Chapter 6
Towards Place-Based GIS

Song Gao

Abstract The space-place dichotomy has long been discussed in human geography, digital humanity, and more recently in cartography and geographic information science. Place-based GIS are not yet well developed, although there is an increasing interest in semantic and ontological approaches. In this chapter, I present the technological building blocks towards the implementation of an operational place-based GIS that requires the input of platial data from crowdsourced data streams, the understanding of place characteristics and associated human activities and cognition, the support of representation and computational models of place, and the development of platial analysis and visualization. Based on the literature review, I found that the platial analysis functionalities with regard to their spatial counterparts were not sufficiently implemented yet. Therefore, more researches are needed into the development of platial operators for place-based GIS.

Keywords Place · Place-based GIS · Platial analysis

6.1 Introduction

The space-place dichotomy has long been discussed in human geography, digital humanity, and more recently in cartography and geographic information science (GIScience) (Couclelis, 1992; Goodchild, 2011; Janowicz, 2009; Jones et al., 2008; MacEachren, 2017; Merschdorf & Blaschke, 2018; Pezanowski et al., 2018; Purves et al., 2019; Tang & Painho, 2021; Tuan, 1977; Winter et al., 2009). Place names are usually mentioned in human conversations while locations with underlying coordinate information (latitude and longitude) are used in digital navigation systems to answer the "where" questions. In the past decades' development of geographic information systems (GIS) and spatial analysis methods, there exist rich studies about the role of space but only a few about the role of place due to the challenges on conceptualization, digital representations, computational modeling and analysis

S. Gao (✉)
Geospatial Data Science Lab, Department of Geography, University of Wisconsin-Madison, Madison, USA
e-mail: song.gao@wisc.edu

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of place in GIS. The typical spatial perspective in GIS is based on geometric reference systems that include coordinates, objects/fields, distances, and directions; while the alternative place-based perspective is characterized by place descriptions and semantic relationships extracted from human discourses, experiences, and activities (Gao et al., 2013; Goodchild, 2011; Westerholt et al., 2020; Winter & Freksa, 2012). The concepts of place (e.g., neighborhoods, vague cognitive regions, and sense of place) are complex and difficult to handle in GIS. One gap lies between the vagueness and richness of place in the human mind and the formalization need for place-based representations and analytical operations in place-based GIS (or platial information systems). Therefore, one of the main goals of place-based GIS research is to integrate the concepts and characteristics of place into platial (or placial) data, operational and analytical standards in GIS (Purves et al., 2019; Tang & Painho, 2021). There have been recent discussions and reviews on the advancements towards place-based GIS. For example, Merschdorf and Blaschke (2018) discussed the role of place in various research branches of GIScience including critical GIS, participatory GIS, crowdsourced geographic information, semantics, and ontologies, etc. Giordano and Cole (2018) argued for a place-based GIS that can integrate quantitative spatial analysis and qualitative methods and data such as social networks and textual corpus. Purves et al. (2019) reviewed the key challenges in representation and modeling of place for information science. Westerholt et al. (2020) organized a special issue on place-based GIS in the journal of *Transactions in GIS* and argued the need for representational models, analytical approaches, and visualization methods for place in GIScience. Tang and Painho (2021) conducted a comprehensive literature review and bibliographic analysis on the topic of place-based research in GIScience. There should also be humans in the loop for place-based GIS. For example, Scheider and Janowicz (2014) showed how place references can be identified and localized by involving participants. Blaschke et al. (2018) addressed the importance of human language and culture differences reflected in place-based GIS. Shaw and Sui (2020) proposed a smart space-place (splatial) framework to synthesize multidimensional information of space and place to study human dynamics. Although the existence of intensive conceptual reviews, few studies have addressed the key technological issues for the development of an operational system for place-based GIS.

To this end, in this chapter, I focus on the discussion of technological building blocks towards the development and implementation of place-based GIS from a systematic perspective.

6.2 Building Blocks Towards Place-Based GIS

As shown in Fig. 6.1, the key technological building blocks for an operational place-based GIS mainly include the input data about various characteristics of place, the representation, and computational models of place, and platial analysis and visualization functionalities.

