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Using small cities to understand the crowd behind OpenStreetMap

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Abstract

As businesses and governments integrate OpenStreetMap (OSM) into their services in ways that require comprehensive coverage, there is a need to expand research outside of major urban areas and consider the strength of the map in smaller cities. A place-specific inquiry into the OSM contributor sets in small cities allows an intimate look at user motives, locations, and editing habits that are readily described in the OSM metadata and user profile pages, but often missed by aggregate studies of OSM data. Using quantitative and qualitative evidence from the OSM history of five small cities across North and South America, I show that OSM is not accumulating large local corpuses of editors outside of major urban areas. In these more remote places OSM remains largely at the mercy of an unpredictable mix of casual contributions, business interests, feature-specific "hobbyists", bots, and importers, all passing through the map at different scales for different reasons. I present a typology of roles played by contributors as they expand and fix OSM in casual, systematic, and automated fashion. I argue that these roles are too complex to be conceptualized with the traditional "citizen as sensor" model of understanding volunteered geographic information. While some contributors are driven by pride of place, others are more interested in improving map quality or ensuring certain feature types are represented. Institutions considering the use of OSM data in their projects should be aware of these varied influences and their potential effects on the data.

Keywords

volunteered geographic information; OpenStreetMap; small cities; crowdsourcing; geoweb; South America

Introduction

In the past decade, the growth of a more interactive and mobile-friendly World Wide Web has allowed people with little formal technical training to produce enormous amounts of online information. The practice of "crowdsourcing" harnesses the work of these diverse and distributed Internet users to collaboratively produce information products, such as the free online encyclopedia Wikipedia. The OpenStreetMap (OSM) project, built on a similar model of open contribution, has proven that cartographic information can also be collected through a crowdsourcing approach.

Goodchild (2007) described this type of mapping crowd as "citizens as sensors", collecting and contributing "volunteered geographic information" (VGI) about the world around them. Human sensors are not as easily managed or calibrated as traditional mechanical sensors are, and it has become clear that OSM and other broad-scale VGI projects face challenges with achieving consistent levels of coverage across space (Latif et al. 2011, Neis et al. 2013) and scale (Touya and Brando-Escobar 2013). Contributors bring individual interests, biases, motivations, business objectives, and life experiences to crowdsourced maps that affect the nature and focus of the data (Budhathoki 2010, Stephens 2013, Glasze and Perkins 2015). The fact that VGI is often created in loosely organized and informal environments can cause hesitance in adoption by governments and other institutions who might otherwise find the data valuable (Feick and Roche 2013, Johnson and Sieber 2013), and institutions that do adopt the data may have a limited awareness of its potential shortfalls.

A multitude of studies have been undertaken to assess the positional or semantic accuracy of OSM, but somewhat less common are forays into the rich social influences driving the construction of the data. Coleman et al. (2009) notes that these inquiries are needed with VGI in general. Although Haklay (2014) observes that the terms VGI and OSM should not be conflated, he similarly advocates studying societal aspects and social influences in OSM as pillars of a proposed "OpenStreetMap studies" genre of research. I address this need in the present study by dissecting the size, composition, and priorities of "the crowd" behind OSM, focusing on small cities that might not attract worldwide interest. In many cases, these cities lack locally organized user groups and have fewer institutions where people with existing digital mapping skills might be found, such as colleges or technical firms. Although OSM has amassed an impressive number of streets, local landmarks, and businesses in major urban areas such as Seattle, New York, and Buenos Aires, studying the data and its contributors in smaller cities may provide a more practical picture of the current usefulness of OSM for applications that require comprehensive geographic coverage.

OSM is a social construction, and when we look at OSM in a place, we see the product of a set of choices and priorities by a finite number of individuals regarding how to represent the world in a digital database. What, then, do the intrinsic characteristics of the data tell us about the size and interests of the "crowd" behind OSM in any given place? In response to this question I will explore the following aspects of the crowd in small cities:

- **How big is the crowd in these places**? – How many contributors are active in these cities, and how has the number waxed and waned over time compared to larger cities? This can help form a picture of what level of variety is represented and the amount of scrutiny that the data has received.
- **How is the work distributed among the crowd?** – Given that most OSM contributors make very few edits to the project (Neis and Zipf 2012, Wood 2014) how can we go beyond the raw number of contributors to determine the size of the *active* crowd in these cities?
- **Where is the crowd coming from?** – Do most of the contributors have local access to the area for onsite data collection, or are they external "armchair mappers" tracing aerial imagery, importing data, and tidying up attributes? The in situ data gathered by local mappers takes more effort to produce and requires a physical presence in or near the mapped area; however, it provides a richness to the map connected to the routines of day-to-day resident life in way that is difficult to achieve through armchair mapping (Quinn, forthcoming).

- **What brings the crowd to this place?** – Why have people edited the map in these cities, especially if they appear to have never visited the area? How do these purposes affect the types of entities that they add to (or leave out of) the map?
- **How does the nature of the crowd vary across different spaces and scales? –** How does composition and focus of the crowd differ when examining small cities from different world regions, or a larger city in the same geographic region?

Many of the above questions can intersect, leading to new dimensions of understanding about how the project is constructed by the crowd. For example, in a given location, are the heaviest contributors the ones with local access? And for a given place, how can we describe the growth (or stagnation) of the set of local OSM contributors working on the project on a regular basis? The answers can help indicate whether OSM will always be an unbalanced map across urban and rural divides.

This study focuses on three small cities in the 40,000-60,000 population range from the Pampas region of South America. The cities lie in three different provinces/departments in Argentina and Uruguay. This region was selected because the few academic studies on OSM outside of the Global North have tended to focus on very large cities. To explore questions about how the results compare with other regions and scales, I also compared data from the three above small cities with those of (a) a large city in the Pampas region with population over 1 million, and (b) two small cities with comparable populations (ie. 40,000-60,000 people) in the Interior Plains of North America.

The publicly available history of OSM activity for the focus cities was downloaded and scrutinized for both quantitative and qualitative clues about the nature of the crowd producing the map in these places. These include the raw number of contributions, the free-form comments they leave when saving their work, the text of the public profiles they create on the OSM website, and the languages they use in these materials. In particular, indications were sought about their motives, geographic locations, amount of content contributed, and special interests or "hobbies" (such as focusing on railroads or power lines) that brought them to edit these cities. This information was used to develop a typology of editor roles describing different contribution behaviors in the map.

Theoretical background and related work

Despite the ability of crowds to quickly produce many gigabytes of data, crowdsourced information products do not appear by magic; they are built piece by piece by human beings. The bottom-up "citizen sensor" means of gathering data presents exciting prospects for the collection of rich place-specific information that perhaps could not be gathered any other way (Goodchild 2007, Elwood et al. 2013); however, a reliance on human sensors introduces vulnerabilities for the rapidly growing set of companies such as Mapbox, CartoDB, and Telenav whose business models lean heavily on open map data, especially OSM. Services provided by these companies such as base maps and routing often require comprehensive coverage of broad regions such as countries; yet academic studies of OSM coverage and quality typically have been restricted to large urban areas, neglecting the rural landscapes and small cities that many map users will inevitably traverse.

