Integrating Fields and Objects in Geographic Information Science

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Describing the world in terms of objects comes naturally to us because our language and our technical analytical tools are highly object-oriented. This works well so long as we confine ourselves to describing situations in which there are well-defined, discrete individuals with clear criteria of identity, but in most real-life situations we are faced with a world of graded transitions and constant flux, in which the picking out of discrete individuals to be the objects of our discourse becomes clearly problematic—and is often acknowledged to be such. This is particularly the case in the geographical domain, where in addition to more or less well-defined objects such as people, buildings, cities, countries, lakes, rivers, roads, and railways (all of which, admittedly, also present identity-related problems), we have to handle numerous *fields*, i.e., functions assigning values of some sort to locations, as exemplified, for example, in maps showing elevation, soil types, land cover, or land use.

It has long been recognised that both the field-based and the object-based approaches to describing geographical phenomena are necessary in different circumstances. At one time the dichotomy between the approaches was presented in confrontational terms: i.e., the designer or user of a GIS had to decide which approach to adopt, and having made the decision, was then faced with the task of coercing all geographical phenomena into the descriptive framework provided by the chosen approach. One result of this was that considerable importance was attached to the development of algorithms for converting field data into object data and vice versa. In its simplest form this is essentially an issue of raster-to-vector and vector-to-raster conversion. An example of the former would be, given a field of elevation values, to derive contour lines as objects; and of the latter, given a set of contour lines to assign to each point in the underlying spatial grid an elevation value (either taken from a discrete sequence of elevation ranges, or, using some form of interpolation procedure, to estimate the actual elevation at each point).

More recently, it has been recognised that the two approaches must co-exist, and it is generally regarded as an important requirement for a geographical information system to provide the means to handle both field data and object data. There remain, however, important problems concerning the relationships between these two types of data, and there does not at present exist an adequate general theory to handle these.

A number of observations are pertinent here. First, it would be incorrect to view the relationship between fields and objects as an equal partnership, with both ways of viewing the world sitting alongside one another, as it were, at the same level. Rather, the field view is in a certain sense more fundamental, existing at a lower level of abstraction; the object view lies above rather than alongside this. Any notion of an object is in some degree an abstraction, requiring the imposition of identity criteria on the underlying (field-type) flux. Some objects may seem to us to be more naturally abstracted from the underlying continua, but this may in part be because they are defined in terms of inhomogeneities that for us are especially salient—whereas for creatures with very different sensory modalities and different ways of life, different sets of inhomogeneities may become salient, leading to the abstraction of different kinds of objects ("carving up the world in different ways", as it is often said).[1] A simple example is a wall covered with red and green stripes which might appear uniformly coloured to a colour-blind person—but we are all "colour-blind" with

[1] Pertinent references here include [11, 1, 10, 6].

respect to many phenomena in the world, for example we cannot see the ultra-violet markings on many flowers which serve as nectar-guides to the bees.

A second observation concerns the distinction between objects which are *abstracted from* the underlying fields and objects which are *imposed upon* them. Smith [9] characterises these as 'bona fide' and 'fiat' objects respectively. He presents the distinction as relatively clear-cut, while acknowledging that there may be problematic intermediate cases. He is particularly concerned to argue against the ("social science") view that *all* objects are fiat in the sense of being arbitrarily imposed social constructions (Searle [8] also is concerned to rebut this view). I have no quarrel with this, except to say that while some objects are certainly entirely fiat (Smith's favourite example of the state of Wyoming, with its bland rectangular boundary, comes to mind here), there are many cases where there is obviously an element of convention about how an object is delineated, although it is far from being entirely arbitrary (compare my discussion of sea-shore zonation and river systems in [2, §3.5]). In particular, a fiat boundary may be linked to a bona fide boundary—e.g., a river—and then the question arises as to exactly how strong the link is: the terms 'accretion' and 'avulsion' are used in legal contexts to refer to gradual and sudden changes in the course of a river or stream, and it is a generally accepted principle that the former type of change carries associated territorial boundaries along with it, whereas the latter does not. It is also true that a fiat object, once established, can give rise to bona fide phenomena as a result of its affecting human behaviour [5, §3.3].

The third observation is that the distinction between objects and fields is itself not quite the sharp dichotomy that is often presented. Plewe (reported in [7]) showed that there are cases which in some sense are intermediate between pure objects and pure fields: they are his hard partitions and his categorial coverages. My own idea of object-fields [3] belongs here too, being perhaps closest to hard partitions, although encroaching also on the domain of categorial coverages. It may not, perhaps, be strictly true to say that there is actually a continuum of intermediates here, but I would be surprised if this four-way split is exhaustive and clear-cut. Hard partitions are generally by fiat: this is the closest we come to the hackneyed metaphor of "carving up" the world—as when, say, the land area of England is divided into counties; whereas categorial coverages are generally bona fide to the extent that they are derived on the basis of what is actually there on the ground, but fiat to the extent that there may be an element of conventionality about which features on the ground are selected as determinative of the categories.

The fourth observation, already hinted at in some of the remarks above, is that there are many ways of deriving objects from fields and fields from objects (and indeed objects from other objects and fields from other fields).[2] Deriving an object from a field, or vice versa, does not mean *converting* one to the other. That is not what is at issue, and probably not even required in an information system which is equally able to handle objects and fields. Rather, it means defining an object which in some sense exists *in virtue of* the field (in the way that a mountain exists in virtue of the distribution of elevation values over the land); or defining a field which exists in virtue of the objects that exist (e.g., a population density field exists in virtue of the existence of individual people).

I believe that the time is ripe for the development of a formal ontological framework within which we can do full justice to the various issues concerning the relationship between objects and fields discussed above. A really useful GIS should be able to handle all of these as a basic part of its functionality, but in order to design a GIS to have such functionality it is necessary first to lay down an underlying conceptual framework which captures the relevant concepts and their interrelations.

[2] Some of these are briefly discussed in [4].

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