Restricting Scalability with Granularity

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Granularity as described by Hobbs [5] is a parameter of context that restricts a) the available objects and b) the categories and properties for characterizing objects. Geographic spatial granularity is mainly determined by size, and surfaces in geography as scale-dependency. Goodchild [4] points out that one main specialty of geographic attributes is *scale-specificity*: A region that is assigned the attribute *urban* is linked to a specific scale. Zooming in on the region should result in details being displayed; the urban region dissolves into city blocks, parks, streets, etc. Zooming out, the region will disappear and an annotated dot will represent the city visually.

Spatial information systems are often ignorant on issues of spatial granularity. Vector graphics are supposed to be arbitrarily scalable, and consequently arbitrarily exact. Geographic entities—as objects determined by approximative measurement—are therefore not accurately represented by data formats like vector graphics, if we cannot restrict scalability. Bennett [2] introduces a concept of forest as dependent on levels of granularity. The forest is a good example for a geographic entity which is not arbitrarily scalable: We may be uncertain about whether a certain given tree at the border of a forest still belongs to the forest, but it seems odd to ask whether a certain leaf on a tree belongs to the forest. An answer of common sense could be: yes, if the tree belongs to the forest; no, if not.

The trees constitute the forest, and the region of the forest is derived from the locations of the trees.[1] The common sense concepts of *forest* and *tree* depend on human object recognition: We know when we are *in a forest*. One could conclude that we know where the region of the forest is, because we obviously seem to know whether the region we occupy is inside the region of the forest. But do we then also know whether some arbitrarily small portion of space belongs to this region? Is a breach in the branches of a tree a hole in the forest?

The two questions obviously contain an error in granularity which is closely linked to the scale-specificity of geographic information in general. We can decide whether a region of a given minimal grain size is inside the forest, but not whether a smaller region or even a point belongs to the region, because there is a procedure that determines the

[1] This holds only for the common sense meaning of the word *forest*. Other criteria are important for the ecological system *forest*, for instance.

regions extent, and this procedure is physically tied to a given level of granularity and therefore not arbitrarily scalable. In the case of the common sense concept of forest, the minimal grain could be, e.g., that of the location of a perceiving person or the location of a tree; for the biological concept of forest as an ecological system, a device for measuring humidity, for instance, could enable a finer resolution.

The solution I propose is to explicitly represent the range of granularities for which an object is to be represented in a context. A context region—for instance a currently visible detail of a map in a GIS—and a minimal grain size provide such a context. The range of granularities of the object is derived from the extension of the object in the context region. Extension is characterized axiomatically in a planar geometry for congruence of certain regions (called *places*) which have the same extension in every direction [6].[2]

This method has two main consequences: a) instead of representing objects (or fields) as defined by *points* of measurement, extended and granularly fixed *places* of measurement can be used; b) the correct representation (e.g. punctual, linear, regional) of an object in a context can be found by comparing the range of granularity of the context with the *local* or *global* range of granularity of the object.

References

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[3] S. Borgo, N. Guarino, and C. Masolo. A pointless theory of space based on strong connection and congruence. In L. C. Aiello, J. Doyle, and S. Shapiro, editors, *KR'96: Principles of Knowledge Representation and Reasoning*, pages 220–229. Morgan Kaufmann, San Francisco, California, 1996.

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[5] J. R. Hobbs. Granularity. In *Proceedings of IJCAI-85*, pages 432–435, 1985.

[6] H. Schmidtke. A geometry for places: Representing extension and extended objects. In W. Kuhn, M. Worboys, and S. Timpf, editors, *Spatial Information Theory: Foundations of Geographic Information Science*, pages 235–252, Berlin, 2003. Springer.

[2]Places are related to circles of a certain metric. The circles of the Euclidean metric provide one system of places. Another system can be obtained, for instance, using aligned squares, which are important for raster-based conceptualizations of space, although the system does not provide a raster. Borgo , Guariono, and Masolo [3] and also Bennett [1] have shown that a full axiomatization of congruence geometry can also be based on mereotopology.