Measuring the space between buildings through OpenStreetMap data

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Summary

OpenStreetMap is a valuable, widely used data source for transport and geographic analysis, owing partly to its global coverage and permissive license. Micro-mobility, electrification and automation transport trends are motivating the production of increasingly high-resolution maps of urban streetspace. Simultaneously, sustainable transport within urban areas is motivating increased prioritisation of placemaking, impacting streetspace allocation. Extracting OSM data from 117 worldwide cities and comparing to alternative data sources we highlight how the OSM data model could be used to support the collection and analysis of streetspace data. Furthermore, we discuss the implicit assumptions of streetspace use encoded by particular streetspace data representations.

KEYWORDS: Streetspace Allocation, Pedestrian footways, OpenSteetMap

1. Introduction

Key themes of liveability, healthy streets and placemaking highlight the transition to urban streets being seen as a 'whole' rather than only facilitating movement. There is an increased need to understand public space design and features of the urban realm including pavements, barriers, and street furniture, all of which are encompassed in the space 'between' buildings (Gehl, 1987). Furthermore, emerging transport innovations and new forms of urban mobility are increasing the demand for diverse high-resolution geographic information.

The introduction of single rider vehicles (micromobility) and increased transport network connectivity through mobility-as-a-services (MaaS) platforms exemplify such innovations. The resulting diversified use of streetspace creates competing demands, motivating the need to measure streetspace. Similarly, MaaS services are enhanced by the availability of detailed access and egress location data, which may reference the space assigned to micromobility services. In addition, the sustainable mobility paradigm (Banister, 2008) also creates demand for spatial information through emphasising the links between landuse and transport planning. For example, the link and place function categorisation of urban roads highlights the role of roads as places in themselves (Jones et al, 2007). Under this paradigm there is a need to consider the (quality of) space afforded to non-travel activities within transport planning frameworks. Whilst a road can be represented by a link i.e. a one-dimensional road centre line, understanding a 'place' and effective quantitative/ qualitative assessments requires capturing activities across a two-dimensional or three-dimensional space which needs more detailed spatial information. Examples include the Healthy Streets framework (Transport for London, 2017) and the Pedestrian Environment Review System (PERS) Street Auditing Tool

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(Davies and Clark, 2009).

Research on OSM has identified the dominance of corporate mappers contributing to the improvement of global road mapping to improve vehicle routing. Road mapping has been identified as the 'map seeder' driving the generation of new street data (Anderson et al, 2019). The 'seed' in this case are Road Centre Line (RCL) geometries which approximate the trajectory of vehicles along the carriageway. This representation can be enhanced through the contribution of additional metadata and geometries which better describe the movements of other road users.

OSM's suggested convention for representing pedestrian routes is by contributing 'Footway' geometries, line segments which record the Pavement Centre Line (PCL). PCL's indicate the presence of pedestrian infrastructure and can allow for further details to be contributed including road widths and street space allocation. Such detailed information is directly relevant to the demands of sustainable transport planning discussed above. As the analysis of streets 'as a whole' increases, PCL's may act as a seed, similarly to RCL, for recording of additional features relevant to pedestrian movement.

This paper makes an initial assessment of the availability in OSM of pedestrian infrastructure data using a sample of 117 cities worldwide. A comparison between conventions for recording this data is made and trends are compared geographically and examined in the context of cities' mobility characteristics.

2. Methodology

We compare the availability of OSM data detailing the location of pedestrian sidewalk infrastructure across a sample of 117 cities in Africa, Australia, Brazil, Canada, China, Europe, New Zealand, and the United States.

