CHAPTER 16

# The Future of VGI

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### Abstract

In this final chapter, we speculate on future developments in the field of Volunteered Geographic Information (VGI); we focus on how VGI will be affected by future technological developments, but we also consider issues such as VGI

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quality, the relationship of VGI with science and citizens, and the impact of VGI in future cities and societies.

**Keywords**

Future of VGI, technology, Digital Earth, Smart Cities, citizen science, legal and ethical concerns

## 1 Introduction

Katherine is a typical citizen of the future. The year is 2030. Like most mornings, Katherine gets up and goes for a run, wearing sensors embedded in her clothes. These sensors monitor her vital signs and communicate with her smartphone, alerting her of anything unusual. With her permission, the sensors also send the data to many different places, including to her medical records, her health insurance company and a vast supercomputing facility, which uses her Volunteered Geographic Information (VGI), along with that of millions of other citizens, to uncover behavioural and health patterns that can be used to provide doctors with preventative health care advice. Before going to work, Katherine controls the environment of her house using her smartphone; this VGI gets sent to her gas and electricity companies, who use the data to bill her, but also to determine customer behaviour so that they can optimise their tariffs and provide customers like Katherine with advice on how to save money while being environmentally friendly. Katherine's driverless electric car takes her to work, where she is a spatial data quality expert at the National Mapping Agency (NMA) in her country. She is responsible for the quality assurance and quality control of the NMA's spatial databases. Today she is focused on doing some routine quality assurance on the main topographic database, which is a dynamically updated set of layers that takes in changes from a range of users, including citizens. She does some checks to ensure that the automated quality assurance procedures are filtering out data that do not meet the minimum requirements for the database and determines where to send field surveyors to confirm any critical changes. Today is Friday and Katherine is looking forward to attending a weekend mapping party, which will focus on helping another country build up their own, quality assured topographic database with seamless input from experts like her, interested citizens, businesses and non-governmental organisations on the ground.

This vision of a future world in which Katherine lives is not that far away and many of these things are already happening, even if only on a small scale at present. Although providing longer term predictions about VGI is a challenge because VGI is heavily reliant on rapidly changing technologies, it is clear that the role of citizen sensors is likely to become much more prominent than it is today. It is anticipated that citizen-derived data will grow considerably and be used in increasingly diverse ways in the near future. The amount of spatial data available is increasing exponentially (Craglia and Shanley, 2015), and the diversity of data sources and types is also increasing, e.g. through current trends such as Digital Earth (Craglia et al., 2012), Smart Cities (Batty et al., 2012), Citizen Science (Bonney et al., 2009; Silvertown, 2009), the Internet of Things (IoT; Ashton, 2009) and Data Analytics (Kitchin, 2013). Thus, this chapter will attempt to examine the relationship between VGI and a number of these current technological trends. We also consider VGI quality, which will continue to be one of the most important obstacles for the future diffusion of VGI, as well as legal and ethical concerns.

## 2 Technology

VGI has been heavily based on advances in the information and communication technology (ICT) domain. Web 2.0 applications (O'Reilly, 2007), GPS-enabled devices and the open availability of very fine spatial resolution satellite sensor imagery, sensor-equipped portable devices and smartphones have all been growth drivers for crowdsourced spatial data. Thus, it is expected that future advances in these areas will continue to play a major role in the future of VGI.

As an initial technological consideration, it can be noted that the basic infrastructure, such as Internet availability, bandwidth and processing power, has an important role to play; such infrastructure examples are all expected to evolve considerably and thus to greatly affect both the number of people online and the quality of connectivity and communication. Based on what we have experienced during the last few decades, it is safe to say that the way in which people are connected online will move to a totally new level.