At the same time, researchers studying a variety of OSM-related topics have indicated that the crowd of volunteer mappers remains scarce in many places. After attempting an examination of collaborative editing patterns in OSM, Mooney and Corcoran (2013) concluded: "The idea that there is a large crowd of contributors working together to gather geographic data and build the OSM database is inaccurate." Lin (2011) found OSM participants remarking that often their hometowns were mapped by just a few individuals. And in an analysis of OSM use for disaster response, Zook et al. (2010) suggested that the small and homogenous group participating in crowdsourced mapping calls into question claims that Web 2.0 has sparked real democratic revitalization of digital content production.

The imbalance of attention to certain places and features in OSM was not unanticipated. Near the beginning of the OSM project, founder Steve Coast was asked if any places would get missed or neglected in the map. His response that "no one wants to do council estates" but that nowhere else would get missed (GIS Pro 2007) was investigated quantitatively by Haklay (2010). After showing that OSM coverage was indeed negatively correlated with socioeconomic deprivation in his UK study areas, Haklay rendered the verdict that "OSM is not an inclusive project, shunning socially marginal places (and thus people)." Stephens (2013) added an examination of the ways that the imbalanced gender makeup of OSM editors has influenced map content and community discussions about which entities on the landscape should be incorporated into the OSM ontology of features.

These examples are manifestations of the "virtual black holes" and uneven geographies of information production that Graham (2010) warned could appear in VGI due to technological, economic, or other cultural barriers faced by people who might otherwise be able to share deep knowledge of a place. Projects such as OSM are consequently constructed by a smaller set of individuals who have the time, inclination, and education necessary to edit the map (Graham et al. 2013), thereby wielding a disproportionate influence in the creation of spatial information. Patterns of digital map construction thus reflect Harley's (1989) observations of cartographic power throughout history, that "to those who have strength in the world shall be added strength in the map".

Why study small cities?

One purpose of the present study is to learn more about how small cities are imparted "strength in the map" in OSM. When we look at a small city in OSM, how likely is it that someone from that city contributed to the map, and is it reasonable to expect that OSM is gaining enough uptake in small cities to be maintained by local contributions over the long term? For all the other people contributing data in this city, what brings them to map places they have never visited where there is otherwise relatively little outside interest?

Small cities were chosen for study for three main reasons. First, most available literature on OSM has focused on either large cities or broader geographic regions such as countries. National-level studies may blunt or hide OSM construction processes occurring (or not occurring!) in smaller domains. Second, maps and apps that require full geographic coverage of an area for navigation, natural hazard planning, etc. need to provide that coverage in small cities just as well as large ones. Finally, with small cities it was conjectured that the entire corpus of edits and editors in a place would be manageable enough that it could be comprehended by a human analyst and studied qualitatively at a deeper level than other studies that have focused on tallying raw numbers of features in the database.

Small cities play an indispensible role in regional economic networks and are home to a notable portion of urban dwellers, even though they are often neglected in academic urban studies (Jayne and Bell 2009). For example, at the time of the 2010 census, 8.8% of US residents lived in "micropolitan statistical areas" centered around urban cores of 10,000 to 50,000 inhabitants and including towns in the immediately surrounding area (United States Census Bureau 2010, 2014). The 2001 Argentine national census found 7.4% of residents living in urban areas containing between 50,000 to 100,000 inhabitants (INDEC 2001a, 2001b). These cities often compete with each other and their larger neighbors to attract businesses, residents, and other amenities, using web presence as a tool (Urban 2002, Grodach 2009).

In a world where our day-to-day decisions are increasingly determined by the results of digital search algorithms and electronic placemarks (Graham et al. 2013, Graham et al. 2014), the presence of a comprehensive online map could spell an advantage for one city over another. If relatively few mappers are involved in the construction of small cities in OSM, it seems reasonable to speculate that mapping activity in these cities could be highly variable. Another potential consequence is that smaller cities remain undermapped when compared to large neighboring cities. Small city residents who use OSM-based services for search, navigation, and other functions may find that their needs are not met as fully as those of their metropolitan neighbors. Perhaps a greater challenge is that amenities and services in their cities languish invisible in the map and its search algorithms, thereby losing patronage to more visible services in competing cities, a digital realization of Harley's (1988) "cartographies of silence" (see also Brunn and Wilson 2013).

Drawing from theories of critical cartography, Perkins (2011) suggests that OSM, like many other mapping products, derives its authority from some level of denial of subjectivity, but that these subjectivities could be easily uncovered in the data. Are these subjectivities starker in cities with a smaller contributor base? "Linus's Law", popularized in the open source technology world by Raymond (1999), and confirmed to some extent for OSM by Haklay et al. (2010) proclaims that "given enough eyeballs, all bugs are shallow", inferring that a large number of contributors will filter out low quality or unhelpful content. The potential smallness of the OSM contributor crowd in particular places is therefore a subject of special concern. Although the OSM blog recently that the project recently surpassed 2 million registered users (https://blog.openstreetmap.org/2015/03/12/two-million-contributors/), most of these are not actively working on the map. Geographically, OSM contributors are centered in Europe and major urban areas, although there is great variation in contributor activity even among major world cities (Neis and Zipf 2012, Neis et al. 2013).

Small cities as a lab for studying contributor motivation and behavior

VGI in general involves an intense focus on the local and the individual (Goodchild, quoted in Wilson and Graham 2013), yet relatively few studies of OSM have looked to intrinsic aspects of the data to discern the locations and nuances of the contributors beyond the positional and semantic accuracy of their collective edits (Glasze and Perkins 2015). The general motivations and practices of OSM contributors have been studied a bit more thoroughly, using the varying approaches of mass surveys (Budhathoki 2010), personal interviews (Lin 2011), and computational analysis of edit types (Steinmann et al. 2013).

For example, by comparing survey results with OSM contribution statistics, Budhathoki (2010, p. 84) identified a desire to share local knowledge as the motivational factor most closely linked to consistent OSM contribution. This motivation was significantly associated with the number of nodes added, frequency of contribution, and longevity of participation. In this same study, a desire to achieve the goals of the OSM project was significantly related to nodes and frequency, but not longevity. Thus, pride of place seems to be a more salient motivator than pride of the map, although both are significantly related to at least several aspects of OSM participation.

Budhathoki suggested that these results could lead to a higher level of map detail in places where there are more human sensors, such as big cities and tourist sites, and could cause the potential for underrepresentation of towns or rural areas. Indeed, Zielstra and Zipf (2010) indicated that in Germany, the completeness of the OSM road network decreased outside of large cities to the point of becoming much less usable in rural areas, while in a study of Greater London, Mashhadi et al. (2015) confirmed that the completeness of OSM points of interest was positively correlated with population density.

