Ontology and Geographic Kinds[1]

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Abstract

An ontology of geographic kinds is designed to yield a better understanding of the structure of the geographic world, and to support the development of geographic information systems that are conceptually sound. This paper first demonstrates that geographical objects and kinds are not just larger versions of the everyday objects and kinds previously studied in cognitive science. Geographic objects are not merely located in space, as are the manipulable objects of table-top space. Rather, they are tied intrinsically to space, and this means that their spatial boundaries are in many cases the most salient features for categorization. The ontology presented here will accordingly be based on topology (the theory of boundary, contact and separation) and on mereology (the theory of extended wholes and parts). Geographic reality comprehends *mesoscopic* entities, many of which are best viewed as shadows cast onto the spatial plane by human reasoning and language. Because of this, geographic categories are much more likely to show cultural differences in category definitions than are the manipulable objects of table-top space.

Keywords: ontology, mereology, geographic kinds, entity types, GIS

1 Introduction

Ontology deals with the nature of being. Communication requires a sharing of ontology between the communicating parties. The formal description of ontology is thus essential to data exchange standards, and to the design of human-computer interfaces. In this paper, we describe some fundamentals of the ontology of geographic space and of the objects and phenomena of geographic space.

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1.1 Why Construct an Ontology?

An ontology of geographic kinds, of the categories or entity types in the domain of geographic objects, is designed to yield a better understanding of the structure of the geographic world. The results can be of practical importance in at least the following ways:

First, understanding the ontology of geographic kinds can help us to understand how different groups of humans, for example different armies in a multinational coalition in time of war, exchange, or fail to exchange, geographic information.

Second, understanding the ontology of geographic kinds can help us to understand certain characteristic types of distortions that are involved in our cognitive relations to geographic phenomena. Above all, there are tendencies in the conceptualization of geopolitical entities that underlie certain forms of territorially based conflict.

Third, geographic information systems need to manipulate representations of geographic entities, and ontological study of the corresponding entity types, especially those at the basic level, will provide default characteristics for such systems.

Fourth, entity types are a central issue in data exchange standards, where a substantial part of the semantics of the data may be carried by the types that instances are assigned to (Mark 1993). Research in ontology as a basis for the development of knowledge-interchange standards has expanded tremendously in recent years (Gruber 1993). This paper is designed as a contribution to such research in the specific field of geography.

1.2 Specific Marks of Geographic Kinds

In what follows, we shall be interested in the theoretical peculiarities of geographic kinds— in those features that set them apart from kinds of other sorts. These features derive primarily from the fact that geographic objects are not merely located in space, but are tied intrinsically to space in a manner that implies that they inherit from space many of its structural (mereological, topological, geometrical) properties.

Existing research on cognitive categories has standardly addressed entities on the sub-geographic scale: manipulable entities of the table-top world, objects of roughly human scale (birds, pets, toys) and other similar phenomena. For such entities, the 'what' and the 'where' are almost always independent. In the geographic world, in contrast, the 'what' and the 'where' are intimately intertwined. In the geographic world, categorization is also very often size- or scale-dependent. (Consider: *pond*, *lake*, *sea*, *ocean*.) In the geographic world, to a much greater extent than in the world of table-top space, the realization that a thing exists at all may have individual or cultural variability. In the geographic world, too, the boundaries of the objects with which we have to deal are themselves salient phenomena for purposes of categorization. These boundaries may be crisp or graded, and they may be subject to dispute. Moreover, the identification of what a thing is may influence the location and structure of the boundary; for example, if a given topographic feature is identified as a marsh, then its boundary may be located farther up the slope than would be the boundary of the same feature if it had been identified as a lake. These are all features of categorization that are all but absent from the table-top world upon which theories of categorization have hitherto been based.

1.3 Categories versus Sets

Science has typically modeled categories as sets in the mathematical sense, and the assumption of a set-theoretic model of categories is commonly made in feature coding schemes, either explicitly (as in geocartographic data standards) or implicitly. Every possible object or event is assumed to be either a member or not a member of each particular set. This view of categories also assumes that there are procedures or rules available for determining set membership from the observable characteristics of the individual. Furthermore, it is assumed that every member of a set would be an equally good exemplar of that set. This familiar model also underlies multivariate mathematical models of classes, such as those used in discriminant analysis, and in most forms of cluster analysis.

