# Towards the Statistical Analysis and Visualization of Places

**René Westerholt**
Heidelberg University, Institute of Geography, Heidelberg, Germany
westerholt@uni-heidelberg.de

**Mathias Gröbe**
TU Dresden, Institute for Cartography, Dresden, Germany
mathias.groebe@tu-dresden.de

**Alexander Zipf**
Heidelberg University, Institute of Geography, Heidelberg, Germany
zipf@uni-heidelberg.de

**Dirk Burghardt**
TU Dresden, Institute for Cartography, Dresden, Germany
dirk.burghardt@tu-dresden.de

**Abstract**

The concept of *place* recently gains momentum in GIScience. In some fields like human geography, spatial cognition or information theory, this topic already has a longer scholarly tradition. This is however not yet completely the case with statistical spatial analysis and cartography. Despite that, taking full advantage of the plethora of user-generated information that we have available these days requires mature place-based statistical and visualization concepts. This paper contributes to these developments: We integrate existing place definitions into an understanding of places as a system of interlinked, constituent characteristics. Based on this, challenges and first promising conceptual ideas are discussed from statistical and visualization viewpoints.

**2012 ACM Subject Classification** Information systems → Geographic information systems, Theory of computation → Probabilistic computation, Applied computing → Cartography

**Keywords and phrases** Platial Analysis, Visualization, Statistics, Geosocial Media

**Digital Object Identifier** 10.4230/LIPIcs.GIScience.2018.63

**Category** Short Paper

**Funding** This work was generously supported by the German Research Foundation (DFG) through the priority programme 'Volunteered Geographic Information: Interpretation, Visualisation and Social Computing' (SPP 1894).

## 1 Introduction

People utilize place for the mental representation of geographic phenomena, to verbalize locations in colloquial conversations, and to orientate themselves geographically [25, 28, 23]. A place may thereby refer to either material or immaterial entities [19] and, most generally, describes a location together with a set of attached meanings [5]. While place has been of recurring importance (e.g., place was crucial to Aristotle, to German geographers of the late 19th century, and to human geographers since the 1970s [5]), the concept has only

recently gained greater attention in GIScience. For instance, platial[1] approaches are still uncommon in spatial analysis and geovisualization. Due to its importance, Mike Goodchild has anticipated a place-based account of geographical information systems (GIS) enabling us to benefit from the latest wealth of subjective user-generated (and thus largely platial) geographical information [13, 12]. This paper contributes to these developments by dicussing conceptual platial statistical and visualization challenges.

## 2 Places as systems of interlinked characteristics

Places are versatile and have been treated differently: as named domains occurring in human discourse [13], sets of realized or unrealized affordances [23, 19], functional relationships between humans and locations [20], or as references to events and entities [28]. What all these definitions have in common is the concept of places as locations with meaning [25], including a locale (the material setting found in a location), and a sense of place. Each of the outlined definitions is useful for a particular aim. We argue here, however, that these aspects can also be considered together simultaneously, by following the systemic tradition of geography emphasized by Alfred Hettner and others [14]. The affordances and other properties of places are often interlinked reciprocally with how people perceive and mentally represent the geometric, temporal, and perceptual characteristics of places. We therefore suggest a combined viewpoint emphasizing that many of the previously described place dimensions are interrelated. This viewpoint largely reflects what Anderson et al. have recently called *assemblage thinking* (including both relations and things) [1]. Further, certain phenomena can only occur in places if all relevant contextual characteristics are fulfilled. The formulation of a reasonable and realistic conceptual place-based counterpart to the field of spatial analysis therefore requires a combined viewpoint instead of accounting for isolated components of places individually. The following paragraphs explicate and utilize this viewpoint.

## 3 Analysing places statistically

The subjectivity of places is in stark contrast to spatial and conventional statistics. The latter often assume *identically* distributed observations [3] through the notions of intrinsic or second-order stationarity (i.e., stable moments up to some order) [10], guaranteeing that all observations originate from the same process and in turn allowing the estimation of statistical properties. The subjectivity of perceived places runs counter to this. Different people apply idiosyncratic modes of perception, verbalize subjective opinions, and assign varying complex meanings to places. Further, because place is heavily rooted in spatially and temporally diverse context, even the platial expressions of only single individuals are not coherent and thus not necessarily comparable. This raises questions about suitable methodological and conceptual approaches.