Taking a more qualitative approach to understanding OSM contributor motivations, Lin (2011) interviewed contributors and identified four social worlds involved in the production of OSM data: (1) business, (2) government, (3) NGO/Third Sector, and (4) individual contributions. This approach acknowledges the influence of a diverse set of stakeholders in the project, whose organizational goals sometimes transcend large groups of employed contributors. Particularly when there is a business interest at stake, pride of place may take a back seat to interests of making sure the map data is comprehensive. In this context, the crowd behind OSM is more complicated than a set of individual sensors contributing their own local knowledges.

The present study makes at least three contributions to the above literature on OSM contributor motivations and actions: First, it draws on the vast body of OSM contributor comments embedded in the project metadata. These comments link qualitative observations by contributors with a specific set of edited features. Second, it uses the text of publicly available profile pages to understand contributor locations and backgrounds, offering a glimpse into the contributors' "social worlds" mentioned by Lin. Third, the study is place-based, allowing the comparison of OSM activity in cities with similar populations or geographies.

The question of scale of edits also plays an important role in this study. If people are editing small cities in OSM as part of some thematic effort across a broader region (such as a state or country), it could signify a general increase in map content for small cities. In this situation, "a rising tide lifts all boats". At the same time, if most edits come from these broad regional level projects, we might also expect a lack of local richness in the data that could miss the amenities and services that make a particular city unique.

The abundant literature on Wikipedia growth may help inform hypotheses on OSM development among small and large cities. For example, Iba et al. (2010) discovered two main article types in Wikipedia: (1) articles of narrow focus created by a small number of subject matter experts, and (2) articles about broad topics, created by thousands of editors. In the case of crowdsourced mapping, perhaps there is an analogy to be drawn between these article types and respectively (1) small cities of a local or regional interest, and (2) large cities of a global interest. To date, literature analyzing OSM activity in small cities has been too scarce to confirm this, leading to the present research.

Methods

For the core of this analysis, three small cities (between 40,000 – 60,000 inhabitants) were selected from the Pampas region of South America. This is an area primarily used for agriculture and grazing, with very low population density outside of its scattered cities and towns. The selected cities were General Pico, La Pampa province, Argentina; Tres Arroyos, Buenos Aires province, Argentina; and Tacuarembó, Tacuarembó department, Uruguay (Figure 1). The straight-line distance between any two of these cities is over 400 kilometers. The intent of selecting three cities in this area was to get a feel for the proportion of OSM contributors active at a regional level versus the proportion that only contribute for one place.

To complement this analysis, the much larger city of Rosario, Argentina (population over 1 million) in the Pampas region was also studied. The motivation behind this was to learn how the contribution patterns in the small cities related to patterns in a larger city in the same region, and what proportion of the contributor sets overlapped between these cities. Argentina's primate city of Buenos Aires was not selected because its massive size causes it to be of disproportionate political and economic importance beyond the bounds of the region. Furthermore, this city has already been examined in Neis et al. (2013).

Figure 1. South American cities whose OSM data was studied in this analysis.

Finally, to compare how editing patterns in South America relate to locations in the Global North, two small cities of population 40,000-60,000 were selected from the Interior Plains of North America, a region similar to the Pampas with regards to its agricultural and grazing land use and low population density. These cities were Salina, Kansas state, USA; and Brandon, Manitoba province, Canada (Figure 2). Although more cities in North America and elsewhere could have been selected for comparison, it was desirable to keep this particular analysis and discussion focused primarily on South America, as there has been less study of OSM in this region. Results by Quinn (forthcoming) indicate that there is substantial influence on the South American OSM coming from residents of other continents, especially in rural areas, futher making this region desirable for additional investigation.

Figure 2. North American cities whose OSM data was studied in this analysis.

To understand the amount of data available in each city for each contributor, the "full history dump" file was downloaded from the OSM website, covering a time period from 2007 until the final week of the year 2014. The data was clipped to rectangular bounding envelopes around each city. Only OSM nodes (points) and ways (lines and polygons) were examined in this study. OSM relations are conceptually and technically challenging to clip to a study area and have no visual component, therefore relations were removed or ignored during processing. Using a Python script, I constructed point and line geometries of each version of each feature in the history file. This allowed the creation of small multiple maps (discussed later) to visualize each contributor's body of work.

A separate file containing the OSM changeset history was also downloaded. A changeset contains metadata about a group of edits uploaded to the OSM database at a single time, typically when the contributor invokes the Save option in his or her editing program. A changeset can be loosely viewed as a unit of work. A useful piece of the changeset metadata is the rectangular bounding box of the edits, showing the geographic range over which the edits were applied. Another valuable part of the changeset metadata is the free-form comment that contributors can attach to the changeset justifying or describing their edits. This comment can provide indications of user language, geographic origin, and motivation.

Each contributor's comments were reviewed by both human and machine. I first analyzed each contributor's set of comments and noted any favored edit types or habits. I then submitted the comments to the langid.py Python language identification module (Lui and Baldwin 2011, 2012). For each contributor, the most common language detected for that contributor across all work in the OSM project was noted. An analysis of the relationship between language of OSM comments and the actual place of contributor origin can be found in Quinn (forthcoming).

Many OSM contributors edit the map in more than one place (Neis and Zipf 2012). In order to understand how much of a contributor's work was dedicated to a particular city, each contributor's total number of changesets in that city was tallied and compared with his or her total number of changesets in OSM. This analysis distinguishes the passer-bys and happenstance contributors from those who dedicate a considerable portion of their efforts to the city.

Another metric calculated was the number of days each contributor was active in mapping the city. From these results it was possible to derive the total number of person-days of mapping activity for each city, summing for all contributors the number of days each contributor made an edit to the project. These metrics reveal the most committed contributors and give a picture of the overall level of mapping activity in each city. Counting the number of active days in the project has some advantages over examining raw numbers of edits or changesets. Some people import or digitize line or polygon features with a high density of nodes, complicating a metric of influence based on the number of edited nodes alone. Counting the number of changesets is also a problematic measure of influence in the project, because some editors save their work much more frequently than others, thereby creating many changesets.

Further information about the motivations and geographic origins of the contributors is available in their OSM profile and wiki pages. These are publicly available web pages in the openstreetmap.org domain where contributors can optionally offer biographical information about themselves and their work. For each contributor who had made a page, I read the page and noted the language of the page and any editing preferences or hobbies. The Google Translate online translation utility was used for assistance with the relatively few cases where the page was in some language other than English, Spanish, or Portuguese.

The contributors' profile and wiki pages also often provided information about their home cities or countries, offering some understanding of which contributors might be considered to have local knowledge of the mapped area. These home locations were noted whenever a contributor mentioned one. In the case where the home location was not directly mentioned on the page (or in any personal website linked directly from the page), the contributor location could sometimes be derived from the reported list of special interest user groups that he or she had joined, (for example "Users in Seattle"). Some people join groups from multiple locations, therefore if two geographies were in conflict, the parent geography was recorded (ie, if the user belonged to "Users in Berlin" and "Users in Dusseldorf", Germany was recorded). If the groups fell within different countries and no other clues were available, no geography was recorded.