The problems with the set-theoretic model as an account of the categories used by ordinary humans in everyday situations are clear. For most such categories, and for most people, some members are better examples of the class than are others; furthermore, there is a great degree of agreement among human subjects as to what constitute good and bad examples. Rosch and others have accordingly proposed that natural kinds be seen as possessing a radial structure, having prototypes of more central or typical members surrounded by a penumbra of less central or less typical instances (Rosch 1973, 1978). Following Couclelis (1988), Mark (1989), and Mark and Frank (1996), a view along these lines will be accepted in what follows.

1.4 Basic Tools of Ontology: Mereology and Topology

Geographic objects are spatial objects on or near the surface of the earth. Furthermore, they are objects of a certain minimal scale (roughly: of a scale such that they cannot be surveyed unaided within a single perceptual act). Geographic objects are typically complex, and they will in every case have parts. An adequate ontology of geographic objects must therefore contain a theory of part and whole, or *mereology* (Simons 1987).

Geographic objects do not merely have constituent object-parts, they also have boundaries, which contribute as much to their ontological make-up as do the constituents that they comprehend in their interiors. Geographic objects are prototypically connected or contiguous, but they are sometimes scattered or separated. They are sometimes closed (e.g., lakes), and sometimes open (e.g., bays). Note that the above concepts of contiguity and closure are topological notions, and thus an adequate ontology of geographic objects must contain also a topology, a theory of boundaries and interiors, of connectedness and separation, that is integrated with a mereological theory of parts and wholes (Smith 1996). The topological structure will bring with it certain sorts of duality, thus for example dual to the distinction between the outer boundary and the interior of a geographic object is the distinction, within the surrounding container or host, between the inner boundary of this container and the exterior or hinterland beyond. Our topological ontology also must be able to cope with the fact that the very notion of 'boundary' can mean, in different contexts, either an abstract mathematical boundary— conceptualized as an infinitely thin line, plane or surface that is located in space but does not occupy (fill out) space— or a boundary zone, of small but finite thickness. Boundaries in the abstract sense are normally seen as falling within the province of standard mathematical topology. For geographical purposes, however, even within the category of abstract boundaries there are certain sorts of boundary phenomena which standard topology cannot deal with. If we cut an object— for instance a land parcel, or an island— in half, we are not left with one piece that is closed and another that is not. This is because abstract boundaries do not take up space, and thus they can be perfectly co-located one with another. To do justice to such phenomena we need to use special mereotopological theories that depart in crucial ways from standard topology (Smith and Varzi 1997).

An object is 'closed' in the mereotopological sense, if it includes its outer boundary as part; it is 'open' if this outer boundary is included rather in its complement. Ordinary material objects are in unproblematic fashion the owners of their surfaces. Where a complement meets an object of this sort, the object will be closed and the complement open (Asher and Vieu 1995). Regarding geographic objects, however, matters are not so simple. Consider the mouth of a volcano: where the hole meets its material host (the crater, a concave mass of rock and debris), the boundary of the hole is the surface of the host. Thus the boundary of the hole, there, belongs to the volcano, and not to the hole itself (Casati and Varzi 1994). Consider, however, the boundary of the hole where it is not in contact with its host: the boundary in the region corresponding to the opening of the hole where it faces up towards the sky. Where do we place the boundaries corresponding to those regions? Within the hole? Within the sky? Either choice would seem arbitrary, and a parallel situation is encountered in the case of bays facing out towards the sea. This very arbitrariness will reveal important features of geographic objects in general and of their boundaries in particular.

