

Spatially Enabling 'Place' Information

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Abstract

Many attempts to embed the concept of 'place' into current location-based technologies and spatial data infrastructures have failed spectacularly. Resolving places to single georeferenced points has been identified as a major factor. The prevailing hypothesis is that more complex georeferenced descriptions of places will resolve the problem. This paper refutes this hypothesis. It challenges it from five perspectives including issues related to: determining positional accuracy, defining vague and dynamic places, administering natural places with uncertain boundaries, supporting vanity and vernacular places, and representing the salience of places. These five perspectives demonstrate that while more complex modeling of place is necessary, it is only part of the solution. Successful spatial enablement of place will require other essential issues to be addressed including: combining absolute, relative, and visual accuracy definitions of place, using emerging sources of data (e.g. crowd-sourced) to develop dynamic descriptions of places, determining how to capture 'places' from remotely sensed data, incorporating vanity and vernacular places into spatial data infrastructures, and embedding measures of the salience of place into spatial data infrastructures. These findings are synthesized into a future research agenda in spatial data infrastructures, or spatial information science in general.

Keywords: Place, Spatial Enablement

1. INTRODUCTION

The drive to simplify and personalize human to computer interactions, such as those experienced in location-based services, has focused attention on the concept of place. People communicate about space by referring to places. They want to go to places, to meet at places and to find services around places. Places are familiar, often with complex cultural meanings, and do not always map comfortably into technical frameworks of geographic information underpinned by coordinates, polygons, or even address strings. Inadequate modeling in computers can lead to spectacular failures of human-computer interaction resulting in consumer frustration with web mapping tools and car navigation systems, to more serious life threatening scenarios for emergency call centers. For example, in a current commercial web mapping service, local search requests often fail to interpret the person's intentions when place information is provided. The request *Carlton and surrounding suburbs* fails to identify the surrounding suburbs, the *cafe opposite the city hall* is instead resolved to the *cafe near city hall*, and certainly more complex requests such as *half an hour from the car park at the reserve's entrance* will fail.

One of the major impediments hindering the modeling of place is the lack of spatial semantics: places tend to be georeferenced and understood in databases as points, in the sense of 'points of interest'. Examples are current gazetteers (geographic names databases) and corresponding mapping services such as Google Maps that return a point on a place request (Winter and Truelove, accepted). This

immature modeling technique often means spatial relationships cannot be resolved: topological, directional, or distance queries often return nonsensical results. For example the teahouse *in* the Botanical Gardens cannot be found if both the teahouse and the Botanical Garden are georeferenced by a point, and the café *in* the CBD cannot be distinguished from the café *near* the CBD. The prevailing hypothesis has been that enabling place datasets to access and store the spatial extent of places will resolve the problem. For example, the teahouse in the Botanical Gardens can be identified by spatial analysis of the polygon describing the Botanical Gardens, and the sets of polygons or points describing the teahouses in the area.

This paper aims to refute this hypothesis and identify additional future research directions that will better allow for the spatial enablement of place information. First, a background to the concept of place and previous attempts at embedding place into spatial technologies is provided. This leads to a discussion of the hypothesis that enabling place datasets to access and store the spatial extent of places will resolve the human-computer communication problems about place. The hypothesis is then refuted by challenging it from five different perspectives: issues relating to determining positional accuracy, defining vague and dynamic places, administering natural places with uncertain boundaries, supporting vanity and vernacular places, and representing the salience of places guide the discussion. Key findings are then synthesized into future directions of research for further approaching the problem of spatially enabling 'place' information. At the end, the paper will have identified essential issues for a further research agenda in spatial data infrastructures, or spatial information science in general.

2. BACKGROUND

2.1 Defining 'Place'

Talking about place is an issue arising in *human-computer* interaction rather than *computer-computer* interaction. Place is a cognitive conceptualization of the geographic environment, based on bodily experience (Lakoff and Johnson, 1999), and hard to formalize (Tuan, 1977; Cresswell, 2004; Bennett and Agarwal, 2007). References to places are explications of these cognitive concepts in language. For Aristotle places belong to bodies (Aristotle, 350BC), hence we may conclude places always have a spatial extent of more than one dimension. Aristotle also claims that places are always of finite extent. However, even if places are bounded entities this does not automatically imply *crispily* bounded entities (Burrough and Frank, 1996). Moreover, there exists ontological distinctions between *bona fide* (physical) and *fiat* (agreed) boundaries (Smith, 1995). Additionally, Aristotle considered a body to have a *proper* place, defined by its spatial embedding, but also, at the same time, to be at an infinite number of other places. The teahouse, for example, is not only at a particular location (its proper place) in the Botanical Gardens, but also *in Melbourne* and *next to a lake*. Relevance theory studies which of these places is selected in the context of a particular communication (Wilson and Sperber, 2004; Tomko and Winter, 2006; Raper, 2007).