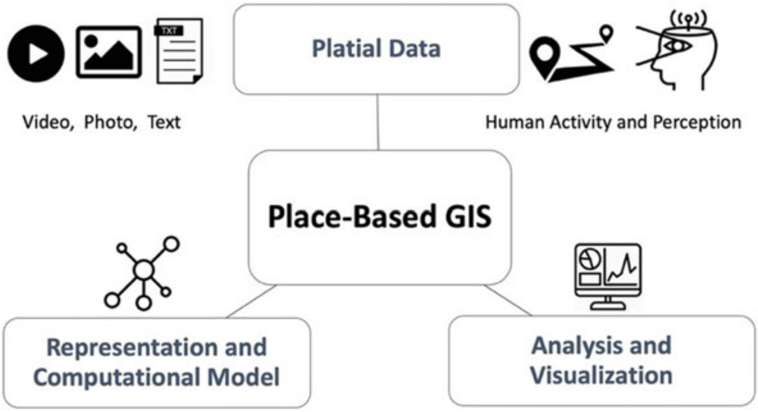

Fig. 6.1 Key building blocks for operational place-based GIS

6.2.1 Platial Data and Characteristics

Place can serve as a function between location and people (Mennis & Mason, 2016), a function of location, activity, and time (McKenzie & Adams, 2017), and a function of social relations (Giordano & Cole, 2018). Traditionally, data about places were collected through mapping agency (e.g., *gazetteer* usually includes place names and related entities) and survey-based narratives. The emergence of geospatial big data brings new opportunities to extract fine spatiotemporal resolution of human-place interaction data and understand the place semantics from large-scale volunteered geographic information and crowdsourced data streams, such as social media posts (including texts, photos, and videos), GPS trajectories, location-based social networks, comments and reviews on points of interest (POIs) or neighborhoods, and other Web documents (Gao et al., 2014, 2017; Hu et al., 2019; Kruse et al., 2021; McKenzie et al., 2015; Zhang et al., 2020). Those multiple data sources and advanced (geospatial) data science and machine learning methods provide a great opportunity to understand and extract the characteristics of place as well as associated human activities, experiences, emotions, and movements in different contexts.

6.2.2 Representation and Computational Models of Place

In order to effectively process, manage, analyze, and visualize the platial data, different approaches have been proposed for formalization, representation, and modeling of place in GIScience. Some key questions to ask include: What is a place? What are the core attributes and methods for a class of "place" in object-oriented programming and system design? Gao et al. (2017) represented a place as a field-object in which the degree of a location belongs to uses a membership function (e.g., Southern/Northern California) and demonstrated that place representations (thematic and culture aspects) might be relaxed in human cognition compared to the metric representation in GIS. Purves et al. (2019) demonstrated the linkage between the ontology of spatial information and the social and cognitive aspects of place and argued that places should include both names and geometries as well as relations. Hierarchical relationship is common to both physical systems and to human cognition (Golledge, 2002), e.g., river networks and administrative divisions. The hierarchical and other semantic relationships between places stored in the information systems support human cognition of places and their affordance in the real world. Recently, user-generated content has been used in extracting place characteristics and representations. For example, Wu et al. (2019) proposed a fuzzy formal concept analysis-based approach to uncovering spatial hierarchies among vague places (local toponym) extracted from social media data.

Digital gazetteers (i.e., dictionary of places) usually contain three core elements of geographic features: place names, place types, and spatial footprints (Hill, 2009). Place names are often used in human conversations and link to entities in gazetteers. A place may have more than one feature type based on different levels of categorization or using different schemata. The footprint of a place may be simply represented as a point in the information systems. However, it is challenging to select such a point for different types of places. The geometric center may not always be the best representative point. For example, one would not use the geometric center for a national park but use the entry points along the road networks. In addition, places may also be represented as areal objects (fields or polygons). Some places such as "downtown" are valuable in nature. Fuzzy-set-based methods and kernel density-based representations are usually used to model the intermediate boundaries of vague places (Burrough & Frank, 1996; Jones et al., 2008). Based on the assumption that a vague object can be viewed as the conceptualization of a field, a categorization framework including five distinct categories to formalize the semantic differences between vague objects using the fuzzy set theory is proposed by Liu et al. (2019), which can be used to model vague places.