2 Geographic Categories and the Geometry of Space

Geographic categories track not only mereology and topology but also qualitative geometry (the theory of concavity, convexity, of shortness and longness, the theory of being roughly round or roughly dumbbell shaped). A theory of geographic categories must take account, too, of the fact that geographic objects may be zero-, one-, two-, or three-dimensional. Consider the North Pole, the Equator, Norway (a two-dimensional object with a curvature in three-dimensional space), or the North Sea. Consider also that 'North Sea' may refer either to the three-dimensional body of water, or to its two-dimensional surface. 'Bay' or 'sound' may refer to the surrounding land, or to the indentation in the shoreline, or to a part of the shoreline, as well as the sheet or body of water. Note that there are different meanings of 'in' (and of other spatial prepositions) according to what the relevant dimension in a given context might be: the island is 'in' the lake means, in one sense, that it protrudes from the surface of the lake, in another sense that it is completely submerged within the corresponding three-dimensional volume.

Ontologists since Aristotle have distinguished between two sorts of predications: *categorial predications* as we are here using this term (called by Aristotelians 'predications in the category of substance'): is a man, is a fish, is a lake, etc.; and *accidental predications* (or 'predications in the category of accident'), for example: is red, is colored, is big, is hungry. The former tell us under what category an object falls. They tell us what an object is. The latter tell us how an object is, *per accidens*, at a given moment; thus they pertain to ways in which instances of the relevant categories change from occasion to occasion.

There is no term for 'big dog' or 'small dog' corresponding to 'lake' and 'pond'. Why not? Because size for living objects is not usually a categorical matter but is an attribute that changes over time. In contrast, instances of geographic categories characteristically do not grow or shrink (as animals do). In this case, size and shape may be matters for categorical predication. The question still remains whether *lake* is a basic level category in the sense of Rosch (1978). Is *pond* a subordinate subclass, a-kind-of lake? Or are lakes and ponds both categories at the basic level, distinguished mainly by size? *Bay* and *cove*, *mountain* and *hill*, form similar pairs. Empirical research with human subjects will be needed to answer this and similar questions.

3 Levels of Reality

3.1 Spatial Reality

We use 'entity' and 'object' synonymously as ontological terms of art comprehending things, relations, boundaries, events, processes, qualities, quantities of all sorts. More specifically, in the context of geographic ontology, 'object' and 'entity' shall comprehend regions, boundaries, parcels of land, water-bodies, roads, buildings, bridges, and so on, as well as the parts and aggregates of all of these.

We assume the existence of a real world, populated by real entities occupying regions of space. Spatial regions form a relational system, comprising also containment relations, separation relations, relations of adjacency and overlap, and so on (Egenhofer and Herring 1991). We assume also the existence of a relation of being located at between things on the one hand (roads, forests, wetlands), and the regions in or at which they are located on the other (Casati and Varzi 1996).

3.2 The Cognitive Domain

On the other hand, there is the domain of cognition, of concepts, perception, memory, reasoning and action. Counterparts of spatial relations exist in this conceptual realm, too. Our cognitive acts are directed towards spatial objects in the world. Interestingly, though, these acts themselves exist in a spatial domain: they are tied to our bodies, which themselves exist in spatial reality, so that some of our spatial concepts, like *here* or *there*, are egocentric. Concepts therefore work spatially in manifold fashion: i) through abstract models or representations of space in our minds, as when we think, abstractly, about whether Peru is to the North or to the South of Ghana; ii) through a concrete being-in-space, when we use indexical spatial concepts such as *yonder*, *to the right*, *down east*, etc.; and iii) through different sorts of mixtures of these. With geographic information systems (GIS) there is also iv): conceptual interaction with spatial entities that is mediated through mathematical models and through computer representations.

Matters are complicated further by the fact that our cognitive representations of space may be under-defined or erroneous. They may show individual or culture-related differences. They may be refined or modified through social and cultural interactions, formal education, and dictionary definitions. Some spatial concepts may even be hard-wired into the perceptual systems in the senses and brain. Other concepts may be changed through use; thus, once a given concept is judged to correspond with a particular situation, then the specifics of that situation may modify the concept.

We assume that people think and reason by manipulating concepts; that computer programs are based on formal mathematical counterparts of relations between entities in the world; and that people use computers to learn about, understand, or make decisions about such entities. Thus, establishing the correspondences and interrelations among the different domains of spatial entities and relations is essential to the construction of geographic information systems and of other systems for reasoning about spatial entities and relations.