Placenames are labels that identify individual places, and *place descriptions* identify individual places by the relationships they have with other places. Not every place must have a placename to be identified. For example, the *place where I have parked my car* has no individual placename. A placename can be seen as a trivial place description, with no further relationship other than with the place itself. For example, the placename *Federation Square* is one such trivial place description, a more complex place description being *the square between the film museum and the national gallery*.

2.2 Approaches and contributions to model and manage 'Place'

People communicate with ease about place. Since every citizen in Melbourne knows Federation Square, an expression, 'Let's meet at Federation Square' will work for both communication partners despite the inherent vagueness (where exactly at Federation Square?) and ambiguity (which Federation Square?). Schelling developed the theory of focal points to explain how people meet with such vague and ambiguous arrangements (Schelling, 1960). A computer, however, has difficulties understanding place descriptions. Gazetteers typically associate a placename with a coordinate tuple (Hill, 2006), mapping a place(name) to a point (a location), although a place must have spatial extent. Google Maps, for example, when asked for *Federation Square*, shows a point. But when asked for the *square between ACMI* (the film museum) and *NGV* (the national gallery), Google Maps returns (in March 2010) eight links of varying relevance, each of them a point on the returned map (the second one in the list is a link to Federation Square).

Geographic databases describe features and their spatial extent in a vector representation. Features can be described in a two-dimensional space as points, polylines, or polygons (Portele, 2007), depending on the granularity of their abstraction. Only polygons capture the spatial extent of the represented objects, but even polygons vary in their level of detail, accuracy, and other parameters.

The spatial relationships in place descriptions are typically qualitative, and fall into a small number of categories: *topological* relations (such as 'inside' or 'surrounding'), *directional* relations (egocentric, e.g., 'in front of', or allocentric, e.g., 'North of'), and *distance* relations ('near'). People prefer such qualitative relationships in their language over quantitative relationships (Talmy, 1983; Landau and Jackendoff, 1993; Couclelis, 1996; Levinson, 2003; van der Zee and Slack, 2003).

Qualitative spatial relationships are a well-researched area in spatial information science (Cohn and Hazarika, 2001), and tools exist to represent and reason over qualitative relationships. Topological relations can be represented in point set topology (Egenhofer and Franzosa, 1991) or in a logical calculus (Randell *et al.*, 1992), qualitative directional relations can be formalized, e.g., in the double cross calculus (Freksa, 1992), and qualitative distance relations can be formalized (Frank, 1992; Hernández *et al.*, 1995). Representations and reasoning vary with the dimensionality of the features linked by the relations.

This means, if places (of objects) were represented by polygons these representations and reasoning could be applied, resolving much of the challenge in interpreting place descriptions such as *the tea house in the Botanic Garden, in Carlton and surrounding suburbs*, or *the square between the film museum and the national gallery*. To enable this kind of interpretation is what we mean by 'spatially enabled place information'. Establishing the link between places and polygons, however, is neither yet realized in most infrastructures, nor that straightforward.

In the following sections we present some of the challenges beyond this level of spatial enablement, requesting more spatial intelligence than just the description of a place by a polygon, and outline additional pathways towards a spatially enabled discussion about place. These suggestions must remain partial, however, because communication about place is a hard problem for computers, as we have introduced earlier (Winter and Wu, 2009).

3. APPROACH

3.1 Issues with the positioning accuracy of ‘place’

As discussed in the previous sections, placenames attached to real world objects are typically georeferenced to the coordinates of a point. In reality, however, these objects are at least areal in their extents (e.g., Federation Square), and taking a point as a representation neglects the spatial meaning and introduces potential interpretation conflicts. For example, while a GIS is able to locate a placename, it is not able to identify a placename for any location.

Identifying a placename for a point—i.e., solving the classical point-in-polygon problem—is heavily dependent on the accuracy of the point coordinates used. Fundamentally, the accurate identification of a place is directly correlated with the positioning accuracy of the points used, that is, an inaccurate position may incorrectly identify a particular place. The research challenge is therefore to ensure that the points used to represent real world features described by polygons are placed correctly within the polygon or are defined with a known error bound.