Results

The above methods revealed new insights on the nature of the crowd, while also reinforcing some findings of previous literature. The differences in contributor patterns between the small cities and the large city do not always fit proportional differences in population size, and reveal that different map construction processes are being enacted at different scales. The results below first report what was learned about the size of the crowd, followed by the geographic origins of the crowd, retention of the crowd, scale of edits, and the individual motivations and editing habits of crowd members.

Size of the crowd

In the small cities studied in this paper, OSM has not reached the level of being built by a "crowd", but rather a dedicated "handful" of contributors who vary in motivations and activity levels in the project. Table 1 shows that each small city was built by just a few dozen individuals.

City name	City type and region	Number of contributors	Total person-days	Contributors active only	Contributors active more than

		in OSM history file	**contributed**	**one day here**	**five unique days here**
General Pico, ARG	Small city – Pampas	35	101	18 (51.4%)	3 (8.6%)
Tacuarembó, URY	Small city – Pampas	25	104	12 (48.0%)	4 (16.0%)
Tres Arroyos, ARG	Small city – Pampas	29	85	17 (58.6%)	3 (10.3%)
Rosario, ARG	Large city – Pampas	191	1028	120 (62.8%)	20 (10.5%)
Brandon, Manitoba, CAN	Small city – North American Interior Plains	46	113	27 (58.7%)	5 (10.9%)
Salina, Kansas, USA	Small city – North American Interior Plains	58	167	33 (56.9%)	5 (8.6%)

Table 1. Contributor metrics showing the size and activity of the crowd in the cities studied.

The number of person-days reported in each row offer some insight into the activity levels of the contributors in the different cities. For example, Tacuarembó has the smallest crowd (with only 25 contributors), but it has a higher number of person days (104) than General Pico and Tres Arroyos. This suggests that at least some contributors working on the map in Tacuarembó are more actively mapping than their counterparts working on the other two cities.

For practical purposes, the actively working crowd in any given city is much smaller than the total number of contributors in that city. The set of contributors never returning to map anything else in the city after their first day of contribution ranges from 48 – 63%. (Steinmann et al. (2013) reported this figure at 53% for the OSM project as a whole.) Furthermore, none of the small cities studied had any more than 5 contributors who were active more than five unique days in mapping. Consequently, a small number of actively mapping contributors can wield a high proportion of influence on the map.[1]

[1] Parr (2015, p. 132-133) described two US metropolitan areas where the majority of the mapping was performed by a single individual. In one of the cases, 99% of the features in the city were added by one contributor.

These varying quantities of edits between users are evident in Figure 3, which visualizes the nodes and ways modified by each contributor in the city of Tres Arroyos. These maps are arranged by the number of unique days the contributor was active in the project, starting at the top with the most active contributors and moving from left to right, then down to the next row and so on until reaching the bottom part of the graphic where the least active contributors are located. Most contributors have only modified one or a few nodes or ways, while a small group of contributors have modified features throughout the town. The two dense gray splotches near the upper-right of the image were from users who modified address ranges on most of the town's streets.

Figure 3. Small multiple maps of each contributor's work within Tres Arroyos over the history of the OpenStreetMap project. Edited ways are green lines and edited nodes are gray dots.

The purpose of Figure 3 is not to comment on the value of each contributor's work, but rather to show that a small group (and small percentage) of people do most of the work in a place. Anthony et al. (2005) demonstrated that contributions of Wikipedia editors who only make one edit can sometimes provide more value to the project (in terms of longevity and "staying power" of the edit) than those offered by more active contributors. This could be the case in OSM as well, as Parr (2015, p.123) found that the users with the lowest mean spatial error in feature placement tended to have low mapping activity, but high attention to the context of the project and the geographic detail of what they were adding. Further research is needed to determine if the activity levels of a user and the actual longevity of his or her OSM feature contributions are connected.

In viewing Figure 3, it's also important to remember that contributors who make only one edit in a particular town are not necessarily "newbies" to the project. Comparing the number of changesets each contributor made in the town versus his or her total number of changesets in OSM revealed many cases where very active OSM contributors were just passing through the town, either physically or virtually, to map a single feature for one of a variety of reasons discussed later in this paper.

Geographic origins of the crowd

Although precise locations of each crowd member are not known, a picture of the crowd's familiarity with any particular city can be formulated through multiple indicators. The most direct way to derive an OSM contributor's location is from self-reported information in the contributor's public profile or wiki page on the OSM site; however, many contributors choose not to create these pages and even fewer indicate their home place. For example, profile and wiki pages indicated a location for 36 (18.8%) of the 191 contributors to the map in Rosario (see Table 2). Another method to infer the locality of the contributor in non-English speaking countries is to detect the language of contributor comments in the changeset metadata and the language used on any profile or wiki pages created (if these exist). Quinn (forthcoming) used the South American OSM to show that places dominated by Spanish and Portuguese comments have a heavier local influence than places commented in English. Finally, a way of inferring whether a contributor is local to a particular city is to calculate the percentage of the contributor's total OSM changesets that fall within the city. Contributors with a higher percentage of edits in the city would be expected to have more familiarity with the city, although this conclusion is not certain for any particular contributor and becomes less reliable when the user has very few total edits.

Figure 4 shows the most commonly detected language in OSM changeset comments for each of the top 10 contributors in the Pampas region cities, where the native language is Spanish. These rankings and all others in this paper were determined by ordering the contributors by number of unique days active in OSM in the city.[2] These languages were detected by the langid.py Python module, as described in the methods section. Languages listed are derived from the contributor's work across the entire OSM project, and not just within the target city. If a country of origin could be determined from the user's profile or wiki page, it is listed in parentheses. Contributors who appear in multiple cities are connected by a line.

Contributor rank (by days active in the city)	Tacuarembó, URY (small city)	General Pico, ARG (small city)	Tres Arroyos, ARG (small city)	Rosario, ARG (large city)
1	Spanish (Uruguay)	Spanish	Spanish (Argentina)	Spanish (Argentina)
2	Spanish (Uruguay)	English (Germany)	Spanish	English (Germany)
3	Spanish	Spanish (Argentina)	English (Germany)	None
4	German	Spanish	English	Spanish
5	Spanish	Spanish	Spanish	Spanish (Argentina)
6	English (Germany)	Spanish	Spanish (Argentina)	Spanish
7	English	Spanish	Spanish	Spanish
8	Portuguese	Spanish	French	Spanish
9	French	None	Spanish	Spanish
10	Spanish	English	Spanish	Spanish

Figure 4. Languages favored in OSM changeset comments by top contributors in each city. Places of origin, if known, are listed in parentheses.

[2] Ties were broken by favoring the contributor with the larger number of changesets in the city. A further tiebreaker (if needed) favored the contributor with the higher percentage of changesets in the city compared to his or her total number of changesets in the entire OSM project.