3.3 Geographic Reality

Geographic reality has many different sorts of properties, features, entities within it, which can be approached theoretically in many different ways. There are aspects of spatial reality that have been

well worked out by earth scientists of various sorts. The cognitive aspects of this domain are however still little understood from the theoretical point of view. This is because those interested in cognition have, with few exceptions, shown little interest in the spatial reality within which cognizing subjects are situated, whereas those interested in spatial reality have shown for their part little interest in cognition. It is the interactions between these two domains that are the principal object of our inquiries here. They relate to the various ways in which human cognition and action, including social and political action, lead to effects of an ontological sort within the domain of spatial reality.

To fix our ideas, let us divide spatial reality into two sub-domains or strata, which can be conceived, provisionally, as partitions of space at different levels of granularity. (Conceive the two strata as laid on top of each other after the fashion of map layers, with the upper stratum comprising objects of larger scale.)

On the one hand is the *microphysical* stratum of spatial reality— it is spatial reality as it is dealt with in the physical sciences. It may be conceived, for present purposes, as a complex edifice of molecules. On the other hand is the *mesoscopic* stratum of spatial reality. This is the real-world counterpart of our non-scientific (naive, normal, everyday, lay) cognition and action in space.

This mesoscopic stratum has three different types of components:

1. Objects of a straightforwardly physical sort— such as rivers, forests, bridges— that are studied also by physics but which, as they are cognized within the mesoscopic stratum, have different sorts of properties. (This is in virtue of the fact that our naive cognition uses very little mathematics, has its own peculiar topology, and endows its objects with qualitative rather than quantitative features and with a social and cultural significance that is absent from the microphysical realm.)

2. Geographic objects like bays and promontories, which are also in a sense parts of the physical world but which exist only in virtue of demarcations induced by human cognition and action.

3. Geopolitical objects like nations and neighborhoods which are more than merely physical, and which exist only as the hybrid spatial products of human cognition and action.

All three sets of components are spatial objects. Indeed we might conceive mesoscopic entities in general as shadows cast by human reasoning and language (and by the associated activities) onto the spatial plane. All mesoscopic objects exist as parts of spatial reality as we here conceive it. This applies even to counties, land-parcels, postal districts, real estate subdivisions, air corridors, and so on.

4 Problems with Geographical Extensions of Theories of Categorization Based on the Phenomena of Table-Top Space

The Rosch-style examples of small mammals, birds, utensils, etc., that have been most extensively treated in the literature on categorization, differ from geographic examples in a number of ways. First, they almost always involve discrete, movable, items. And while research on categorization by cognitive scientists does indeed indicate that humans tend quite generally to discretize even where they are dealing with what are essentially continuous phenomena (as is shown, not least, by the case of GIS), an adequate ontology of geographic kinds should embrace not only categories of discreta but also categories that arise in the realm of continuous phenomena.

Table-top examples tend further to reinforce a view according to which nature can be cut at its joints— that is, a view to the effect that there is a true, God-given structure, which science attempts to make precise. As we shall see, geographic categorization involves a degree of human-contributed arbitrariness on a number of different levels, and it is in general marked by differences in the ways different languages and cultures structure or slice their worlds. It is precisely because many geographical kinds result from a more-or-less arbitrary drawing of boundaries in a continuum that the category boundaries will likely differ from culture to culture (in ways that can lead to sometimes bloody conflict as between one group or culture and another).

Finally, the familiar Rosch-style examples form a family of separate categorial systems possessing simple tree structures, with each tree having little to do with the other trees. Geographic categories, in contrast, because they relate to objects intrinsically interrelated together within a single domain (called *space*), form categorial systems that interact to form a single structure. The mereological, topological and geometrical, organization of space thus has deep implications for the structure of our cognitive system of geographic categories.

5 The Realm of Fiats

As shown above, geographic objects will often be identified by specification of the locations of their boundaries. It is important to distinguish between *bona fide* and *fiat* boundaries. Following Smith (1995), the former are boundaries that correspond to genuine discontinuities in the world, the latter are projected onto geographic space in ways that are to a degree independent of such discontinuities. The surfaces of extended objects such as planets or tennis balls are clearly boundaries of the bona fide sort. Shorelines and water courses can also readily be considered to be bona fide boundaries. In contrast, many state and provincial borders, as well as county lines and property lines and the borders of postal districts, provide examples of boundaries of the fiat sort, especially in those cases where, as in the case of Colorado or Alberta, they lie skew to any pre-existing qualitative differentiations or spatial discontinuities (coastlines, rivers) in the underlying territory. Boundaries of areas of a given soil type, of wetlands, or of bays or mountains are also at least partly of the fiat type, although here the boundaries may result from cognitive rather than from legal or political processes.