The accuracy of a position is traditionally defined as how closely the coordinates (of a point as determined by some measurement process) relates to its true position on the surface of the Earth. The further away the measured position is from the true position, the lower the accuracy and vice versa. For the diversity of location-based services being developed today, there are a wide array of positioning technologies available to determine real-time positions of mobile users: GSM-based positioning, radio frequency identification (RFID), ultra wideband (UWB), ultrasound, Wi-Fi, traditional network surveying, and inertial and satellite-based positioning. The inherent strengths and weaknesses of these technologies means that the achievable positioning accuracy varies greatly (Table 1).

Table 1: Positioning technologies with their corresponding observables and accuracies (IMST, 2003; Duffett-Smith and Craig, 2004; Kong *et al.*, 2004; Chon *et al.*, 2005)

Positioning Method	Observations	Accuracy
GNSS	GPS	± 6 – 10 m
	DGPS	y, x, z ± 1 – 4 m
Cellular Phone Positioning (GSM)	Cell ID	± 150 m – 35 km
	Solo Matrix	y, x ± 50 – 100 m
WLAN Positioning	IMST ipos	y, x, z ± 1 – 3 m
UWB Positioning (TDoA)		y, x, z ± 0.2 – 1 m
RFID Positioning (active landmarks)		y, x, z ± 6 m
Bluetooth (active landmarks)		y, x, z ± 10 m

Much research is already underway to improve the positioning accuracy of these technologies, and various integration and filtering architectures have demonstrated some success in this regard. What remains a challenge, however, is that it is still possible for the derived coordinates of a point to be statistically outside the polygon that it intends to represent. To address this issue, two additional positioning accuracy

definitions need to be considered: visual accuracy and relative accuracy. Visual accuracy refers to the correction of a measured coordinate to its logical position; for example, a car navigation system will always locate the driver to a position on a road, based on the logic that this is where a car should be. Relative accuracy is defined as how closely a measured coordinate relates to other nearby points, for example, comparing distances between features on a map and the distance measured between the corresponding objects on the surface of the Earth.

It is proposed here that an approach that integrates these three definitions of accuracy is required. This will provide a robust infrastructure that constrains the point coordinates used to georeference an object, i.e., describe its place. Similar to map matching algorithms, the first processing phase will compute a position solution using measured or derived data from individual combinations of technologies. The second phase will introduce synthetic measurements based on known relationships between features, and the final phase will integrate logical constraints based on the user's context. The outcome will be a visually correct position with parameters describing its absolute, relative and visual accuracy.

3.2 Defining vague and dynamic places

Many of the terms and spatial relations commonly used to refer to places are vague. Although the term *vague* is often used in vernacular loosely, vagueness has (somewhat antithetically) a very precise meaning in the philosophical literature. Vagueness concerns terms or concepts that have no precisely defined boundary (Keefe and Smith, 1996). For example, consider place descriptions like *downtown* or *near the clock tower*. There will typically exist locations that are definitely at that place (e.g., right under the clock tower, or in the main city center shopping mall); locations that are definitely not at the place (e.g., out of sight of the clock tower, or in a rural field far from urbanization); and crucially many locations for which it is indeterminate whether or not they are at that place.

The vagueness inherent in many place descriptions raises two important problems: representing and reasoning about places. Most spatial information systems use data structures (like polygons and lines) that enforce crisp boundaries of features: locations are either in or out of the polygon, or left or right of a directed line. Using three-valued logics can help to relax this crispness somewhat. In a three-valued logic, statements can be true, false, or indeterminate. In the context of vague place descriptions, this gives rise to regions with indeterminate boundaries (Cohn and Gotts, 1996). One well-known example of such a model is the egg-yolk calculus (where the *yolk* of the egg contains locations that are definitely in the region; the *white* of the egg represents the indeterminate boundary; and locations outside the *egg* are outside the region). Such a model can be relatively easily implemented using conventional spatial data structures. However, while such approaches are a useful step reducing the commitment to a crisp in/out dichotomy, they still require a commitment to a crisp in/indeterminate and indeterminate/out trichotomy. This issue is an example of a well-studied, but so far insoluble problem known as higher order vagueness. Switching to more discerning formal models, like 4- or n-valued logics, or even to degree theories, like fuzzy set theory, refines the representation but cannot overcome the problems of higher order vagueness.

