Multi-cultural Aspects of Spatial Knowledge

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It is trivial to observe differences between cultures: people use different languages, have different modes of building houses and organize their cities differently, to mention only a few. Differences in the culture of different people were and still are one of the main reasons for travel to foreign countries. The question whether cultural differences are relevant for the construction of Geographic Information Systems is longstanding (Burrough et al. 1995) and is of increasing interest since geographic information is widely accessible using the web and users volunteer information to be included in the system (Goodchild 2007). The review of how the question of cultural differences was posed at different times reveals a great deal about the conceptualization of GIS at different times and makes a critical review interesting.

At the heart of the discussion of cultural differences relevant for GIScience is a Whorfian hypothesis that different cultural backgrounds could be responsible for differences in the way space and spatial relations are conceived. Whorf claimed that people using a language with more differentiation, for example in terms describing different types of snow, also perceive reality differently from people using a language with less differentiation (Carroll 1956). An early contribution picked up on suggestions made by Mark and others (Mark et al. 1989b) and identified several distinct issues that could be investigated individually (Campari et al. 1993):

1. the cultural assumptions that is built into the GIS software may differ from those of the user;
2. the influence of decision context in which a GIS is used;
3. the conceptualization of space and time may differ;
4. differences in the administrative processes and how they structure space;
5. the sense of territoriality, ownership or dominance of space, is different between people, again citing ethnographic examples;
6. the influence of the material culture, the ecosystem, economy and technology.

Campari and Frank in this early paper asked the question whether a single or a few GIS software packages could serve universally or local (national) development of GIS software, which still existed at that time, were justified by cultural differences.

1 Initial Focus on Cognitive Cultural Differences

Montello (1995) concentrated on cultural differences in the conceptualization of space and argued that a large share of spatial cognition is universal, i.e., the same for all human beings, because the problems the environment posed to humans during their

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development and to which their cognitive apparatus adapted, is basically the same for all humans; Montello refers to substantial empirical evidence for this claim. Evidence to the contrary had, despite efforts, not be found. For example the study by Freundschuh investigated whether growing up in a regular “Manhattan” grid would influence the spatial cognition compared with other teenagers who grew in a modern, curved road suburban setting; the results were not conclusive (Freundschuh 1991).

Linguistics has explored the different ways that the languages of the world express spatial relations. Well known are the central—periphery organizations used in Hawaii(Mark et al. 1989b), the use of up-down in valleys or on slopes(Bloom et al. 1994). Montello also addresses the Whorfian hypothesis and mentions the lack of evidence that 'language structures space' in a direct way (as a paper title by Talmy (1983) may be misunderstood to suggests). The differences in methods to express spatial situations in different languages, e.g., the preference for egocentric or absolute frames (Levinson 1996; Frank 1998a; Klatzky 1998), are observed in situations where no best solution exists and are preferences rather than absolute choices: Western cultures prefer an egocentric expressions (the glass on the left) whereas others, often rural groups prefer cardinal directions (Perderson (1993) for India, observe also the use of cardinal directions in a fight between two men in Synge's play 'The Playboy of the Western World' in Anglo-Irish); these are only *preferences* for one method and the other method is available as well. Montello's contribution suggests for the GIS development that multiple software modules that recognize and work with spatial situations could be useful universally and no cultural adaptation for differences in spatial conceptualization is likely necessary.

Egenhofer gave mathematical definitions for spatial terminology to express topological relations between regions and to make precise studies of what natural language terms like 'touch' mean possible (Egenhofer 1989; Egenhofer et al. 1991). He defined, for example, a large number of differentiable topological relations between a region and a line. With Mark he observed how people would group these relations in groups that are differentiated in verbal expressions (Mark et al. 1992; Mark et al. 1994). The testing situation asked questions about a road (the line) and a park (the region); it must be suspected that the context created in the testing situation, affects the grouping—separating cases that contain differences that are practically relevant in the situation. More tests could be worthwhile to see how context influences, but tests to discover cultural differences were not successful (Mark et al. 1995a) and revealed more commonality (Ragni et al. 2007).

Comparable to the formalization of topological relations are efforts to construct qualitative distance and direction relations (Frank 1992; Freksa 1992; Zimmermann 1993; Hernández et al. 1995; Zimmermann et al. 1996) from which qualitative spatial reasoning emerged as a subfield of spatial information theory. This line of research produced typically tables showing the result of composing two (or more) relations: e.g., Santa Barbara is west of Los Angeles and Los Angeles is west of New York, therefore we can conclude that Santa Barbara is west of New York.