Once fiat outer boundaries have been recognized, it becomes clear that the opposition between bona fide and fiat boundaries can be drawn not merely in relation to boundaries but in relation also to the objects that they bound. Examples of bona fide geographic objects are the planet Earth, Vancouver Island, the Dead Sea. Fiat objects include King County, the State of Wyoming, the Tropic of Cancer. There are, of course, cases of objects that ought reasonably to be classified as fiat objects whose boundaries involve a mixture of bona fide and fiat elements. Haiti and the Dominican Republic, which together occupy the Island of Hispaniola, are examples which spring to mind, but every national boundary will in course of time involve boundary-markers: border-posts, watch-towers, barbed wire fences and the like, which lend a physical aspect to what was initially an object of the fiat sort.

5.1 Types of fiat boundary

There are various different ways in which we can divide up the realm of fiat boundaries: some fiat boundaries are long-standing, crisp and determinate, the products of deliberate legislation; others are vague or transient, the products of momentary territorial adjustments (for example in battle zones). Fiat boundaries all have in common that they exist only in virtue of the different sorts of

demarcations effected cognitively and behaviorally by human beings. But they are otherwise of many sorts. They may be complete or incomplete, symmetrical or asymmetrical. They may lie entirely skew to all boundaries of the bona fide sort, may involve a combination of fiat and bona fide portions, or they may be constructed entirely out of bona fide portions that however, because they are not themselves intrinsically connected, must be glued together in fiat fashion in order to yield a boundary that is topologically complete. We will deal with this manifold variety of fiat boundaries in some detail in what follows.

5.2 Fiats and vagueness

There are fiat objects (deserts, valleys, etc.) that are delineated not by crisp outer boundaries but rather by boundary-like regions that are to some degree indeterminate. This is not to say that the ontology we are here expounding is ultimately vague— that the fundamental categorial scheme should allow for a distinction between crisp and scruffy (fuzzy, hazy, indeterminate) entities, as some have urged. Rather, vagueness is a conceptual matter: if you point to an irregularly shaped protuberance in the sand and say 'dune', then the correlate of your expression is a fiat object whose constituent unitary parts are comprehended (articulated) through the concept dune. The vagueness of the concept itself is responsible for the vagueness with which the referent of your expression is picked out. Each one of a large variety of slightly different and precisely determinate aggregates of molecules has an equal claim to being such a referent. When you have a map, and it has a shoreline with ins and outs, and on the water adjacent to one of the ins is a label saying 'Baie d'Ecaigrain', it is fairly easy for a human to see where the bay is. The outer boundary of the bay (seaward) is probably irrelevant to action or practice, unless some regulators have ceded all the islands (or oil) in the bay to some other country. But try to tell a computer that the bay is here, and that it extends from there to there on the coastline, but then just fades off to seaward, and get the computer to reason with that information the way that a person would.

Mountains, hills, ridges, also a cape or point— we can all agree that they are real, and that it is obvious where the top of a mountain or the end of a cape is to be found. But where is the boundary of Cape Flattery on the inland side? Where is the boundary of Mont Blanc among its foothills?

5.3 Consensus Fiats

Fiat boundaries may be products of informal consensus, reflecting for example linguistic usage as this evolves informally over time. Bays, peninsulas, etc., are parts of spatial reality, physical parts of the world itself. But they are parts of reality that would not be there absent corresponding linguistic and cultural practices of demarcation and categorization.

In a world with our everyday human practices, a bay or a hill is just as real as a chair or rock. The former are real consensus fiat objects, the latter are real bona fide objects. Bona fide objects are for obvious reasons more likely to be objects of categorizations that enjoy a high degree of cross-cultural invariance. Fiat objects, in contrast, because they are inculcated into the world by cognition, are more likely to show cultural dependence.