OSM features are assigned tags, key-value pairs of metadata that indicate what real-world object the feature represents. The "highway" tag is assigned to line features to indicate that they represent any intentional route that connects one place with another. Two dominant conventions are used to indicate the presence of sidewalk infrastructure. Firstly, "highways" can be assigned the *["sidewalk"= "both|left|right|no"]* keyword tags. This convention does not provide any spatial information regarding the location of sidewalks, only their presence or absence on one or both sides of the road. Secondly, line segments which record the Pavement Centre Line (PCL) can be added to the map. These are referred to as "footways" in the OSM data model and are assigned the tags *["highway"="footway"]* or *["footway"="sidewalk"].*

Using the OSMNx python package (Boeing, G. 2017) we query OSM for all highway geometries with "sidewalk" tags and all footway geometries that lie within the administrative boundaries of the 117 cities sampled. We also download the walking network for each city, following the definition used in OSMNx (**Table 1**).

Table 1 Features included in the walking network are required to satisfy all these tag filters

Tags
["highway"]["area"!~"yes"]
["highway"!~"abandoned|bus_guideway|construction|cycleway|motor|planned|platform|proposed|raceway"]
["foot"!~"no"]
["service"!~"private"]

We calculate the total length of footway geometries and the total length of highway geometries with sidewalk tags (geometries tagged as having sidewalks on both sides of the road are counted twice). This gives two measures of the amount of sidewalk location data in each city. To make comparisons between cities we divide these lengths by twice the total length of the walking network in each city (accounting for the possibility of a sidewalk on both sides of the road). We interpret this ratio as a measure of the coverage of sidewalk location data. High coverage ratio values indicate greater equivalence between the availability of walking route data and sidewalk location data.