### 3.1 Platial index sets and units

Mike Goodchild describes the geographic world as a "set of overlapping continua" [11, p. 36]. These continua represent spatially and temporally superimposed places [12], reflecting that different people represent and verbalize their very own subjective places in the same locations

[1] The term *platial* is used here as a complement to the term *spatial*.

and times simultaneously. Place can therefore only be treated in limited terms in the sense of spatial analysis, which is based on spatially exclusive observations. The latter is reflected by the types of spatial indexes applied: geostatistical, lattice-based, or spatially stochastic units prevail [4]. Reducing places to their spatial domain is thus insufficient, and recent results obtained this way revealed issues in terms of the reliability of spatial-statistical results and with respect to drawn conclusions [26, 27]. Platial analysis requires index sets, methods, and concepts beyond the spatial domain.

It is the context which allows certain phenomena to occur. A platial notion of index sets should thus take account of multiple contextual conditions in the combined way suggested in Section 2. The contextual dimensions should thus form part of the domain over which platial phenomena are defined. For example, a regular workplace must allow the respective work to be carried out. At the same time, different employees will attach certain idiosynchratic senses of place to the respective location, which are also linked to emotional attachements and other influences. In a platial perspective, these conditions are not treated as spatially referenced attributes, but are part of the coordinate system that allows phenomena to occur in the workplace. The phenomenon *chatting with colleagues at work* is then not defined in terms of space and time, but also in terms of coordinates reflecting the outlined contextual factors. The context thus determines platial units, which are elements of a platial index set and thus of a platial domain.

One possibility to conceptualize platial units could be the definition of regions in *conceptual spaces* [9]. A conceptual space $C$ is spanned by so-called quality dimensions $q_1 \times \cdots \times q_n$, which, following their original interpretation, represent how people judge stimuli to be similar. These dimensions are well-suited for representing saliency, which places have to fulfill in order to allow people distinguishing different places [28]. Quality dimensions further represent psychological *integral dimensions*, which are roughly interpreted as decompositions of perceptual stimuli into their base components. Thinking of places as concepts, and of their subjective properties as quality dimensions, regions in multidimensional conceptual spaces could form platial units in analogy to spatial units like administrative regions or raster cells. Such platial units would automatically meet the conjectured container property allowing objects and processes to be "in" a place [28]. Similar to measures of spatial and geographic distance, the calculus offered by conceptual spaces could further be used to define distance relationships between places. However, the framework is borrowed from cognitive science and applying it to places will require future technical adaptations.

## 3.2 Platial concepts and data

Operationalizing platial analysis requires the definition of mature adapted statistical concepts. For example, it is unclear what the study of *platial autocorrelation* would mean. Spatial autocorrelation is a key concept in spatial analysis and it refers to an association between correlation-based pattern within attributes with some notion of spatial distance [7]. This characteristic largely resembles the so-called *first law of geography* [24]. Gao et al. suggest a place-based counterpart to this law by stating that "every place is related to other places, but more similar places are more interlinked" [8]. Still, in the light of the different discussed available notions of place, it is yet unclear what exactly *interlinked* means in a generalizable sense. By analogy, concepts like heterogeneity, stationarity, and randomization must be coherently defined to enable a solid statistical theory of platial analysis.

One promising source of platial information is user-generated geographic information, like those extracted from geosocial media feeds. These datasets reflect peoples' subjective impressions, which is why they have been conjectured to be of platial instead of geospatial

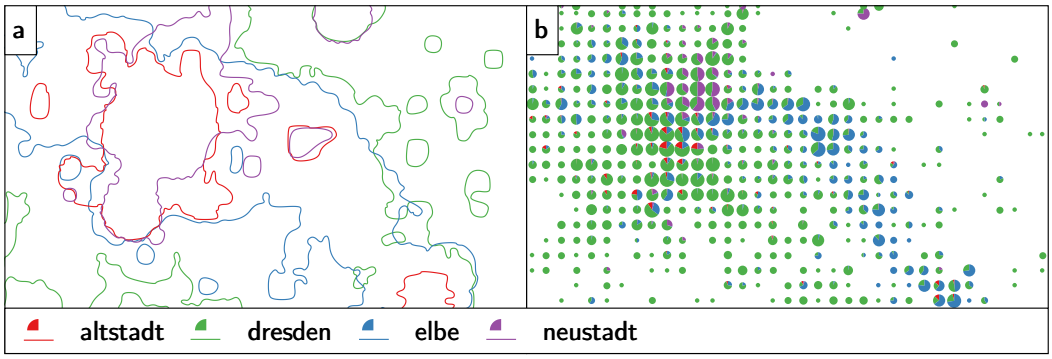


**Figure 1** Maps of the named places *Dresden*, the *Elbe* river, and the urban districts *Altstadt* and *Neustadt*, based on Flickr tags visualized as (a) isolines and (b) micro diagrams.