Most of the top contributors speak Spanish and are likely from the country they are mapping; however, in the smaller cities there is a greater share of contributors employing languages other than Spanish, to the point where Tacuarembó sees five different languages among the top 10 contributors. The smaller cities, therefore, may be receiving more influence from armchair mappers and might have a need for more place-specific knowledge to be added by contributors who can collect data on site.

When considering all contributor locations reported in profiles (not just the top 10), the most prevalent countries of origin were, in order, Argentina, Germany, Brazil, and Uruguay (Table 2). Although this information is likely reliable, it is unclear how well it extrapolates to the entire body of contributors in these cities, just because so many users did not report a location. The presence of Germany is not a surprise as Neis and Zipf (2012) estimated that over a quarter of all OSM users are from Germany. Even if this figure has diminished in the past several years, the table below suggests that German influence in OSM across the world is still substantial. When looking at the number of contributions in the study areas (not reported in this table), German contributors in the Pampas cities tended to be lighter contributors than Argentines and Uruguayans.

Tacuarembó, URY (small city)	**General Pico, ARG (small city)**	**Tres Arroyos, ARG (small city)**	**Rosario, ARG (large city)**
18: Unknown	24: Unknown	19: Unknown	155: Unknown
2: Germany, Uruguay	6: Argentina	5: Argentina	12: Argentina
1: Brazil, Canada, Italy	3: Germany	4: Germany	8: Germany
	1: Canada, Uruguay	1: Canada	4: Brazil
			3: UK
			1: Belgium, Bolivia, Canada, Hungary, Sweden, Switzerland, Turkey, Uruguay, USA

Table 2. Countries of origin determined from public OSM user profile and wiki pages, in the format <number of contributors: country>.

Retention of the crowd

The activity level of the crowd in the small cities has fluctuated over time, as shown in Figure 5. This graph measures the attention given to each of the five small cities by tallying the number of person-days of activity seen each year. In this calculation, the person-days do not represent units of 24 hours of work (we do not know the number of hours spent on making the edits), rather they are the total of unique days spent by all contributors to the project during the year. Although a slight general increase is visible from the beginning of the project to the present, the numbers often move up and down from one year to another. In contrast, the larger city of Rosario has increased its amount of mapping activity in each of the past five years. This suggests that larger cities may be more likely to amass a consistently growing contributor base over time (most likely including local residents), while smaller cities are at the mercy of more transient mapping activity by passers-by.

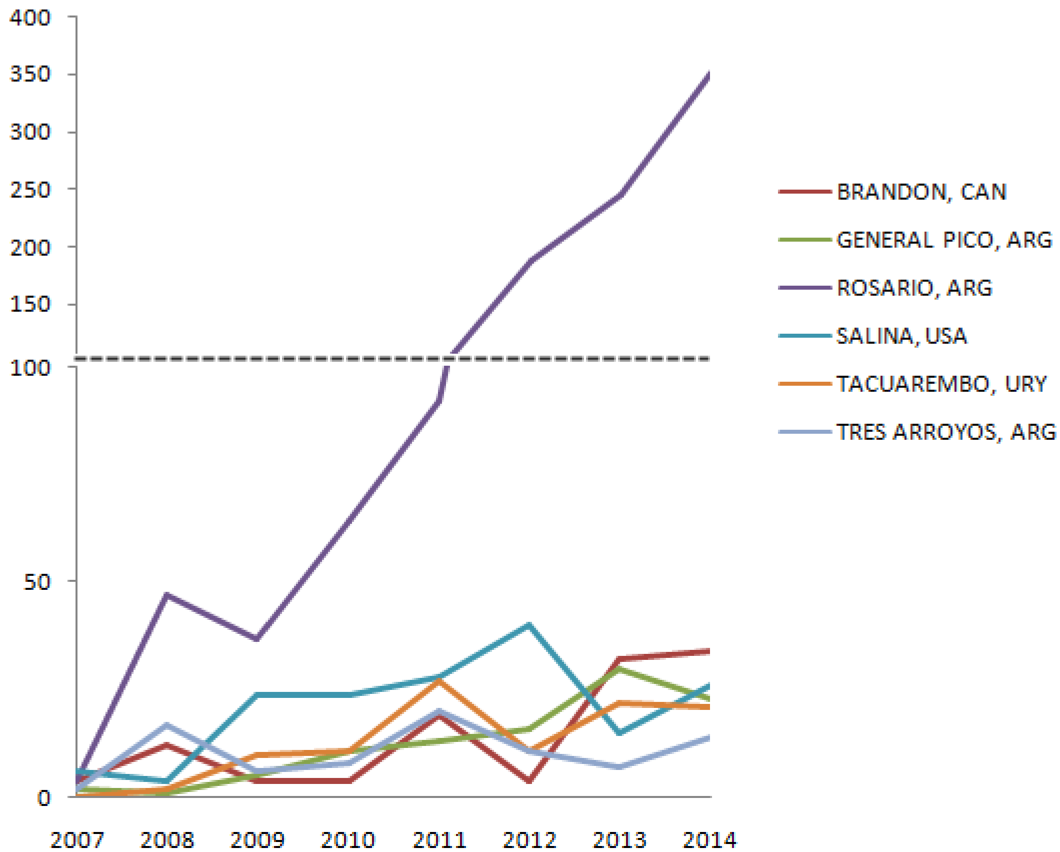

Figure 5. Yearly person-days of mapping

Although the larger city of Rosario is increasing its mapping activity at a greater rate, it performs about the same as the other cities when considering the percentage of contributors active during the most recent year (Figure 6). Most cities hover around the 25 – 35% range; however, not all cities exhibit the same proportions of active contributors. General Pico, in particular, saw over half of its contributors active in 2014. For many of these contributors, 2014 was the only year they edited the city. Although a group event such as a mapping party or local school project could skew the numbers in this way, there is no evidence that this occurred in General Pico; however, several paid mappers and a bot appeared in the area making fixes during 2014 (discussed further below). This might indicate that more attention is being paid to smaller cities in recent years as part of a broader effort to improve regional OSM quality.

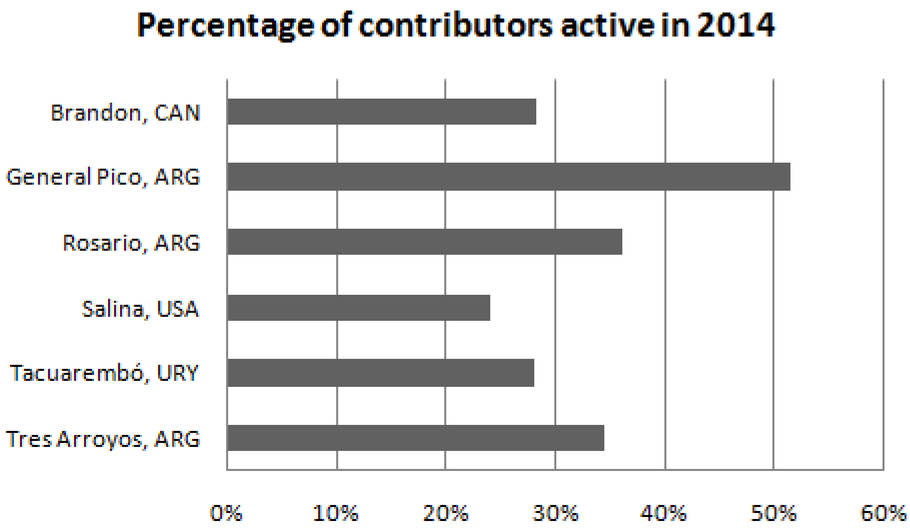

Figure 6. Percentage of contributors active in 2014.