3. Results

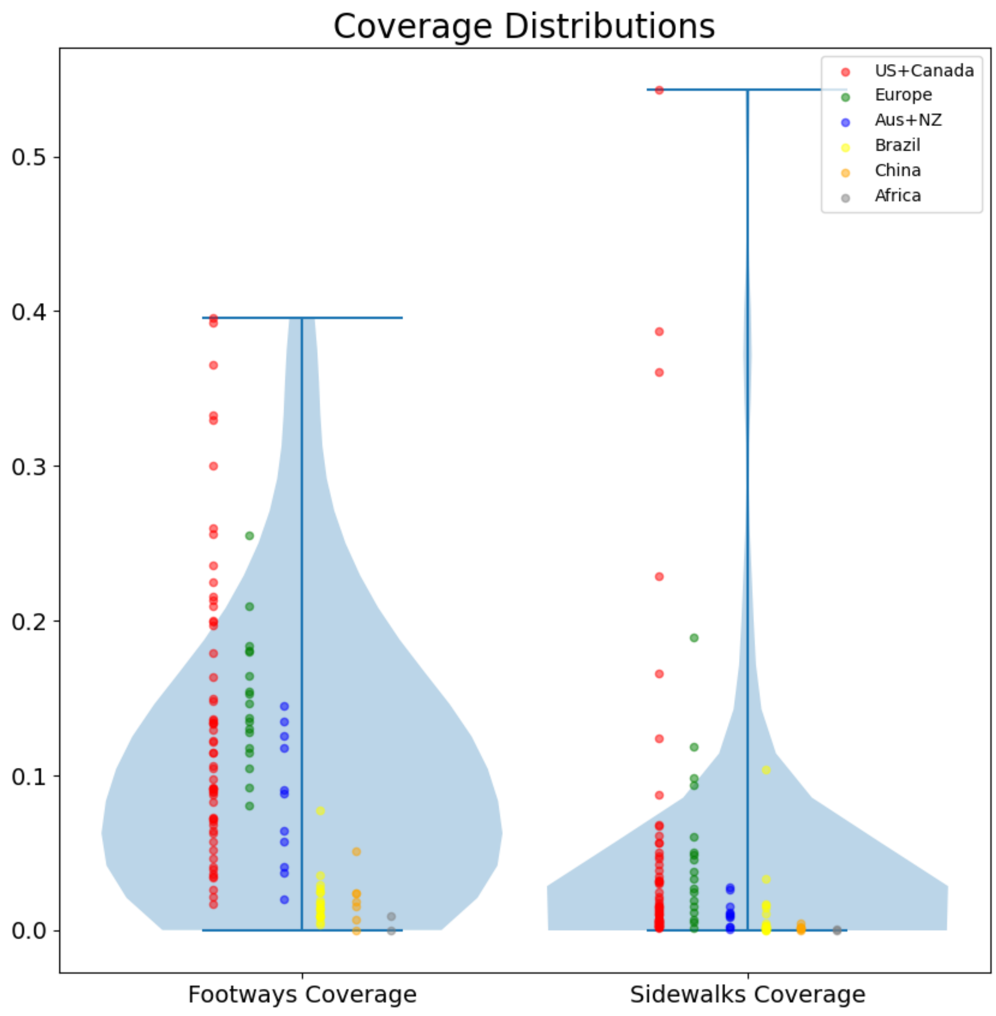

Figure 1 Distribution of footway and sidewalk coverage data. Kernel Density Estimation is shown in blue. Individual city values are plotted and coloured by world region.

Figure 1 shows that the coverage of footways tends to be greater than the coverage of highways with sidewalk tags. There is large variation in coverage of footways between and within world regions. The United States and Canada region has the largest representation of cities in the sample and displays the widest range of coverage values.

Table 2: The median footway coverage for cities in each of the 6 regions.

Region	N	Median Footways Coverage	Median Sidewalks Coverage
US+Canada	59	0.115	0.010
Europe	18	0.142	0.031
Australia+NZ	11	0.088	0.009

Brazil	20	0.015	0.003
China	7	0.019	0.001
Africa	2	0.005	0.000

We find that cities in the US+Canada region cannot be distinguished from cities in the Europe and Australia+NZ regions on the basis of footway coverage (Mann-Whitney U rank test, $p<0.05$ threshold). We find that European cities can be distinguished from all other regions apart from US+Canada.

The Pearson correlation coefficients between footway coverage and the per capita jobs accessibility by different transport modes in the same set of cities taken from (Wu *et al* 2021) are shown in **Table 3**.

Table 3: Correlation between footway coverage and number of jobs per capita accessibility in 30 minutes by different modes of transport.

Auto	Walking	Transit	Cycling
-0.025	0.069	0.000	0.084

4. Discussion

The different patterns observed in the sampled cities show that there is the potential of serving pedestrian routing purposes that amplify sustainable mobility choices other than the most densely mapped driving choices (Anderson et al, 2019). While the coverage of OSM sidewalk location data is insufficient to conduct a detailed analysis of street space in the vast majority of cities in our sample, we found evidence that suggests that in time not only the coverage of these geometries could increase but also may be related to the cities' dominant transport modal share or the presence of more active mapping communities.

A persistent issue with the use of OSM data is distinguishing between absent data and the real absence of physical objects. While maps are never finished, the quantitative approach proposed here can help identify mapping emphasis and trends that often reflect the values and priorities of their creators (Kitchin and Dodge, 2007), which in this case may lead to a better understanding of the street built environment.

5. Conclusion

Detailed spatial information regarding urban streets is becoming an increasingly important resource as a result of related sustainable mobility trends: micromobility, electrification, automation and placemaking. To investigate the availability of such data in OSM, a global, freely accessible map, we downloaded geometries indicating the presence or location of pedestrian sidewalks for a sample of 117 cities across the world. We find that coverage of this detailed street level information in each city is significantly lower than coverage of the walking network itself, reaching 40% of the length in the highest case (excluding one outlier). However, differences between regions are significant, with generally higher coverage of footway geometries across the United States, Canada and Europe compared to other world regions.

As it has been observed on previous OSM research on roads, the presence of data that describes the space of the street in greater detail may be looked as a positive sign to inform sustainable transport research beyond the car-dominant data availability, and even go further on as 'map seeding' for the growth of street data that leads to understanding streets holistically not only as links but also as places.

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Biographies

All contributing authors should include a biography of no more than 50 words each outlining their career stage and research interests.

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