The problems of representing vagueness are further exacerbated when we come to reason about vague places. The problems of reasoning about vague concepts have been cogitated on since ancient Greek times (e.g., the sorites paradox, Fisher, 2000). As an illustration of the types of reasoning problems that occur, Duckham and Worboys (2001) investigated whether different places on a university campus were

judged to be near one another. Properties like symmetry do not hold in such vague place descriptions (e.g., if place A is near place B, it does not necessarily follow that place B is near place A).

While many theoretical challenges remain, advances have been made. A variety of innovative and ingenious systems for representing and reasoning about vague places have, and continue to be proposed (e.g., Bennett, 2001; Galton and Hood, 2005). Up to now, a major barrier in realizing such systems is a lack of available data about human understanding of places. But, recent growth in geotagging, crowd-sourcing, and volunteer geographic information offers the potential for a rich source of data about human understanding of places (e.g., Grothe and Schaab, 2009; Schlieder and Matyas, 2009). To take advantage of these new data sources, we require new practical techniques for fusing diverse, natural language descriptions of places. In this context, polygon descriptions of places appear anachronistic: emerging techniques will provide for far richer depictions of vague and dynamic places (Davies *et al.*, 2009).

3.3 Administering natural and uncertain 'places' boundaries

Natural places are common in language but they lack the clearly defined boundaries of the human built environments. This lack of boundary clarity is not a problem with the spatial database; it is an inherent quality of these spaces (Burrough, 1996). If a tourist talking of their visit to Melbourne were to mention the beautiful mountain forest on the eastern boundary, a Melbourne resident would know the place that was meant even though no exact location has been mentioned. However, if they were speaking to another tourist who did not know Melbourne, that tourist would search in vain for this place on maps. The forest in question is partly national park, partly state forest park and partly on private land. It has many geographic names associated with it, there is no precise definition of its boundary and yet it is all the same forest, which can have only one proper place.

What is true of forests is true of many natural places, for example, where exactly is the boundary of a mountain range (Smith and Mark, 2003)? There is also an inherent uncertainty in the terminology used for such places. When exactly does a treed plain become an open forest? While there are technical definitions for such things, these do not always correspond with common usage that is often variable and inconsistent (cf. Bennett *et al.*, 2010). Any polygons used to reference such places would thus have a somewhat arbitrary character and would impose an artificial, and false, definition to the boundary.

This is especially true if we consider the means used to define these polygons. One common approach is land use mapping via remote sensing techniques. The problems of land use definition and *mixel* classification have been well documented (cf. Anderson *et al.*, 1976; Townshend *et al.*, 1987; Chen and Stow, 2003). These problems are even greater when we consider the concept of place. There are two major and related problems here: the scale of the imagery, which constrains the definitions of objects and their place.

The picnic table at which I eat my lunch is an object with a proper place, but it is within the clearing that is the picnic ground, which is also a place, and this is within the forest, another place. In remote sensing spatial scale is determined by the pixel size and the image coverage (Jensen, 2007). It is fixed in a way that place references are not. Is the picnic ground clearing a part of the forest? Can the picnic table be seen to exist? The answer to these questions depends on the image data used and will be inflexible within that data set.

The greater problem is one of definition. Remote sensing tools classify the Earth's surface by grouping pixels of similar spectral character (Drury, 1987). This may relate well to the perceived character of a place, for example forest/not forest. However, there are many natural features that do not have a clear spectral marker, for example a mountain range or a hill. The advanced analysis approaches used in hyperspectral imagery, such as End Member Analysis (cf. Plaza *et al.*, 2004) actually make this problem worse since they focus on the distribution of specific features rather than on the amalgamation of these features to form a place.

These are difficult problems that need a great deal of further investigation into how people perceive and define natural places. Imposing a series of arbitrary polygons is not going to form an adequate solution since it respects neither the innate properties of the places themselves, nor the way in which people conceive and talk about them.

3.4 Dealing with vanity and vernacular 'places'

Places and placenames often have a perceived (market) value. This leads to vanity addressing by individuals and industry, particularly those involved in markets dealing with place. Vanity addressing is the process whereby a person deliberately distorts an address in order to improve the value of a particular property, business, or other activity. For example, in the Australian context it is common for real estate agents to link an advertised property to the most attractive surrounding suburb, rather than to the official postcode. Shop traders also regularly list themselves in more attractive places than their actual postcode might suggest.

