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Research Article

Density and diversity of OpenStreetMap road networks in China

Yingjia Zhang[a], Xueming Li[a,*], Aiming Wang[b], Tongliga Bao[a], Shenzhen Tian[a]

[a]*School of Urban and Environmental Sciences, Liaoning Normal University, Dalian 116029, China*

[b]*Department of Educational Psychology, Miami University, Oxford, OH 45056, USA*

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Abstract

OpenStreetMap is a geographic information platform designed to provide real-time updates and user-generated content related to its freely available global map, and it is one of the most widely used examples of volunteered geographic information, a technique associated with so-called neogeography. This paper, based on the data from China's OpenStreetMap road network in May 2014, taking 340 prefecture-level cities in China as its study area, presents the geometric-related (road density) and attribute-related (type diversity) spatial patterns of the OpenStreetMap road network, and explores their relationship. The results are as follows. (1) The distribution of OpenStreetMap road density in Shenzhen, Shanghai, Hong Kong, and Macao predominantly obeys a "positive skewness distribution". OpenStreetMap data for eastern China shows a higher overall and circular structure. In central China, there are noticeable discrepancies in the road density, whereas in western China, the road density is low. (2) The OpenStreetMap road diversity shows a normal distribution. The spatial pattern for the so-called "Hu Huanyong line" was broken by the effect of diplomatic and strategic factors, showing a high diversity along the peripheral border, coastal cities, and core inland cites. (3) China's OpenStreetMap is partitioned into four parts according to road density and diversity: high density and high diversity; low density and low diversity; high density and low diversity; and low density high diversity. (4) The OpenStreetMap geographical information-collection process and mechanism were analyzed, demonstrating that the road density reflects the preponderance of traffic in the real world. OpenStreetMap road diversity reflects the road-related geographic information demand and value, and it also reflects the interests of users toward to OpenStreetMap geographical information.

Keywords: OpenStreetMap; Road density; Road diversity; VGI; Spatial pattern; China

1. Introduction

OpenStreetMap (OSM), founded in 2004, has grown from a local project into a worldwide map with widespread use and high-quality data. Since 2012, OSM has been embedded into Apple's iPhone, and it has provided services for Flickr, Foursquare, MapQuest, Wikipedia, Microsoft, etc. Currently, OSM is a strong competitor to Google Maps. OSM, through users' online cooperation, uses a handheld GPS terminal, high-resolution remote-sensing

*Corresponding author.

E-mail addresses: zyj575657@163.com (Y. Zhang), lixueming999@163.com (X. Li), wanga@miamioh.edu (A. Wang), tongliga113@126.com (T. Bao), shenzhen890038@163.com (S. Tian).

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images, and individual spatial cognitive knowledge as a basic geographic reference to create, edit, manage, and maintain geographical information. It is freely available to all users online around the world. Like Wikimapia and Flickr, OSM is the representative example of user-generated content (Haklay & Weber, 2008), and it is the Internet media platform authorized for ordinary user-generated global geographical information based on Web 2.0 network technology (Elwood, 2008). This platform works with user content known as volunteered geographic information (VGI), developed in 2007 by Goodchild (Goodchild, 2007). Compared with traditional geographic information, OSM exemplifies a new era of geographic data with the following characteristics: (1) The diversification of OSM data acquisition includes cartography by amateurs and volunteers, professionals of geographic information systems, and staff at national surveying and mapping agencies. Such users are not only information suppliers, but also disseminators and consumers (Goodchild, 2009). (2) Transparency and openness of data editing, copying, distributing, and transfering. As such, everyone can use the OSM geography information provided that they indicate the OSM copyright and acknowledge the contributor's work. However, traditional road data is protected with a security protocol or data encryption. (3) OSM is digitizing geographic information that is updated online in real-time. Nevertheless, traditional static road data has a fixed format, and it is updated at regular intervals. (4) OSM road data is collected in several ways, giving importance to user participation and creativity in order to enhance its multiple applications and increase its popularity as a public service.

After an evaluation of London's OSM information, Haklay concludes that OSM data is relatively accurate (Haklay, 2010). Girres and Touya (2010) evaluated a larger set of spatial data in France, showing that the advantage of OSM lies in its responsiveness and flexibility. Through the evaluation of OSM data, researchers have consistently held a positive attitude to OSM, considering it a representative of massive VGI data and marking a new age of geographic information (Goodchild, 2009; Haklay et al., 2008; Jacob et al., 2009; Li & Shao, 2009). OSM's road-related geographic information is often a central feature in research (Chen, Sun, & Vodacek, 2014; Estima & Painho, 2013; Fritz et al., 2009; Graham, 2015; Hagenauer & Helbich, 2012; Li, Fan, Luan, Yang, & Liu, 2014; Mooney & Corcoran, 2012; Neis, Goetz, & Zipf, 2012; Over, Schilling, Neubauer, & Zipf, 2010). Such research proceeds from a number of perspectives. First, research has been conducted to evaluate the quality of OSM road information. Haklay et al. (2010) applied a separate buffer analysis for each road category. The results indicated that the positional accuracy for OSM exceeded 80%, and that primary roads were better mapped. Zielstra and Hochmair (2012) compared pedestrian datasets for OSM, TIGER/Line, and other proprietary datasets in Miami, San Francisco, Berlin, and Munich, and found that OSM can provide relatively comprehensive data with increased user options. Second, researchers have explored the quality and quantity of contributors to OSM. Haklay et al. (2010) also verified that Linus' Law applies to OSM, and demonstrated that the relationship between the number of contributors and the quality of the data is not linear. An empirical study of western Kenya by De Leeuw et al. (2011) discovered that when volunteers, with local knowledge, classified roads, they were over 92% accurate on average. This is much more accurate than the results from professional surveyors without local knowledge. Third, research on OSM's road information has analyzed the status and evolution of the OSM road dataset. Neis, Zielstra, and Zipf (2011) sorted the evolution of Germany's OSM road network from 2007 to 2011. Other scholars in England, France, Iraq, and the USA have conducted research on OSM road status and evolution, generally showing a heterogeneous pattern, with stronger road-network concentrations in urban areas compared with rural areas (Neis & Zielstra, 2014). Finally, the application of OSM road data has been studied. OSM road data facilitate smart road search and navigation; for example, by using OSM geodata, the location of an ambulance can be evaluated and relocation models can be established to ensure optimum coverage of emergency medical services (Azizan et al., 2012). OSM outdoor pavement and indoor corridor information can be used to customize road navigation for international conferences and support multi-lingual guidance (Jacob, Zheng, & Ciepłuch, 2011). Amirian, Basiri, Gales, Winstanley, and McDonald (2015) pointed out that the use of OSM data can facilitate in establishing next generation navigational services by the integration of augmented reality and graph databases through standard textual and cartographic interfaces, and augmented images. The most famous model of the application of OSM data for urban management is the humanitarian aid provided in the 2010 Haiti earthquake; this was done to map roads and refugee camps in a short duration for government agencies, NGOs, and rescue teams to facilitate them to save lives (Coast, 2011). In addition, OSM is now being used for urban planning, urban modeling, sustainability, and environmental modeling (Mooney, 2015). Jia and Jiang (2010) used OSM street-node data to measure urban sprawl and define urban boundaries. By using OSM data related to road infrastructure and buildings, Over et al. (2010) investigated the prospects for generating data that can be used for establishing interactive 3D city models. Using OSM data, Gil (2015) built a