The continuing developments in location-aware, data capturing devices are likely to impact greatly on the future of VGI. The removal of the selected availability of the GPS signal (Clinton, 2000) has led to the proliferation of GPS-enabled sensors in even low-cost everyday devices. Thus, location-enabled devices are now everywhere, from smartphones and cameras in our pockets to cars, airplanes and ships around the world. However, there is a clear distinction to be made: on the one hand, there are human-controlled devices that collect data in relation to an individual's activity, while, on the other hand, there are sensors that constantly collect and transmit location-aware data about a phenomenon. Regarding the former, our generation has witnessed the appearance of mobile phones, which then evolved into smartphones and have now been transformed into location-capturing devices; when combined with web applications and social networking, the volumes of data created are immense. There are many examples of Web-based applications, such as Facebook, Flickr, Foursquare, etc., where the data come from the conscious use of these applications but the geographic information (GI) is generated implicitly by the users without the original aim of actually creating geospatial datasets. This can be distinguished from the proliferation of all kinds of sensors that passively collect spatial data, mostly in an urban context. From high-end sensors to do-it-yourself, low-cost devices based on hardware platforms such as Raspberry Pi and Arduino, the flow of sensor-recorded location data is expected to increase. All these connected sensors are part of the vision of the IoT. Widespread sensor networks may dominate the urban fabric initially, but then expansion to a global-wide sensor network would be a natural continuation of this trend in sensor technology.

While the human-controlled and sensor network data sources of GI have, up until now, been working in a complementary way, this situation could also change in the future. A key question is whether developments in ubiquitous sensing will lead to a decline in human-collected VGI. For example, to know how people are moving inside a city, will it be necessary to tap into data from wearable technology if we can use sensors to automatically count the number of people crossing every street in every city? Will we need people to measure air quality (Goodchild, 2007) or make noise-maps (Foerster et al., 2010) if we have low-cost air and noise sensors located on every street corner? Moreover, sensor-collected data will not suffer from some of the quality issues or biases that usually accompany human-collected VGI. Some technologies may, however, rely on VGI to function properly or to realise their full potential. Take, for example, smart thermostats, which are intended to learn over time and make adjustments that improve the efficiency of heating/cooling systems while maximising the comfort of users. Such connected devices or sensors of the IoT require some active human intervention and thus will always involve some form of VGI. Many more electronic devices of this nature are expected to emerge in the near future.

Technological trends also cover advances in software and algorithms. It is likely that the technology for handling large and complex datasets will advance in ways that will more fully exploit the use of VGI. Data quality is a major issue related to VGI at present, so it is likely that in the future we will develop new, sophisticated algorithms to address biases and quality issues that arise from the spatial distribution of participation (see e.g. Haklay, 2010; Antoniou, 2011; Barron et al., 2014). This will reveal the areas and feature types that suffer more in terms of quality and thus need more directed attention from volunteers. Just imagine a map with the following stated differences in scale, and hence in positional accuracy, due to heterogeneous citizen contributions: 'in urban areas roads are of scale 1:5,000, buildings are of scale 1:25,000 and land cover is of scale 1:50,000, but in rural areas land cover is of scale 1:10,000, roads are of scale 1:25,000 and buildings are of scales 1:10,000; urban areas are more complete than rural ones'. One could imagine similar caveats regarding thematic accuracy. It is, therefore, anticipated that VGI projects, based on this algorithmic evaluation of quality, will want to guide their contributors to specific areas or spatial feature types in order to counterbalance any recorded biases (see for example how Geograph[1] informs its contributors). However, it is uncertain what this 'algorithmic management' (Lee et al., 2015) will do to VGI. On one hand, it may greatly enhance the quality and thus the acceptance by a broader audience of VGI. On the other hand, if this results in removing features such as the freedom of expression, fun and intuitiveness from the contribution process, this may severely curtail VGI as a phenomenon in the future.

In summary, technology will continue to evolve, and VGI will certainly continue to leverage technological advances. Strong indications of what the near future will bring are already visible. Indoor positioning and mapping devices (see for example Google's Tango project[2]) will bring VGI into built-up areas. Drones are becoming increasingly popular and we are still exploring their potential as a source of data for many different fields, from humanitarian applications to land cover and elevation mapping. Finally, wearable technology, which is still at an early stage, is expected to become ubiquitous and will vastly multiply the amount of spatial data on the Web. These are just a few examples of what the future holds, and they have the potential to vastly influence and shape the field of VGI.

## 3 VGI, Smart Cities and Digital Earth

Both the growth of VGI and the evolution of technology have pushed forward the initiatives of Smart Cities and Digital Earth. The transformation of our living environment into a smart, interconnected place will lead to a more detailed recording, and hence a better understanding, of the spatial-temporal pattern of human activity. As Roche (2014) points out, the future of smart cities will probably be spatially enabled and develop new spatial skills. Thus, if we better understand the structure of future cities and of the human activities taking place within them, we will also be better placed to understand the role of VGI within them.