Additional evidence of large cities retaining contributors appears when examining the range of active years for the top contributors for each city. It is helpful to study this by first examining the data for a large city. Figure 7 summarizes the top 10 contributors in Rosario, ranked by total days active in the project. All of the contributors in this list have been active during at least two different years, and over half have been active during at least four consecutive years, with most of those years occurring in the more recent history of the project.

Top 10 contributors in Rosario, Argentina

User rank	Active days	Changesets here	Percent of user's changesets here	Active years here '07 '08 '09 '10 '11 '12 '13 '14
1	348	769	42.5%	○○○○○○●●
2	83	213	1.1%	○●●●●●●●
3	55	434	33.1%	○○○○●●○●
4	32	49	62.8%	○○○●●●●○
5	29	38	1.7%	●●●●●○○○
6	28	51	10.4%	○○○●●●●●
7	23	111	4.5%	○○○○●●●●
8	21	59	51.3%	○○●●●●●○
9	20	26	12.7%	●●●○○○●○
10	19	33	47.1%	○○●○●●○○

Figure 7. Activity levels of top 10 contributors in Rosario, Argentina (large city).

In contrast, the top contributors in the smaller cities have been active for fewer years, a natural result of them making fewer contributions overall. A key difference is that most contributors in a given small city have made only a very small percentage of their OSM changesets there, suggesting they do not have a primary interest in the place being mapped and may be less likely to have collected data on the ground there. For example, in Tacuarembó, only two top contributors have made over 10% of their OSM changesets in Tacuarembó (Figure 8), whereas in Rosario seven out of the top 10 contributors have made over 10% of their edits in Rosario. Similar patterns exist for the other small cities studied here. Thus, pride of place as a motive for editing OSM may have a better chance of being observed in larger cities, whereas smaller cities are primarily built by other motives such as pride of the map, in other words, the desire to ensure that high quality OSM coverage extends everywhere.

Top 10 contributors in Tacuarembó, Uruguay

User rank	Active days	Changesets here	Percent of user's changesets here	Active years here ('07 '08 '09 '10 '11 '12 '13 '14)
1	27	39	0.6%	○○○○○●●●
2	18	31	2.5%	○○●●●○○○
3	9	32	2.1%	○○○○○○●●
4	6	7	0.2%	○○○○●○○○
5	5	15	62.5%	○○○●●○○○
6	5	8	< 0.1%	○○○○●●●○
7	4	7	2.3%	○○○●●○○○
8	4	5	0.2%	○○○●○○○○
9	4	5	< 0.1%	○○○○●○○○
10	3	33	18.8%	○○○○○○○●

Figure 8. Activity levels of top 10 contributors in Tacuarembó, Uruguay (small city).

Scale of edits

Each OSM changeset is accompanied by metadata containing the rectangular bounding box of the encompassed edits. This box is defined by the minimum latitude, minimum longitude, maximum latitude, and maximum longitude of the edits. Mapping the changeset bounding boxes can show the scales at which editors typically approach their OSM edit sessions and, by extension, their regions of focus.

The analysis of bounding boxes in all six cities shows that the map is made by a mix of editors focused on different distinct scales focused around 1) the city itself, 2) the local region such as a state or province, or 3) the containing country. The map in Figure 9 of changeset bounding boxes for General Pico shows these patterns in action.[3] The city itself is surrounded by a dense number of bounding boxes as expected, which are just a small "pinpoint" in these maps. There are also many bounding boxes covering the Pampas region and the La Pampa province in central Argentina, to which General Pico belongs. Beyond that, there are relatively few bounding boxes until reaching the national boundary of Argentina itself. The numerous bounding boxes surrounding the country indicate that some contributors were brought to General Pico because of edits they were applying at a national scale. This systematic approach to OSM at the geopolitical unit level discounts affinity toward a particular town as a motive for the edits, and contradicts an imagination of VGI as a product of citizens sensing only their local domains.

[3] A very small number of intercontinental bounding boxes (such as those produced by global data imports) were ignored in this map, although I acknowledge the role of these types of edits in the map creation process.

The maps in Figure 9 are colored by language used in the changeset comments as determined by me. Envelopes commented with nothing or text where the language was indistinguishable (such as toponyms or tag names) are colored gray, whereas envelopes commented in English are blue and envelopes commented in Spanish are red (No other languages were observed in this city). The maps demonstrate that a notable contingent of the English speakers who made an edit in General Pico were passing through as part of a more systematic editing project at the country level scale or making a very localized update within the town. In contrast, the edits by Spanish speakers tend to be more varied, with many changesets covering the region around General Pico and its province of La Pampa. The changesets whose comments were blank or indistinguishable exhibit both patterns.

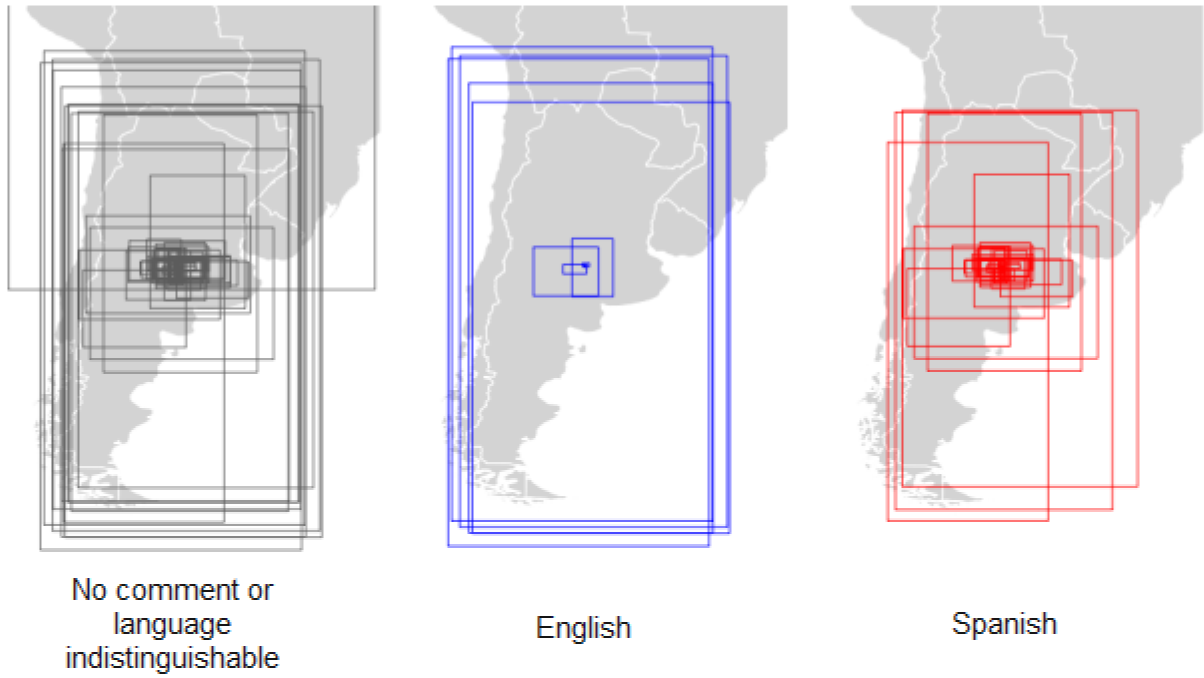

Figure 9. Changeset bounding boxes for General Pico, colored by language of the changeset comment.