5.4 Legal fiats

Some fiat boundaries, like the boundaries of nations or postal districts, are social entities, analogous to rights, claims and obligations. Usually, when the legal system takes a fuzzily bounded region, it has to add a rule to crisp up the boundary. Private property in some jurisdictions extends to the mean low water mark, and for any seacoast part of the US or Canada you would find a legal definition based on mean low, high, average, etc. tide level, as to where private property stops and a commons starts. The boundary between the North West Territories and the provinces of Manitoba, Ontario, and Quebec around Hudson and James Bays in Canada, is the mean low tide level. And then there is a definition of how the boundary crosses the mouths of rivers. A legally-protected wetland has to have standing water on average more than n days per year. There may also be a minimum size rule. There is an area in Jim's back yard about 3 x 5 meters, that might qualify as a federal wetland, but might not be detectable by the appropriate authorities.

If one needs to know where the shoreline is, perhaps in order to regulate access or trespassing, then one selects some particular stage in the tidal cycle, such as mean low tide level; this produces a fiat shoreline that is fixed and reasonably crisp, and that approximates a bona fide shoreline that moves with the waves and tides. You cannot see or touch or trip over the fiat shoreline; but the fiat shoreline is there, nonetheless, as a part of reality: if you cross it, you may be prosecuted.

5.5 GIS fiats

Fiat crisping occurs also in the scientific realm. Consider soil, a continuously-varying mass of material that lies, in most places, just below the surface of the earth. At a scale of sand grains and roots, it might be thought of as made up of a myriad of objects or entities. But at a larger scale, the percentage of sand, silt, and clay often varies gradually and continuously over space, as might water content, pH, organic content, thickness, etc. Soil scientists have traditionally imposed upon this continuum a set of nominal soil types (categories or kinds); these are mathematical fiats that are artifacts of a certain technology. They might, for example, be some function of measurable quantities of a sample of the soil. If pH < 7.3 and percentage sand < 10 and percentage organic $<$ 2, and thickness < 1.1 m, then it is type X. Soil chemical and physical properties may constitute fields that vary more or less continuously and somewhat independently across geographic space. In such a system, soil boundaries are pieces of the 7.3 pH isoline, the 1.1 meter isopach, and so on. With perfect information, we can apply that typology to the continuous variables and get crisp boundaries for soil types. We can then represent the patch of soil of that type as a polygon, or draw the boundary with ink, and see soil as a world of geographic objects with crisp boundaries. These are scientific fiat boundaries, not bona fide boundaries. If we change the classification system, our boundaries will move; some of them will disappear; new ones will have to be created. If we do not keep the original continuous data, we cannot even determine where the new boundaries should be.

Soil scientists in the field of course do not measure everywhere. They observe where the boundaries probably are, and draw them on the map, based on changes in underlying geology, in vegetation, in topography. Then they dig in the middle of each polygon, and use the results obtained in the laboratory to classify the whole polygon. It is said that soil scientists seldom sample near the boundaries, perhaps because they know that they are not really there. Fields for each soil property would be a better thing to store. The polygons with crisp boundaries misrepresent the phenomenon, but they were the best that could be done with static, printed, ink-on-paper media.

5.6 Fiats in the realm of concepts

The concept of fiat boundary was introduced as a means of doing justice to the fact that we divide

up the spatial reality out there in more or less arbitrary fashion into sub-regions. But there is an element of arbitrariness or fiat also in the domain of our concepts themselves: we can partition the family of spatial concepts, of geographic entity-types, in more or less arbitrary ways into sub-concepts.

Imagine the instances of a concept arranged in a quasi-spatial way, as happens for example in familiar accounts of color- or tone-space. Suppose that each concept is associated with some extended region in which its instances are contained, and suppose further that this is done in such a fashion that the prototypes, the most typical instances, are located in the center of the relevant region, and the less typical instances are located at distances from this center in proportion to their degree of non-typicality. Boundary or fringe cases can now be defined as those cases that are so untypical that even the slightest further deviation from the norm would imply that they are no longer instances of the given concept at all.