Spatially enabling our cities is easier said than done but will very soon prove to be a priority. According to the United Nations Environment Program (n.d.), while cities will cover only 3% of the Earth's inhabited land area by 2050, almost 80% of the population on the globe will live in cities, which will account for 75% of the total energy consumed and 60–80% of Greenhouse Gas (GHG) emissions. It is easy for anyone to understand that sustainability is one of the most important, yet elusive, societal concerns. However, if we do not want to lower our living standards, then improvements in urban functions will become a necessity. To this end, geospatial data and particularly VGI can be a valuable input. Urban planners, authorities, local administrations, NGOs and active communities can benefit from detailed, up-to-date, timely and freely available GI. A list of examples of how VGI is used by governments and authorities is provided in Haklay et al. (2014), where the added value of using VGI alone or in combination with authoritative data to improve resource allocation, efficiency and transparency is presented.

While technology will continue to play an important role in Smart Cities, human capital is equally fundamental to city intelligence. Spatially literate citizens are needed both to embrace new developments and to push for innovative solutions. To this end, VGI has much to offer now, and even more so in the future. Ubiquitous crowdsourced spatial information can serve as the base-layer on top of which all future 'smart' functionalities of a city could develop.

## 4 VGI Quality

Although VGI has been a growing phenomenon for over a decade now (Capineri et al., 2016; See et al., 2016), one of the major factors that hinders the more widespread diffusion and uptake of VGI is the lack of a robust and standardised way to evaluate data quality, as outlined in Chapter 7 by Fonte et al. (2017). VGI could both facilitate and accelerate the transition to Smart Cities and Digital Earth if it were credible enough to trust and hence use in applications that require accurate GI. However, this quest for trust, fitness-for-purpose and usability of VGI data comes down to implementing or devising tangible ways of measuring and reporting VGI quality. Without concrete knowledge of the state of a VGI dataset, its use might end up being a leap of faith that no serious stakeholder is willing to take. Yet if the quality requirements for VGI are too stringent in terms of data specifications, precision, update cycles, spatial coverage or metadata, then we may end up discouraging volunteers. At the same time, we need to avoid the situation whereby VGI is considered to be 'laypeople's data' of de-facto inferior quality, full of biases, with no metadata and only occasional respect for protocols and best practices; such a development would disrupt the momentum and the dynamic that VGI has developed so far and will mark this kind of data out as marginal or as a cheap and untrustworthy replacement for authoritative datasets. It is important to note that VGI is already sometimes as good as, if not superior to, authoritative data and can even exceed the quality requirements of NMAs for common mapping applications (Olteanu-Raimond et al., 2017).

For these reasons, the evaluation of VGI data quality has been a hot topic in academia (see e.g. Haklay et al., 2010; Bégin et al., 2013; Antoniou and Skopeliti, 2015; Foody et al., 2015; Senaratne et al., 2016; Fonte et al., 2017), and research on this topic will continue in the future, not least because improving the methods for reporting quality could end up becoming a catalyst for the widespread diffusion of VGI in mainstream geomatics engineering. Well established methods for spatial data quality evaluation (e.g. ISO specifications), while still valid, need to be supplemented with additional evaluation tools that take the specific nature of VGI into account (Antoniou and Skopeliti, 2015; Fonte et al., 2017). If adequate quality assurance tools and algorithms fail to materialise, then the future uses of VGI might not expand much beyond what we see today. That said, VGI is highly interdisciplinary, combining underlying social, economic and technological factors within the geospatial domain; the result is the recording of space and phenomena based on what citizens perceive to be important. Thus, uncertainty, biases and noise in the data might never be fully eliminated. Instead, we need to understand, model and handle these issues so that VGI can be used effectively.

Future efforts might focus on data harmonisation, which can play an important role in the era of big data since it may enable data comparison, allowing the application of the law of large numbers, i.e. the tendency to arrive at the expected value by averaging the results obtained from repeating an experiment a large number of times (Kuhn, 2007), and contribute to an automated and fast preliminary data quality assessment and even data conflation. To address the availability of multiple sources that may potentially be useful, methodologies need to be developed to assist users in choosing the right dataset or the right combination of datasets for each application. Decisions such as these will be aided by the provision of information about the data, and hence metadata are likely to become increasingly important accompaniments of citizen-derived datasets. Given the huge amount of VGI foreseen in the future, it is likely that there will be a focus on the development of approaches that are more automated for the assessment of VGI quality; this development will be challenging given the greatly varied nature of the data, which can be unstructured and heterogeneous, but is nevertheless of high potential value.

