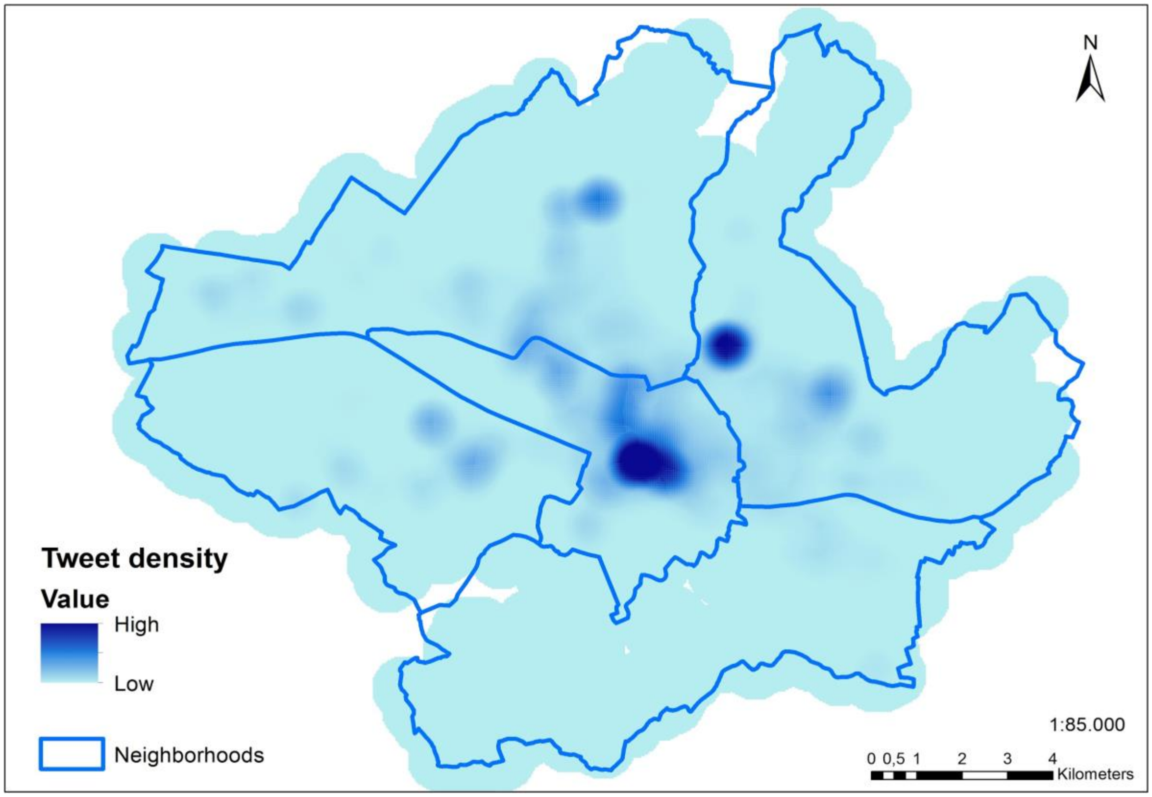

Figure 4. Kernel density distribution of tweets in the urban area of Florence, Italy