Whilst governments and other administrators of 'places' do not condone this behavior, it is certainly not illegal in Australian jurisdictions. Addresses emerged from the bottom up and in many ways still maintain a social or cultural quality. Despite the best efforts of state governments to develop address registries and placename gazetteers (cf. ANZLIC, 2009), the issue still persists.

Cardinal directions in names provide another complication. These are often incorporated into Australian suburb names in correspondence to the direction of the originating suburb. Sometimes these places have a defined postcode, other times they do not. Examples include Fitzroy *North*, *South* Melbourne, Brunswick *Lower*, or *East* Coburg. Vernacular permutations often emerge and gain widespread use within a community. For example, Fitzroy North is commonly referred to as North Fitzroy by Melbournians. These simple variations have minimal impact on person-to-person interactions; however, their result on person-to-computer interactions can be profound. Online web mapping systems such as Google Maps become unreliable or utterly fail when vernacular places are used in the person-computer dialogue (Winter and Truelove, accepted).

A key issue then is how to deal with vanity and vernacular places in spatial data infrastructures and location-based services, particularly those used by governments to administer societal activities and provide government services. For example, if a vanity address has gained social credence, the dispatch of emergency services or provision of directions can be greatly impeded. Four strategies are available to administrators: do nothing, regulate, educate, or incorporate. Of these, the final three warrant some discussion.

Some jurisdictions, such as those in Europe or South Korea, use *regulations* to successfully create authoritative approaches to addressing. However, this method

requires community agreement and tends to ignore the social aspects of addressing that are prevalent in other jurisdictions. Another approach is to incorporate *educational* processes into systems. This approach is already gaining traction in online location search tools where ‘Did you mean...’ server responses are provided to users. *Incorporation* takes the educational strategy further: not only does the search tool list several alternative matches, it is smart enough to work out which of those addresses the user was actually searching for. This process is underpinned by the Semantic Web concept (Berners-Lee *et al.*, 2001) and will rely on tools such as the Web Ontology Language (OWL). The concept is gaining traction, however, it is still a very much in the developmental phase. A preliminary example can be found in the multi-criteria route-planning systems developed by Niaraki and Kim(2009).

At any rate, dealing with vanity and vernacular places is a difficult problem. Directed research is required into how and when people use such descriptions, and how the phenomena can be embedded into spatial technologies. Any suggestion that modeling places with polygons resolves vanity and vernacular place naming issues is ill conceived. Such a solution only recognizes the spatial aspects of the problem, not the social and cultural aspects.

3.5 Adding salience to ‘places’

Although linking placenames with polygons can generate more intelligent spatial representations, such representations still fall short compared to cognitive representations. Cognitive representations are known to be distorted (Stevens and Coupe, 1978), hierarchic (Hirtle and Jonides, 1985), and led by anchor points (Sadalla *et al.*, 1980; Couclelis *et al.*, 1987). Sadalla *et al* (1980) relate these anchor points directly to landmarks (Lynch, 1960; Presson and Montello, 1988). The very existence of landmarks means that features of the same type are not equally important; some—the landmarks—are cognitively more salient. Correspondingly, in expressions about places some placenames—the more salient ones—are used to ‘anchor’ a given place.

The documented cases of referring expressions about place take the asymmetry from spatial (part-of) hierarchies, which typically lead to zooming-in or zooming-out expressions (Shanon, 1979; Paraboni *et al.*, 2007). For example, in *Federation Square, Melbourne* the referent (Federation Square) is anchored by another more prominent placename (Melbourne) in a clear order by their part-of relationship, and since several Federation Squares may exist in the world, specifying the one in Melbourne resolves potential ambiguities. A second case of asymmetry is imposed by cognitive salience, between objects without an order relation by type. For example, in *the building next to the library*, the referent—an unnamed building—is anchored by a more prominent and named building, the *library*.

The first asymmetry is completely explained by the spatial extent of places. Federation Square is a proper part within Melbourne, and hence, also smaller than Melbourne. The latter kind of asymmetry, based on cognitive salience, is not sufficiently explained by the spatial extent of places. The building next to the library is not necessarily smaller than the library. For a service to understand and generate place descriptions this asymmetry needs to be built into the service’s intelligence.

So what makes geographic features cognitively more salient, such that their places are used for ordering cognitive spatial representations? Some preliminary work suggests visual, social and structural characteristics when combined can serve for a measure of salience (Sorrows and Hirtle, 1999; Raubal and Winter, 2002; Elias,

2003; Duckham *et al.*, 2010). We are expanding this list, claiming the following factors can have an impact on cognitive salience:

- Perceptual factors including visual ('the blue building' or 'the large building'), aural ('the quiet place') and olfactory;
- Individual experience ('the place where I met you for the first time') and individual preference ('a place where I can get good coffee');
- Collective experience, including historical ('the place of first settlement'), cultural ('the sacred place') and functional factors ('the (place of the) library');
- Structural factors in reference to the street network ('the place at the intersection').