## 5 VGI in Science

Despite VGI quality being an obstacle to the larger diffusion of crowdsourced data in everyday applications, there has been considerable use of VGI in scientific research, in particular in citizen science projects. Citizen science typically refers to the involvement of citizens in scientific research, either in collaboration with or under the direction of professional scientists (Silvertown, 2009). A considerable number of such projects actively use geospatial or geotagged data. Citizens usually use smartphones, cheap do-it-yourself devices or more advanced purpose-built sensors to observe or measure a phenomenon associated with geographic information on a volunteered basis.

Large-scale scientific projects that need a regional or even global-wide spatial coverage are now feasible via the power of the crowd. In fact, any project of such scale needs to seek assistance from the crowd in order to collect the volumes of data needed for research. Examples include the Christmas Bird Count[3], Asteroid Zoo[4] or iNaturalist[5]. Apart from simple data collection, people participating in citizen science projects might get more involved in the analysis of the data or in the interpretation of the results; for an analysis on the typology of participation see Haklay (2013). This increasing trend in citizen participation in citizen science projects will most likely continue in the future, particularly given the success of many different citizen science projects and the active interest shown by authorities such as the European Union in building citizen observatories. This trend is also an important development for VGI on many levels. First, as more and more citizens get actively involved in scientific projects at a local or global scale, collaboration and volunteerism will become stronger. Also, involvement in science has much to teach enthusiastic but untrained contributors of VGI. If we start considering VGI observations and measurements as scientific ones, then following rigorous data protocols for production and evaluation, explicitly documenting measurements with metadata, and the ability to replicate results may become more important for VGI projects; in some cases it may even become obligatory, as with many current citizen science projects.

## 6 VGI, Citizens and Societies

Throughout the book, it has been repeatedly shown that the driving force of VGI is volunteers and their modes of engagement. Although technological advancements provide the means for novel ways of ubiquitous data capturing, what transforms the technological means into a global-wide phenomenon that challenges the fundamentals of the geospatial domain is the role of citizens and their engagement with volunteered contributions of location-based data. Consequently, the future of VGI is closely related to the future of social trends and social evolution.

Crowdsourcing, volunteerism, active communities, citizen science and social enterprises are early formations that can take the lead in the sustainable production of VGI. If such social initiatives evolve further, gain momentum and become commonplace, then the bottom-up production of geotagged data will rise to entirely new levels. For example, it is worth noting how online communities in citizen science projects address real-world problems. Similar examples exist in the VGI sphere, and can be found in the efforts of the Humanitarian OpenStreetMap Team (HOT), which mobilises volunteers in mapping areas that have been hit by natural disasters. Interestingly, such grassroots collaboration overcomes societal barriers and enables citizens to participate in the management and improvement of quality of life, a common goal of visions such as Digital Earth and Smart Cities.

A really intriguing, and equally interesting, future development might arise if we consider location and spatial information as common goods (Roche et al., 2012) that are mainly produced and maintained by people. What changes will this generate in our society? What will be the benefits to and responsibilities of the citizens and the authorities? For instance, we will need to steer future societies into geospatial crowdsourcing, understand its value, its benefits, its potential and the steps that we need to take in order to create and sustain spatial infrastructures. Consequently, citizens should be initiated and trained into the world of geospatial information from the early years of their education. Geography curricula and lessons should be redesigned to include the collection of geotagged information in a volunteered and collaborative mode. There are already excellent examples available to provide initial best practice. These include the activities of the Finnish Environment Institute and the Finnish National Land Survey Agency, which have introduced citizen science and crowdsourced data collection in elementary schools, the Muséum National d'Histoire Naturelle in France, which introduced collaborative science on biodiversity into French schools, or the positive experiences of the Dutch Kadaster, which introduced a new curriculum on crowdsourcing and mapping in elementary schools.

It should be noted, however, that future developments in citizen sensing may require greater consideration of the citizen as well as the end use of the data generated. A greater understanding of citizen sensors is required as there is a two-way dialogue between those using and contributing the VGI, especially as citizens may also be the source of very useful ideas. Feedback to citizen contributors is likely to become much more important, especially in developing the citizens' skills and maintaining motivation. A new reality in which the role of geospatial information is highlighted, which renders its collection and maintenance a common responsibility, might prove a very efficient way to secure the motivation and long-term engagement from large parts of the population that is needed to support global-wide geospatial data collection.