The research in spatial cognition applied to GIS was driven by a hope that natural language like communication with humans would become the way we interact with a GIS; the influential paper 'Naive Geography' by Mark and Egenhofer discussed the differences between formal and human conceptualizations (Mark et al. 1995a). It was expected that computer programs could correct for typical human incorrect

conceptualizations (e.g., alignment error (Stevens et al. 1978) in the coast line around Santa Barbara, which runs conceptually north-south, but geographically east-west). Despite well-documented, regularly observed cases, where human and formal definitions systematically differ, no formalization has been published so far, but it was found, that these typical human spatial reasoning errors are independent of cultures. For example, Xiao found similar effects of regionalization in China as is observed in western cultures (Xiao et al. 2007).

2 Linguistic Differences

Users of GIS with a native language different than the one used for the user interface of the software could encounter difficulties and errors and misunderstandings result. Campari investigated (1994) the command language of GIS and the differences that result when non-native speakers are confronted with command language terms originating from English. It showed in detail that a native Italian speaker could misunderstand the meaning of translated command language terms because the connotations and metaphors evoked are different. For example the English term 'layer' has different connotations than the corresponding Italian term 'copertura'. The concern in the early 1990 was that spatial professionals would have only a basic knowledge of English and would use translated manuals and command language; today, GIS specialists learn the English based GIS command as they learn other computer terms, fully aware of the limits of metaphorical transfer of common-sense knowledge to the virtual realm. The difficulty Campari pointed to is absorbed by the trained GIS specialist who builds the application for users and bridges the differences from the English based technical GIS vocabulary to the user's description of operations in his language.

The differences between the vocabulary appear simpler: Different vocabulary terms seem to describe the same class of things and translation a simple mapping: from French 'chien' to German 'Hund' to English 'dog'. Unfortunately, for most terms, translation is not as simple: the English use the two terms 'in' and 'on' whereas German differentiates 'in' 'an' and 'auf' (Frank 1998b) and a direct mapping fails: Germans ride 'in' the train or bus, whereas English ride 'on' the train or bus. In a landmark paper Mark (1993) compares natural language terms for landscape features in English, French, and Spanish; it becomes apparent that these closely related languages use different distinctions (Frank 2006) to comparable (but not strictly translatable) landscape terms. Despite the clear-cut definitions in dictionaries, comparison with the pragmatics of landscape terms, i.e., their actual use, is strongly influenced by the ecological context. His work was based on dictionary definitions, but comparing actual use of such terms in toponymes casts doubts on the strictness of the definitions (Mark personal communication).

Current research of Mark and his colleagues in ethnophysiography investigates landscape terminology used by indigenous people in different parts of the world (Mark et al. 2007). They are careful to select people in similar ecological situations (arid regions in south western USA and in northwest of Australia) to reduce the effects of ecotopes. An observation surprising us is that a stream-bed and the water flowing in it can be strongly separated conceptually. They also observe a strong

tendency to 'populate' the landscape with spirits (ghosts), which is a reflection of a polytheistic religion and thus a cultural difference.

3 Differences in the Spatial Structure and the Physical Environment

GIS still force our understanding of the world to fixed, exactly bounded objects. This is, on one hand, the effect of the use of coordinated geometry, and on the other, the inheritance from a land use planning tradition, where land use is planned for non-overlapping, clearly bounded regions. Legal traditions differ in how sharp they create boundaries; current European law varies between a concept of general boundary that is formed by a (possible wide) hedge in England and Wales and geometrically sharp boundary lines fixed by coordinates in Austria.

A variety of aspects were discussed in a workshop (Burrough et al. 1996b); resulting in reports that show the counter-intended effects sharp boundaries can have (Burrough et al. 1996a). Campari (1996) discussed the conflict between clear-cut two dimensional planning regions as they are applicable in the physical environment for which the earliest planning GIS were built in the 1970s, i.e., the U.S. Midwest suburban towns and their planning, and applications of GIS to capture the reality of traditional towns, built on steep inclines, e.g., in southern Europe. The limited two dimensional view is insufficient and a three dimensional representation is necessary, but not likely resulting in sharply delimited and single use regions that can be entered in a GIS; the 'open' space in a town serves for transportation, access to sunlight but also for rainwater runoff. The application to GIS in other cultures, with other building styles, climates etc. may require other deviations from the two dimensional, sharp boundary model.