Approached this way salience is a quantitative measure, that is, salience does not identify landmarks, but characterizes the 'landmarkness' of a feature or its place. One preliminary work has used quantitative measures to organize a hierarchy among neighboring features or their places (Winter *et al.*, 2008), reflecting the anchor points in cognitive spatial representations. In other preliminary work it has already been suggested to use such a measure of salience to generate (Tomko and Winter, 2009) or understand place descriptions (Wu and Winter, 2010).

What is completely missing, however, is a spatial data infrastructure that enables the provision of measures of salience. This infrastructure must provide for the data to determine the factors, and the analysis methods to process this data. The data is partially environmental, that is sensors in the environment can capture it, and partially social, that is it can be collected from individual behaviors. Challenges are in the type of analysis (e.g., the 'color of a facade') or in the sheer size of data required in addition to existing spatial data resources, a factor that is already discussed in (Duckham *et al.*, 2010).

4. RESULTS AND DISCUSSION

The approach above highlights the inadequacy of the stated hypothesis: that polygonal georeferenced descriptions of places alone will resolve the problems of modeling and using 'place' in spatial data infrastructures and location-based technologies.

The above discussions reveal five exemplary areas where future research activities should be directed in order to deliver computer-based representations and reasoning methods for spatial data infrastructures and location-based technologies that adequately deal with the concept of place. Table 2 summarizes these directions as key themes, associated disciplines and the underlying research questions. Together, these research questions provide a research agenda for spatial data infrastructures, and spatial information science more generally.

Table 2. Key elements of a research agenda for spatially enabling 'place' information

Research Theme	Associated Disciplines	Research Questions
1. Issues with the positional accuracy of place	Geodesy	How do we combine absolute, visual and relative definitions of accuracy to provide for more robust descriptions of the spatial accuracy of 'places'?
2. Determining vague and dynamic places	Spatial Information Science, Spatial Data Infrastructures	How can we use emerging spatial data sources (e.g. crowd-sourced data) to automate the development and maintenance of more organic dynamic place descriptions?

3. Administering natural and uncertain place boundaries	Remote Sensing	How should we deal with issues of scale and definition when attempting to use imagery and remote sensing to articulate natural places with uncertain boundaries?
4. Dealing with vanity and vernacular places	Spatial Data Infrastructures	How do we best deal with the phenomena of vanity and vernacular places in relation to spatial data infrastructures? Should we ignore, educate, regulate, or incorporate?
5. Adding salience to place	Spatial Information Science, Spatial Data Infrastructures	What tools are required to enable measures of salience to be incorporated into spatial data infrastructures? How should we build these tools?

Clearly there are more issues associated with spatially enabling 'place'. These include other technical challenges such as designing the human-computer interface, including cartographic expressions of place and cartographic generalization of place information. Other, and broader issues associated with place require attention as well, such as philosophical, social, and governance issues.

5. CONCLUSION

This paper opened by suggesting that many attempts to embed the concept of place into current location-based technologies and spatial data infrastructures have failed spectacularly. Resolving places to single georeferenced points was identified as a major factor. The prevailing hypothesis that more complex georeferenced descriptions of places—polygons—will resolve the problem was declared problematic. In response, this paper refuted the hypothesis.

The hypothesis was challenged from five different perspectives including issues related to: determining positional accuracy, defining vague and dynamic places, modeling indigenous concepts of place, administering natural places with uncertain boundaries, supporting vanity and vernacular places, and representing the salience of places. These five perspectives demonstrated that while more complex modeling of place is necessary, it is only part of the solution.

The five perspectives revealed that successful spatial enablement of place will require other essential issues to be addressed including: combining absolute, relative, and visual accuracies of place; using emerging sources of data (e.g. crowd-sourced) to develop and maintain dynamic descriptions of places; determining how to capture natural 'places' from remotely sensed data; incorporating vanity and vernacular places into spatial data infrastructures; and embedding measures of the salience of place into spatial data infrastructures. These findings have led to the development of a future research agenda in spatial data infrastructures, or spatial information science in general. The challenge now remains to respond to this agenda.

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