nature [21]. Cognitive psychology shows that meaningful thoughts and experiences are stored in the *long-term memory*, especially in the fraction called *episodic memory* [22]. Given the meaningful nature of places, geosocial media data raises the question of the extent to which the messages posted on such feeds originate from long-term memory. If large portions of the posted contents may reflect short-term (and thus non-platial) information, it would be questionable whether geosocial media is a useful source of platial information. It is instead likely that the data found on these feeds represents a mixture of platial and non-platial information, making it difficult to interpret obtained analysis results. An alternative possible source of platial information is data collected through survey techniques like the event-sampling method (ESM) [2]. This technique enables the collection of in-situ information by triggering context-based surveys. These and related methods thus allow to collect platial information in a systematic manner. Future research should clarify to what extent user-generated information and the ESM technique are useful for investigating human platial experiences.

## 4 Visualizing Places

Communicating results dervied from platial analysis requires new techniques and strategies. Below we present ideas for visualizing places through an example using data from the photo-sharing platform *Flickr*. Places are frequently extracted and visualized from this kind of data by using selected assigned tags [15, 17]. A more sophisticated approach combining multiple, different sources into a joint classification of topics and thematic regions is found in [19]. Another frequently applied method of visualizing spatially continuous qualitative areas is kernel density estimation. The isoline method is an alternative approach to this, the results of which can be portrayed along with the underlying data points [15]. The approaches outlined present pre-processed analysis results to the viewers of maps and visualizations. Another related idea called tag maps [6] is to avoid extracting places a priori, but to instead show all contained tags in one map and to let the viewer decide about reasonable places. It is further possible to derive 2.5-dimensional pseudo surfaces known from GIS. For this, interpolation methods like inverse distance weighting (IDW) can be used in a first step to produce surfaces, from which isolines or hill shadings can then be derived. The dominance of place representations can be visualized through proportional symbol grid maps or by means of grid choropleths [16, p. 137].

The approaches presented are not optimally suited for the visualization of mental place representations. For example, kernel density maps create the wrong impression of a spatial continuum, which might be misleading for some types of places. Further, when combining information derived from multiple datasets, various individually estimated kernel density surfaces may not be one-by-one comparable, making their joint mapping problematic. Similarly, because places are characterized by multiple dimensions, it is often of interest to visualize more than just one attribute, as it is the case with the outlined techniques. We thus suggest the aggregation of point-based data through regular grids based on point counts as a viable alternative to the outlined interpolation approaches. In this way, the viewer at least does not get the wrong impression of a possibly non-existent surface.

The micro diagram method is another promising approach for mapping diverse places [18]. This method utilizes different kinds of diagrams to represent multiple types of aggregated qualitative information. We show the potential of this approach for the visualization of places using an example based on Flickr data from Dresden. Figure 1a shows the spatial extents of named places based on their occurrences in the Flickr tags. The visualization is based on isolines extracted from a statistical surface estimated by IDW. This type of visualization demonstrates the aforementioned superimposed nature of subjective platial verbalizations. In contrast, Figure 1b shows the results for the micro diagram method, which shows the detailed quantitative composition of the locations in terms of how people interpreted them as places. Other than in 1a, the Elbe river is now notable (blue), and the *Altstadt* (red) and the *Neustadt* (violet) are distinguishable. Beyond this proposed symbology, we suggest avoiding the use of background maps, classical scale bars and other cartographic elements to avoid the impression of a one-to-one mapping between space and place, which may not always exist. Such an omission, however, requires the viewer to have a certain topographical knowledge of the respective region.

## 5 Conclusions and future research

Investigating places is important for gaining a thorough understanding of peoples' everyday lives and to obtain insights on the perceived structures of urban areas. Current statistical approaches from spatial analysis are not suited for this. We discussed challenges and useful solution paths that may bring us closer to the long-term vision of a platial analysis framework. One major challenge is to find suitable units upon which statistical analyses of places can be conducted. Conceptual spaces have been identified as one promising way to define such units, though an in-depth harmonization of this framework with places still needs to be done in future work. Further, platial counterparts to important spatial-statistical concepts must be formulated in order to develop a valid and rigorous statistical theory of places. It is not yet clear to what extent data taken from user-generated feeds is truely platial. Since data is a crucial ingredient to achieving insights on places, this is one of the major empirical steps to be undertaken in the near future. In terms of visualizing places, the major issues with current approaches include wrong spatial impressions created through interpolation techniques, the problem of displaying multifaceted place-based information at once, and the combination of different subjective places in one map. However, the proposed example using micro diagrams has shown first promising results for the presentation of multidimensional, qualitative information together with the spatial outline of places in a conceivable way.

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