In this fashion counterparts of the familiar topological notions of boundary, interior, contact, separation, and continuity can be defined for the conceptual realm, and the notion of similarity as a relation between instances can be understood as a topological notion (Mostowski 1983; Petitot, 1994). In the realm of colors, for example, a is similar to b might be taken to mean that the colors of a and b lie so close together in color-space that they cannot be discriminated with the naked eye. A similarity relation is in general symmetric and reflexive, but it falls short of transitivity, and is thus not an equivalence relation. This means that it partitions the space of instances not into tidily disjoint and exhaustive equivalence classes, but rather into overlapping circles of similars. This falling short of the discreteness and exhaustiveness of partitions of the type that are generated by equivalence relations is characteristic of topological structures. In some cases, there is a continuous transition from one concept to its neighbors in concept-space, as for example in the transition from lake to marsh to wetland. In other cases, circles of similars are separated by gaps (regions of concept-space that have no instances). This is so regarding the transition from, say, lake to reservoir.

Terms like 'strait' and 'river' represent arbitrary partitions of the world of water bodies. The English language might have evolved with just one term, or three terms, comprehending the range of phenomena stretching between *strait* and *river* or, in French, between *détroit* and *fleuve*. For while the Straits of Gibraltar are certainly not a river, and the Mississippi River is certainly not a strait, there are cases— such as the Detroit River and the Bosporus— that exist on the borderline between the categories. All are flat, narrow passages that ships can sail through between two larger water bodies (lakes, seas), and all have net flow through them, due to runoff, etc. Is Lake Erie really a lake, or just a wide, deep part of the river-with-five-names that is called the St. Lawrence as it flows into the sea? Well, that depends on what you mean by 'lake'.

6 Conclusions and Future Work

In this paper, we have presented some reasons why ontologies for geographic objects will differ from the ontologies of everyday objects commonly examined by philosophers and cognitive scientists. For one thing, topology and part-whole relations appear to be much more important in the geographic domain. Research on this topic must be careful to distinguish the domain of the real world from the domain of computational and mathematical representations, and both of these from the cognitive domain of reasoning, language, and human action. Human practice is an important part of the total ontology. Cultural differences in categorizations are more likely to be found for geographic entities than for objects at table-top scales. Geographic ontologies are more strongly focused on boundaries, and a typology of boundaries is critical. Work involving formal comparisons of geospatial and cartographic data standards and dictionary definitions in a variety of languages will provide an important starting point for the cross-cultural experiments with human subjects that will be needed to refine the details of the ultimate ontology of geographic kinds.

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Geographic Information Science and Systems: A case of the wrong metaphor

by

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Abstract

The breadth of the subject material of spatial or geographical information science has been articulated in a number of places, but it is argued here that efforts to address the broad ontological and methodological issues have been mis-guided. This has led to a number of questions as to the appropriateness of the subject area as either a coherent science, or as a science at all. This paper reviews some of these statements, and argues that the recently proposed metaphor of a continuum between the extremes of science and system is wrongly inspired. It is argued that the continuum concept arises from the ability of people to locate and identify *themselves* in terms of the end-points and the continuum. An alternative relationship between the system and the science can be seen as a cycle involving the crucial processes of concept development, implementation, testing and revision. It is therefore seen that a critical use of Geographical Information Systems fits with a number of ideas of the nature of science in general and the advancement of scientific knowledge in particular. The argument presented here, therefore supports the study and development of GIS (whichever meaning is ascribed to the acronym) as part of a scientific endeavour. Two further consequences follow from the discussion. First, it reaffirms the frequent assertion that education must focus on spatial theory, as opposed to training (which is specific to one or more systems). Second, the use of systems is an important stage in the development of spatial theory, providing a testing ground for that theory, and, furthermore, because all theory is a state of knowledge at a particular time, which becomes embodied within a system, use of the system should always be informed by a critical understanding of that theory.

Introduction

Recently it has been suggested that those working in Geographical or Spatial Information Science should pay some attention to the intellectual basis of their research in general, and how it fits with ideas about scientific endeavour in general. Discussion, which has centered around whether GIS is a collection of software items gathered into a system composing a tool (Taylor and Johnston, 1995), or is a coherent field of scientific