## 7 Understanding the True Value of VGI

Much of the literature on VGI is about understanding this phenomenon. The subjects examined range from the motivation behind volunteered contributions, the quality of the data obtained or the biases that VGI datasets might possess to the integration of VGI with other sources of data. Little has been written about the true value of VGI. By 'true value', we refer to what VGI has offered not only to the geomatics domain but also to people and society as a whole.

The bottom-up production of VGI has democratised the production and use of GI. VGI has changed a landscape where spatial data creation was once the responsibility and privilege of a few governmental agencies or large corporations (e.g. NMAs), and where the access to spatial information was limited and usually very expensive for the public. What VGI did, and probably will continue to do in the future, was to create a closer relationship between the public, on the one hand, and geography, cartography, web mapping and geospatial applications, on the other hand; in a sense, the public have been introduced to the value of GI. The omnipresence of GI in everyday devices and the multiple applications and services offered today that are based on spatial data would not have been possible without this new, enlightened relationship. Moreover, there is a constantly increasing demand for more GI, both in terms of quantity and detail. As VGI has, in a sense, spatially enabled our societies, the need for more data of this nature will only intensify in the future. Now, for the first time, it is possible to have a tangible picture of how people understand space, what matters to them and what they think needs to be on a map. The horizon of what GI should cover has been considerably broadened, ranging from the mapping of litter[6], noise pollution (Maisonneuve et al., 2010) and other relevant urban problems[7] to the support of Smart Cities and a wealth of other applications. This information is valuable for understanding how societies function and what we need to do in the future to help improve them.

## 8 Future Legal and Ethical Concerns

The importance of legal and ethical issues has already been raised in Chapter 6 by Mooney et al. (2017), but much more attention will need to be given to these issues in the future. It is anticipated that VGI will increasingly be harvested from diverse sources including social media and wearable devices. While potentially yielding vast amounts of useful VGI, including information about human location, movement and behaviour, this comes with a suite of data privacy, ethical and legal concerns. These are complex issues, since legislation tends to lag behind advances in technology and also differs from country to country. There are also serious concerns with the reuse of VGI; in many instances, especially when it is mined from open resources, VGI may be used for different applications than the original purpose of data collection, which some volunteers may be uncomfortable with. As the ability to integrate and fuse together greater numbers of complex and disparate datasets increases, it is of crucial importance that the issue of data reuse be addressed. Data reuse also links to legal concerns; for example, if the VGI was acquired by digitising from a map or image without the relevant permissions, what are the implications for those that reuse the VGI? Equally important are possible cases of vandalism. Intentional deterioration of the quality of a VGI dataset or the insertion of false data could have considerable ramifications if the data are then used in decision-making or policy implementation. It is anticipated that in the future, as VGI gains momentum, there will be a need to better safeguard the integrity and objectivity of this data source.

## 9 The Final Word

This is a time of very rapid change – in the last decade the geomatics domain has witnessed unprecedented growth. GI has moved from the control of a few producers to the hands of many, who now have the power to produce and update many different spatial data repositories. At the same time, demand for timely, free and accurate GI is multiplying. Whether from the move to a digitised environment or from the frequent use of map-based applications, the value of GI has been widely recognised by many. VGI has been a catalyst for these changes, but we are currently standing at a very important crossroads: either VGI will move to a new level in which it will be the key enabling factor for future developments or it will remain at current levels of acceptance, running the danger of being overtaken by developments in other domains, and possibly even decline or decay. The responsibility for what happens is, at least partially, in the hands of GI professionals as well as citizens. Fortunately, networks such as COST Action TD1202[8], out of which this book has arisen, are succeeding in bringing together an interdisciplinary community including professionals from NMAs. By working together to address VGI quality issues and potential dangers to the field of VGI, we will strive to ensure that VGI has a strong and exciting future.

## Notes

[1] http://www.geograph.org.uk/
[2] https://get.google.com/tango/
[3] http://www.audubon.org/conservation/science/christmas-bird-count
[4] https://www.asteroidzoo.org/
[5] http://www.inaturalist.org/
[6] http://www.litterati.org/
[7] https://www.fixmystreet.com/
[8] http://www.citizensensor-cost.eu/

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