Contributor motives and activities

Small cities provide a bounded and comprehensible subset of contributors that can be further studied to understand how OSM takes shape in a place. The fact that few of the these contributors seem unlikely to have performed local surveys in the areas they are mapping makes it easier to sort out the wide range of other contributor motives that feed into OSM construction beyond the basic desire to share local knowledge. By also analyzing the large city of Rosario, I found that these motives are not exclusive to small cities; however, they were easier to identify when working with the small and highly variable sets of contributors in small cities.

By analyzing the editor comments in these cities, I have developed a typology of roles played by contributors as they approach the OSM project. Although Steinmann et al. (2013) created useful "contribution profiles" to categorize OSM contributors based on the types of geometry and attribute data modified, there has not been an attempt to describe user activities based on actions and thought processes mentioned in the changeset comments. The closest has been Parr (2015) who factored changeset comment length into his activity-context-geography model of OSM contribution; however, Parr's model was applied to a massive dataset of all OSM contributions in the US and no qualitative analysis of the comment text was attempted. The analysis below is also unique in that it acknowledges that contributors could be assuming more than one role at a time when they make certain contributions.

The roles always involve mapping new features or fixing/enhancing existing ones. These mapping and fixing roles can be enacted in either a casual, a systematic, or an automated fashion. In combination with these mapping and fixing roles, I have identified some "special interest" motivations. These in particular have the potential to bring armchair mappers to reach beyond the major urban areas into small towns and cities. Table 3 shows the identified types of contributor roles, accompanied by changeset comments that are representative of each role. The comments were taken directly from the history of the five small cities in this study. A more detailed discussion of each role follows.

Role type	Role	Example changeset comments
Mapper roles	Casual mapper	• "Service station ACA El Bolson"* • "Added SnoMan trail"
	Systematic mapper	• "Stoplights in the downtown area of General Pico"* • "Adding/correcting maxspeed tags on interstates in Kansas. Some from personal knowledge, some from KDOT maps. Removed some that I know were wrong but insufficient resolution on map (like I70 in Topeka - will survey on next trip)"
	Automated mapper (Importer)	• "canvec import in western manitoba " • "adding airports from ourairports.com" • "Active Mines and Mineral Plants in US http://www.data.gov/details/13"
Fixer roles	Casual fixer	• " Fixed connectivity issue spotted thanks to www.maproulette.org • "The name is TaCuarembo, not TaGuarembo :)"
	Systematic fixer	• "Splitting ways"* • "Reclassifying highways with new criteria, UY."* • "hgv=* on high priority corridors"
	Automated fixer (Bot)	• " Removing surrounding whitespace and empty tags"
Special interest motivations (always enacted through mapper or fixer roles above)	Topophilic mapper	• "Fast food. Serves Hamburgers and Ice Cream. Kind of like Dairy Queen but can be more reasonable" • "My parents' house"*
	Paid mapper	• " fix unconnected roads (http://osmlab.github.io/to-fix/?error=unconnected_major1) "
	Feature-specific hobbyist	• "railway work in MB" • "power lines"
	Event or "crisis" mapper	• (Not observed in these towns, but documented elsewhere)

Table 3 . Roles describing OpenStreetMap contributor activities, with changeset comments representative of each. * indicates a translation from Spanish by the author.

Below I describe these roles in more detail, accompanied by some commentary about how they may appear in editor comments in small cities.

Casual mapper

Neis and Zipf (2012) showed that most OSM contributors only make one or a few edits during the duration of their involvement with the project. Sometimes these casual contributors are residents of small cities, mapping items from their town.

In other cases, a heavy OSM user has visited or passed through on vacation, business travel, and so forth. Such a contributor's influence on the town may be limited to a "casual" one or two changesets, which are still potentially of great value because they originate from a local survey.

Systematic mapper

In the study areas it is apparent that a few contributors have taken upon themselves the work of adding certain feature types in a systematic and comprehensive fashion across the entire city. These include street names, address ranges, stop lights, and other entities that make the map more useful for routing and other functions. In some cases, a single contributor was instrumental in initiating more than one of these projects in a given city.

Some degree of local knowledge or ground survey experience is helpful when addressing the project in this role, although some activities such as manual tracing of building footprints from remotely sensed imagery may be performed by "armchair mappers".

Contributors in the systematic mapper role tend to have high numbers of edits in the OSM project in general. They are what Steinmann et al (2013) called All-Rounders. Systematic mappers are also often heavily involved in the "fixer" roles described below.

Automated mapper ("Importer")

Provided there is buy-in from the local mapping community, OSM allows users to import geographic data whose license terms are compliant with the Open Database License. These imports sometimes cover scales as large as a country, and therefore wind up encompassing small cities. The US Census TIGER street data import is one such example that affected the city of Salina, Kansas in this study. Another import brought in a dataset of airports from around the world.

Imports can affect vast amounts of data in one transaction, therefore a contributor with a small number of changesets and days active can still have an enormous effect on the map for a long period of time. Because of the skill and community communication required, contributors who can act in the importer role are rare; however, their actions are highly visible.

Casual fixer

OSM editors assume the casual fixer role when they notice existing features that could use correction or enhancement some way, such as through adding or updating attributes or adjusting geometric topology. These actions could be spurred by noticing something that contradicts their own local knowledge when browsing the map in a place of interest. At other times, contributors familiar with the OSM project may notice aspects of data that contradict or fall short of the community-established attribute schemas.

Contributors can also receive suggestions of places to fix from third-party applications that randomly display features deemed as likely errors in the map. MapRoulette and MapDust are examples of such applications that could bring contributors to small cities and towns that they would not otherwise map. In some cases these applications are built by companies who have based their business models on OSM data and have an interest in high-quality coverage across the landscape. This business activity may therefore be driving an improvement of OSM quality in small towns.

Systematic fixer

Some OSM contributors focus on tidying up and improving existing metadata and geometry information instead of, or in addition to, mapping new features. McConchie (2013) calls these contributors "map gardeners", after the term "wiki gardener" used in Wikipedia contexts. They adjust nonstandard tags, re-align geometries, split up ways into routable segments, clean up imported data, etc. in a systematic fashion across geographies, influencing small cities as well as large ones.