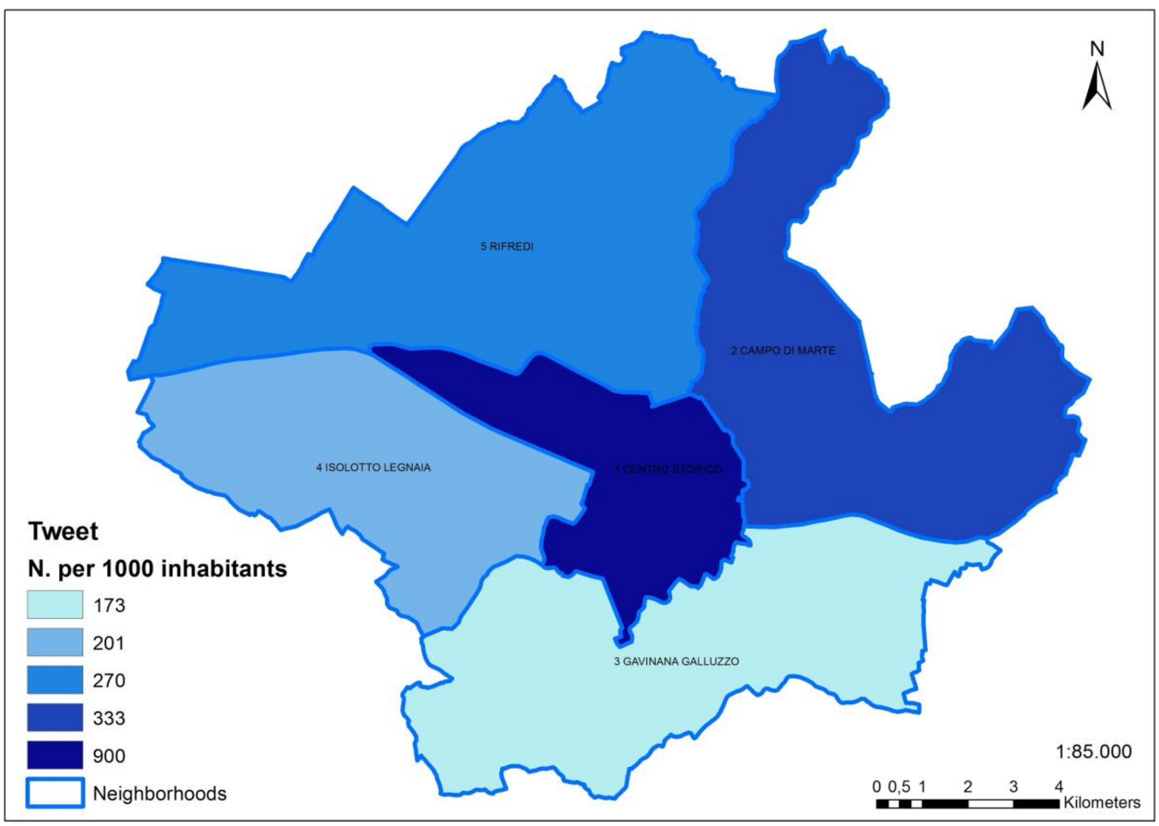

Figure 5. Tweet/resident population in the enumeration districts of Florence, Italy

The fourth type (Figure 6) is the creative representation which derives from the interaction of the citizen/producer with a base cartographic map upon which information is added according to the aim of the investigation or field work. This is the type of map generally used in problem-solving applications, such as PPGIS or citizen science.

Figure 6. Community mapping for non-technical users[6]

Conclusions and Future of VGI

It is always a challenge to predict the future. Nevertheless, here we make an effort to envision the future of VGI taking into account the technological and the societal trends that can affect this phenomenon. These two intertwined factors generated the VGI phenomenon and nothing suggests that they will not be its driving forces in the future.

First, on the technological front, while it is expected that communications bandwidths will keep increasing, the cost of hardware will keep dropping and the number of people online will keep growing, the true

[6] Source: Ellul et al. (2009).

revolution of VGI is expected to come from the development of devices for capturing spatial data that will proliferate or be introduced in the future. On one hand we have the ubiquity of sensors that passively collect spatial data, mostly in an urban context. The transformation of our living environment into smart cities inevitably gives rise to a better understanding and a more detailed recording of space and human activity. Thus, future smart cities should be spatially enabled and develop new spatial skills (Roche, 2014). This development is based on the idea that location and spatial information are common goods and promotes their availability in order to stimulate innovation (Roche *et al.*, 2012). Thus the flow of spatial data generated in a smart city will present new challenges to urban planners and cartographers.

On the other hand we have the individually controlled devices. For example, only for a few years now we see the spread of drones and we are still exploring their abilities to contribute in systematic data gathering despite surveillance and privacy issues which we do not discuss here (see, for example: *http://opendronemap.github.io/odm/*). The transition of the ability for immediate image capturing from authorities and private companies to citizens is expected to fuel the creation of more user-generated spatial data, similarly to what happened with the availability of Yahoo! Imagery and their role in the evolution of OSM. Moreover, the evolution of wearable technology, while still in its early days, is expected to contribute to the evolution of VGI. The omnipresence of wearable sensors will multiply the availability of spatial data on the Web. A similar impact is expected from the development of indoor positioning and mapping (see for example Google's Tango project) which will extend VGI into new fields.

It is obvious that, technology-wise, there are already various means for collecting VGI and there will be even more in the future. However, what transforms the device-capturing capabilities into a phenomenon that is reshaping the geospatial domain is how people are using these means. Thus, of high importance, are the social factors that drive the creation of VGI. The future of volunteerism, of crowdsourced efforts and of the mentality of collaboration and the pro-active role of the citizens who are called to participate in the management and improvement of the quality of life (e.g. environmental quality, security, crisis mitigation, and so on), will prove equally important factors in the evolution of VGI as the technological advances.

To an extent, this is a time of very rapid change. Most of our prior efforts in map making have been for the relative long term but we now have a much more immediate sense of how space is changing in terms of physical features, value and importance. What we need to do, and VGI is a key enabling factor to this, is to replace the notion of static geospatial data which served the idea of authoritative maps rather well in the past with the comprehension of the spatiotemporal environment that we live in. Once this is achieved, then it is easy to imagine a new breed of online maps that escape from the restricted notion of base or topographic mapping towards more agile and flexible forms which better suits contemporary societal requirements.

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