Efforts to define approximate spatial relations between vague regions are important to bridge the gap between the geometric reasoning of GIS and the human users. Sharma described in his PhD thesis an approximate calculus for distance and directions (1996) following the approach by Frank (1992) and Rezayan et al. (2005).

Specialized systems for spatial navigation in cars but increasingly also for pedestrians have become very popular and questions of how humans give directions are now practically important (Lovelace et al. 1999) studies in the 1980s (Denis 1997) have shown (small) differences between genders, but no differences between, say European and USA (unpublished thesis TU Wien). State of the art in commercial devices give satisfactory wayfinding instructions in simple cases, but they are not satisfactory in complex situations where the spatial reasoning by the system differs widely from the way humans conceptualize a situation. To give precise verbal instructions to navigate a complex, multi-bifurcation is assisted by using graphical displays—distracting the driver in a situation where his attention should be on the other moving cars around him; equally distracting are the differences between the system's view of where a turn instruction is necessary and where not—indicating that the concept of 'following a road' based on the road classification and numbering scheme and the visual perceived reality conflict.

It is apparent that geographic information could be used to improve the search on the web. In many cases, a query has a spatial focus and objects satisfying the

conditions but far away are not relevant (e.g., search for a pizza place, or an ATM). To process queries like 'show me the pizza places downtown' or 'find a hotel in the black forest' we require a definition of where 'downtown' (Montello et al. 2003) or what the 'black forest' is. Efforts to glean this information statically from the use of such terms on the web are underway and often reported as using 'vernacular' location terms (to differentiate from the toponymes collected in official gazetteers) (Twaroch et al. 2008).

The context dependence of qualitative spatial relations is well known but poorly understood. Most of the above issues to make GIS more usable and more 'user friendly' depend on understanding how the present context influences the meaning of the terms used. Linguists have studied context dependence of semantics in general and have—unfortunately—not come up with a satisfactory answer. A recent publication by Gabora, Rosch and Aerts (2008) gives a very precise account of the difficulties of previously proposed approaches and sketches a novel method; it uses quantum mechanics as a calculus for transforming expressions between different contexts and claims that it corresponds to empirical observations. The application to spatial situations is a promising, but open question.

4 Conclusions

Differences between cultures affect how GIS is used and 'cultural differences' form a major obstacle in the application of GIS. The initial fears of substantial differences in the cognition of space by human beings from different cultures has not been confirmed. Similarly, the way spatial relations are described appears more situation (context) dependent than culturally different. Studies formalizing spatial reasoning showed very substantial "cultural" differences between the way a computer system treats geometry and human performance, a field of research, were many questions are still open—but fortunately simplified in so far as we may expect that human spatial cognition and human spatial reasoning is universal. Differences in the conceptualization of spatial situations—independent from the socio-economic (cultural) context—are not documented, but large differences in language expressions to communicate spatial situations exists. A possible explanation is that the conceptualization and the mental classification is much finer and only for communication mapped to the coarser verbal expression. Early research in spatial cognition in GIS assumed a close connection between the mental concepts and the verbal expressions (Mark et al. 1989a) and followed a linguistic tradition to reported the verbal expression as spatial concept.

Large differences exists in the way, spatial information is used in different cultures. The practice of spatial decision making is different, because the cultural (social, legal, economic) situation provides a different context and requires different distinctions (Frank 2006) between objects to form classes of situations that can be dealt with similarly. Such cultural differences are visible between countries—especially those using the same language—but are also observable between different agencies in a single city, or even between different parts of a single organization. To understand multicultural influences in geographic information, research today could be focused on the following aspects:

- Differences in the vocabulary: terminology differs (lake vs. lac, in the distinctions used to separate the terms, e.g., small-large to separate pond and lake, vs. l'etang separated from lac by man made—natural;
- Differences in graphical style, perhaps most obvious in the cartographic styles found in maps of different National Mapping Agencies. Some of the differences follow from the landscape, ecological, economical and political situation;
- Cultural meaning of terms; evident are the differences even between countries sharing the same language (USA, Canada, India, UK, etc. or Germany, Austria and (part of) Switzerland). The cultural (legal) environment defines concepts and terms, which are meaningful in this social-cultural context (X counts as Y in the context Z—(Searle 1995)) and differ widely, even when using the same word.
- Differences in conversation style (Grice 1989): is it acceptable to anthropomorphizing computers, level of politeness required even in a computer dialog. Length of turns between the partners in a conversation.

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