

Fundamental Spatial Concepts

KARL GROSSNER

PhD Candidate (Geography)

UC Santa Barbara

The prospectus for this meeting refers to “spatial concepts that lie behind GIS” and “spatial concepts of design,” asking how these sets relate to each other in practice, with the goal of informing both software requirements and educational curricula. This begs more basic questions of what concepts comprise those sets, whether they overlap, or even whether they are separate sets at all. Recent efforts to answer half of the first basic question are reported on here. There have been numerous efforts to organize concepts of spatial thinking in the domains of geographic knowledge, geographic education and GIS practice (see *References*). An effort is now under way to examine and perhaps unify those lists. We hope this meeting will help answer the remainder of those basic questions, an integral step in what are in essence a suite of mapping and design projects: mapping the conceptual space of ‘spatial thinking’ and design of optimal (at least useful) pedagogical strategies and complementary software tools.

The Center for Spatial Studies (spatial@ucsb) at the University of California, Santa Barbara is coordinating development of a collaborative web site (www.teachspatial.org) devoted to improving our understanding of how spatial thinking contributes to science and society, and to providing resources that promote applications of spatial concepts and spatial tools in teaching and learning. Now at an early stage of development, the site we’re developing will features three parts:

- **Part 1** enumerates and defines the core concepts of spatial thinking, presented in the original words of authors excerpted from (to date) 11 source documents. Users of the site are invited to read the original publications to appreciate the contextual frameworks used by these authors. To expand the range of disciplines and specializations represented, we seek suggestions for additional source documents.
- **Part 2** will present schemas that interpret, synthesize, and model aspects of spatial thinking, drawing on selected concepts from Part 1. We are soliciting submissions of schemas and explanatory text, to be posted for commentary and questions in on-line discussions.
- **Part 3** will provide an archive of user-contributed resources for teaching and learning. We seek contributions of pedagogic strategies, exercises, demonstrations, and course syllabi for use and consideration by others in their efforts to enhance spatial literacy.

The initial effort has produced a preliminary list of 98 distinct terms as the intersection of those asserted to be fundamental, or “core” concepts of spatial thinking in eleven source documents from the fields of geography and geology. We anticipate the list will grow significantly as more disciplines are added, then be reduced in a collective effort at generating an ontology of spatial thinking as a utilitarian framework for subsequent phases. Clearly the concepts cited most frequently by our initial sources (*Table 1*) are not particular to the geographic or geologic domains.

Arguably, as one goes further down the list, terms become more domain-specific. While the web site so far organizes the 98 concepts alphabetically and by referring source, some intuitive conceptual clustering should make them easier for workshop participants to review (*Table 2*). Several questions come to mind, including for example whether terms like ‘neighborhood’ and ‘neighborhood and region’ are redundant, and whether concept and method are a useful first-order division.

count	term
7	direction
6	location
5	connection
4	distance
4	scale
4	network
4	shape
3	magnitude
3	adjacency
3	interpolation
3	pattern
3	neighborhood
3	region
3	hierarchy
3	boundary
3	space-time

Table 1 - Most frequent terms

References

- de Smith, M., M. F. Goodchild, and P. Longley (2007). *Geospatial Analysis: A comprehensive guide to principles, techniques, and software tools, 2nd Edition*. London: Troubador
- DiBiase, D., M. DeMers, A. Johnson, K. Kemp, A. T. Luck, B. Plewe, and E. Wentz (Eds.) (2002). *Geographic Information Science and Technology Body of Knowledge*. Washington DC: Association of American Geographers.
- Gersmehl, P. J. (2005) *Teaching geography* New York: Guilford Press
- Gersmehl, P. J., and C. A. Gersmehl (2007) Spatial thinking by young children. Neurologic evidence for early development and “educability.” *Journal of Geography* 106:5,181–191
- Golledge, R. G. (1995). Primitives of Spatial Knowledge. In Nyerges, et al. (Eds) *Proceedings of the NATO Advanced Research Workshop on Cognitive Aspects of Human-Computer Interaction for Geographic Information Systems*, Palma de Mallorca, Spain, March 20–25. Boston: Kluwer Academic Publishers.
- Janelle, D. G. and M. F. Goodchild (in press 2009). Concepts, Principles, Tools, and Challenges in Spatially Integrated Social Science. In Nyerges, T. H. Couclelis, and R. McMaster (Eds.) *GIS & Society Research*. Sage Publications.
- Kastens, K. A., and Ishikawa, T. (2006) Spatial thinking in the geosciences and cognitive sciences: A cross-disciplinary look at the intersection of the two fields, In Manduca, C. A., and Mogk, D. W., eds., *Earth and Mind: How Geologists Think and Learn about the Earth*; Geological Society of America Special Paper 413, p. 53–76
- Golledge, R., M. Marsh, and S. Battersby (2008). Matching geographical concepts with geographic educational needs. *Geographical Research*, 46:1 p. 85–98
- Marsh, M. R. Golledge and S. E. Battersby (2007). Geospatial Concept Understanding and Recognition in G6-College Students: A Preliminary Argument for Minimal GIS. *Annals of the Association of American Geographers*, 97:4, 696–712

Nystuen, J. D. (1963). Identification of some fundamental spatial concepts. *Michigan Academy of Science, Arts, and Letters*, 48, 373–384.

O'Sullivan, D, and D. J. Unwin (2002). *Geographic Information Analysis*. Hoboken NJ: Wiley

Table 2 – An intuitive clustering of 98 fundamental concepts of spatial thinking in the geographic and geological domains

spatial heterogeneity	identity	absolute space	field	gradient
arrangement	object description	space	field view	surface
distribution	attribute	space and time	fields in space and time	grid
pattern	multiple properties of place	space as time		
density	condition	space-time	object	area
density estimation	comparison	time	object view	polygon
object location recall	analog	event and process	objects and fields	shape
	category		discrete entities	
diffusion	classification	location		
dispersion	object classification	coordinate	representation	scale
	exceptions		map	
hierarchy		direction	map perspective	
	magnitude	orientation		
sequence		position	map overlay	map projection
transition	adjacency	distance	overlay	
	adjacency and connectivity	distance and length	spatial integration	
spatial sampling	neighborhood	length		
spatial interpolation	neighborhood and region		deformation	
interpolation	region	buffer	dimensional transformation	
spatial probability		boundary	linearizing space	
uncertainty	areal association			
spatial model	association	spatial dependence	profile	
modifiable areal unit	correlation	distance decay		
	aura	proximity and distance decay	place	
frames of reference		spatial interaction	place and landscape	
spatial context	connection	competition for space	subjective space	
reference frame	connectivity		virtual reality	
	interaction			
	network			