The work of systematic fixers is critical for OSM's quality. OSM power users often play both the systematic mapper and systematic fixer roles.

Automated fixer (Bot)

The OSM community allows for automated programs (also known as "bots") that do data cleanup and maintenance activities in a manner more global and consistent than could be achieved by manual work. For example, a bot may remove trailing whitespace from tags, or adjust punctuation or spelling to meet certain conventions. Bots are often deployed on a global, continental, or country scale in OSM, and therefore their work is evident in small cities.

Topophilic mapper

The topophilic mapper is driven by expansive local knowledge and pride of place, resulting in participation across both mapping and fixing roles in either a casual or systematic fashion. In the small cities studied here, contributors fitting the topophilic mapper role are sometimes not native to the small city itself, but rather from the surrounding region. In these cases, they can still access the city for ground surveys and other rich data, and they may have more interest in the city than others simply because it has a greater chance of being part of their lives.

For example, using a ranking mechanism where contributors are sorted by days active in the city, changesets in the city, and percent of all OSM changesets in the city (see Figures 7 and 8 for examples), three of the same contributors appear in the top 10 list for Rosario, General Pico, and Tres Arroyos, Argentina. Similarly, in Salina, the top mapper is based out of urban Kansas, but not Salina itself, and in Tacuarembó, one of the most prolific contributors has made thousands of edits throughout Uruguay.

Paid mapper

In the past several years, some tech companies specializing in web mapping have begun relying heavily on OSM to provide contextual background data, routing, and other services. As these companies base their services and strategies on OSM, their incentive to see a high quality map grows, and they are willing to invest in paying employees to fix errors and build out geographies needed by clients (Barth 2015). The same has occurred with governments wanting to use OSM for basemaps while ensuring that the data meets a particular standard of accuracy and overall quality (see McHugh (2014) as an example). This paid mapping work can affect small cities where errors or holes may have persisted in the data. Paid mapping is likely to be systematic in nature, whether it involves mapping new features or fixing existing ones.

In the cities studied here, several edits made by a mapping corporation's data quality team were found. Their edits focused on fixing unconnected roads, a feature needed for cross country navigation and logistics applications, whether in the routing engine itself or in the base map. Ultimately we cannot be certain of the purpose of these particular efforts, but they were easily detected because mappers hired by this particular corporation clearly identify themselves and their employers via OSM profile pages. Other paid mapping efforts may not be so readily noticed, depending on the transparency policy of the employer and the nature of the work (whether the OSM editing is full time or just a small part of a broader job).

Feature-specific hobbyist

One of the motives for nonlocal users to edit OSM is a desire to map certain types of entities that are closely related to personal hobbies or interests. These can include railroads, power lines, bicycle trails, places of worship, and so forth. Many contributors identify in their user profiles that they tend to specialize in one or more of these types of features.

The desire to add hobby-related features across a particular geography, such as a country, can bring OSM users to new places and cause them to contribute to the map construction within small cities and towns. For most hobbyists, it is not so much interest in the place nor interest in the map that drives the work, but rather interest in the mapped entity itself. A substantial proportion of OSM entities in small cities appear to be contributed because of hobbyists virtually "passing through" the map as they expand coverage of their hobby interest through imagery tracing or imports. At other times, the hobby work is more casual and occurs because a hobbyist physically visited the area for some reason.

Event mapper

Although not detected in any of the small towns studied here, it is well documented that the desire to help with humanitarian or "crisis" mapping has brought many OSM editors to work on the map in places they have never visited (Zook et al. 2010, Peylen et al. 2015). Such efforts were instrumental in creating maps for aid personnel following the 2010 Haiti earthquake, Typhoon Yolanda in the Philippines in 2013, and the 2014 Ebola outbreak in West Africa. The resulting mapping work affects small cities as well as large ones, and in some cases heavy mapping occurs in places that saw little or no attention previously. This mapping is systematic in nature, but can be limited in depth if nobody is available to supplement remotely traced data with local knowledge.

Conclusions

Viewing the history of OSM in any given place reveals a chance conglomeration of individuals with all kinds of motives and interests, including feature-specific hobby work, local surveying, and map quality assurance. Studying small towns and cities provides bounded study sets of contributors, whose sparse numbers of systematic local mappers actually make it easier to identify the other types of contributor personas involved in the project. Some contributors are driven by pride of place, some by pride of the map, and some by pride of a certain type of feature related to personal hobbies. Just as small cities often spring up around junctions of long-distance highways and thoroughfares, the digital maps of small cities in OSM represent a crossroads of virtual mappers passing through for their own unique reasons. These myriad influences behind OSM reveal that VGI cannot always be conceptualized as the product of altruistic citizen sensors who are sharing personally-collected tidbits of spatial knowledge.

In each of the small towns studied, the "crowdsourced" data of OSM was actually created by several dozen individuals, only a few of whom were active in the project on a consistent basis. The amount of work performed by each contributor varies greatly, and can be better conceptualized by mapping each contributor's work side-by-side and studying the number of days and changesets contributed to the project. Some of the top mappers in any given city may actually do most of their work in other places in OSM. Regional contributors who have some local knowledge and access to the place on the ground can play a great role in building the map in small cities.

Different visualization approaches can help with distinguishing casual vs. systematic vs. automated contributions. For example the small multiple maps in Figure 3 exhibit great "blobs" of data for users who have employed systematic or automated contribution strategies. Likewise, the changeset extent boundary maps in Figure 9 indicate where systematic and automated contributions have been employed at different geographic scales. Introducing interactivity in the visualization strategies may offer greater potential for understanding OSM contributor characteristics and editing habits. This will be explored in an upcoming publication.

In comparison with larger cities, OSM in small cities appears to be struggling with attracting and retaining new users. Increasing the number of topophilic mappers seems to be in the best interest of data quality and comprehensiveness in OSM's small cities. Recruitment through secondary or vocational schools may be a promising channel for finding new active mappers in places where there are no large universities or communities of technical professionals. Also, urban areas with active local OSM groups can reach out to hold mapping parties in nearby small towns and cities, thus diffusing the knowledge of OSM throughout a region.

In order to examine a few places in depth, the present research is limited to a strategically selected handful of cities. In further research, it would be worthwhile to make a comparison with cities in countries like Germany or the UK where OSM has reached a greater level of maturity than in the Americas. Also, studies of suburban or peri-urban areas in OSM might reveal the geographic limits of OSM influence emanating from large cities with active mapping communities.

Organizations considering using OSM data should be aware that the data may greatly decrease in quantity and quality when moving outside major cities due to the general lack of attention and scrutiny paid to the map. Improving OSM in small cities is in the best interest of companies who are leaning their business models on OSM-based routing and logistics services; governments who are using OSM as a basemap for their services; applications that must provide global, national, or state-level map coverage; and humanitarian agencies that supply maps for crisis response in rural areas.

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