Places can be modeled using graphs where nodes represent place entries and edges represent semantic relationships among places (e.g., part-of, directions, nearby). Patterns and relations between places can be computed and extracted from place graphs. For example, Chen et al., (2018a, 2018b) proposed a computation procedure to georeference textual place descriptions to gazetteer entries based on string and semantic similarities and qualitative spatial relationships using place graphs and natural language processing techniques. Zhu et al. (2020) analyzed place characteristics in geographic contexts through graph-based convolutional neural networks. Mai et al. (2019) proposed to represent places as Linked Data and demonstrated how to utilize Semantic Web reasoning and ontologies to extract and represent additional properties of places. A Linked Data connector was also developed as a set of ArcGIS's toolboxes to enable the retrieval, integration, and analysis of Linked Data from Web resources within GIS (Mai et al., 2019). In addition to the structured Linked Data, future developments of place-based GIS need to further integrate un-structured data about subjective human narratives about their experiences on places and dynamic relations among places over time.

6.2.3 Platial Analysis and Visualization

The spatial analysis and statistical functions are key capabilities of current GIS and based on the concepts of space, location, distance, and direction. Regarding the characteristics of place, what are the equivalent platial operation functionalities for their spatial counterparts? Gao et al. (2013) designed two platial analysis functions using semantics, namely *platial join* and *platial buffer*. Analogous to spatial join, the purpose of platial join is to attach the properties from the join entities to the target place using semantics (e.g., part-whole relation, qualitative spatial relations) rather than geometric constructs (e.g., geographic distance). The platial buffer might be able to mitigate the uncertainty issue of using spatial joins when objects are closed to border regions (Gao et al., 2013). In addition, platial buffer is to infer places or derive place-based knowledge through the connectivity, hierarchical relations, or other semantic relations between places. For example, using the semantic predicts between subway lines and shared transit stations as well as the station-to-station connectivity information, one can automatically generate a platial configuration on the subway system without accurate geometric information of the subway lines. The fundamental principles of platial operations rely on semantic relations between places rather than geometry. However, the operators for places in GIS are not sufficiently implemented yet. More researches are needed into the development of functionalities for place-based GIS. Some of the research directions may include platial associations, platial focal/zonal/global analyses on place graphs.

Recent advancements in geospatial artificial intelligence (GeoAI) and geospatial data science provide new opportunities for place-based analysis (Janowicz et al., 2020). For example, A quantitative measurement framework for place locale was developed using urban scene elements obtained from street-level images using a deep learning model (Zhang et al., 2018). A data-driven approach was proposed to uncover the inconspicuous-nice places in cities using street view images and social media check-in records combined with deep convolutional neural networks (Zhang et al., 2020). Using AI-powered facial expression detection techniques, a computational framework for extracting human emotions from over 6 million georeferenced photos at different places was proposed to enrich the understanding of sense of place (Kang et al., 2019).

Geospatial semantic queries and visualizations are also important functions in place-based GIS. Yan et al. (2017) proposed a novel approach to reasoning about place type similarity and relatedness by learning embeddings of places from augmented spatial contexts. Papadakis et al. (2020) developed a rule-based framework to support functional queries of a place (e.g., shopping areas). Hu et al. (2015) constructed thematic and geographic matching features from the textual descriptions of places and implemented semantic search for linked-data-driven geoportals on ArcGIS Online using geospatial and semantic expansion operators. As for visualization, MacEachren (2017) addressed the importance of leveraging geospatial big data with visual analytics to understand places and their inter-connectedness. A geovisual analytics framework *SensePlace3* for place–time–attribute information is proposed and implemented by Pezanowski et al. (2018). Moreover, graph visualization and interactive visual analytics techniques would be useful for place-based knowledge discovery and supporting human decision making.

6.3 Conclusion

In this chapter, I discussed the notion of place in GIScience and presented the technological building blocks towards the development and implementation of an operational place-based GIS, which requires the input of platial data, the understanding of its characteristics, the support of representation and computational models of place, and platial analysis and visualization. Joint efforts from multiple disciplines such as human geography, computer science, cartography and GIScience can facilitate the design and development process towards future place-based GIS.

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