Cognitive Mapping for ITS Services

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ABSTRACT

Spatial enabled Intelligent Transportation Systems and Services (ITS) are becoming the real framework for traffic management, providing support for response planning and analysis, and integrating facilities such as incident management, infrastructure maintenance, telematics and communication operation, floating car data, traveller information and data dissemination.

Within this exciting area, geographic databases and services makers face the challenge to meet higher content and quality requirements for their products and solutions, providing detail, functionality, performance and integration. However, the demand for such facilities, based on content, positional accuracy, detail, timeliness, etc., does not necessarily meet the most intelligible interface for operation or exploitation.

As an alternative to physical representations, mental or cognitive maps [1] enables the ability to codes and simplifies the way our spatial environment is arranged, applying systematic distortions, highlighting how a person sees or should see the real world.

This paper is concerned with the implementation of cognitive maps used to manage the operational activity in Brisa Motorways, and how these applications are based in GIS services, providing in parallel conventional mapping.

GEOGRAPHIC INFORMATION SYSTEMS FOR TRANSPORTATION

The use of computer and telecommunication-based applications to improve transportation analysis and management is a fact of life significantly older than the ITS institution, comprising a wide range of tools for managing transport networks and services for travellers. However, transportation information and management tools have often not been accessible in a user-friendly manner and, the effective integration of data from diverse sources has too often been a challenge in itself.

Geographic Information Systems (GIS) have provided partial solutions for human-machine interaction and have revolutionized spatial planning and decision making by using the spatial dimension of depicted world as a common thread according to which all information can be referenced [8]. The application of GIS to Transportation (GIS-T) is one of the most important and rapidly growing domain from both areas, allowing a challenge to interconnect infrastructure planning, design and management, traffic analysis and control, transportation safety analysis, environmental impacts assessment, etc..

A key issue to enhance the GIS-T technology is the ability to be a supply-side "pusher" of geographically enabled tools for the demanded trends, providing solutions for the complex and highly interrelated system subject for land and transportation.

In the other hand, intelligent map base solutions suppliers along with the corresponding technology that use it, aim to provide applications where managers and users can visualize a problem and allow the appropriate tools to assist with final decisions.

Supported by a huge marketplace GIS-T has provided new tools in the hands of transportation geographers to not only create maps much more efficiently, but to analyze spatial data in map form as well.

COGNITIVE MAPS

The term "cognitive map" was firstly used in 1946 by Tolman [1], to describe the behaviour of rats escaping from a maze and made a "bee-line" for a reward box. However, the idea of cognitive maps dates back to 1913, where Trowbridge [12] carried out investigations in cognitive maps, which he called "imaginary maps". His primary interest was to investigate why some people were more easily confused when performing orientation tasks than others. For a long time, it was assumed that cognitive maps were like real cartographic maps in the sense that they accurately represent distances and directions between locations in the environment, based on formal geometric principles. This point of view has been reassessed over the last two decades as researchers have shown that they are less precise than proper maps, although the use of the term "map" might suggest otherwise. In fact, distortions in cognitive maps are the rule, rather than the exception [6].

Basically there are three main distortion effects commonly applied to a build a cognitive map: alignment, rotation and nested hierarchical structures. In the first case, places in the cognitive maps tend to gravitate into relative alignment with vertical and horizontal lines. Such is the reason why, for example, the Madeira Island is typically represented as lying due west of the Algarve, and south of Portugal rather than strongly to the southwest, as it really is. In the second case, individual structures tend to be rotated so that their natural axes become aligned vertically and horizontally; that is the reason explaining why the Azores might be represented as directly above Madeira, rather than slightly to the west. In the third case, the estimation of distances and directions is influenced by the layout of structures hierarchically above, at least in part, to make estimations of the relationship between elements; accordingly, in a mental map, the direction from Lisbon to Madrid is clearly east rather than east-northeast. In fact, the main relationship direction from Portugal to Spain is east.

"Cognitive mapping" is defined as process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls and decodes information about the relative locations and attributes of phenomena in their everyday spatial environment [9]. Simply put, it is the process of creating a mental map.

Schema-driven Perception

Experiments in cognitive science suggest that some aspects of the classical view of categories are not true for most of the categories that individuals use to organize their worlds. Such developments propose that the categories that people use are not necessarily "objective" [5]. According to this view, perception and cognition do not involve "direct" interaction with the world, but rather occur through cognitive models, image-schemata, etc.

Geographic visualization

Visualization through mapping has long been treated as a fundamental geographic method. This point of view is shared by Philbrick [11] who stated that "[…] not only is a picture worth a thousand words but the interpretation of the phenomena geographically depends upon visualization by means of maps". Following this approach, visualization can be considered a renewed way of looking at one application of analysis/visual thinking and of communication/presentation.

The fundamental idea is that maps can be conceptualized in two continuous axes: 1) from a kind of private use of maps, where an individual generates a map for his own needs, versus public one; 2) an usage that is directed towards the revealing of unknown or otherwise hidden data as opposed to the presenting of known data, where the user is attempting to access particular spatial information.

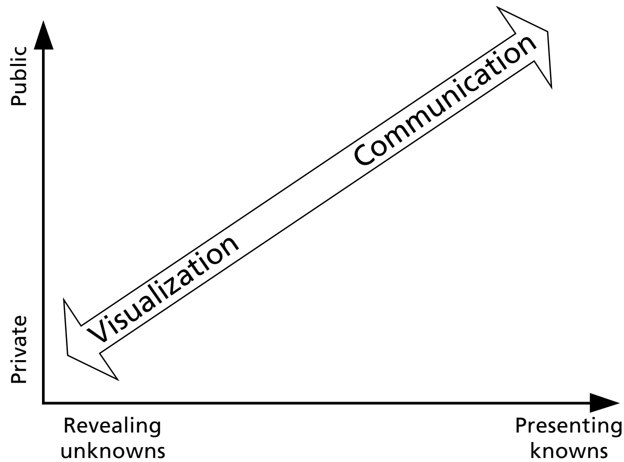

Fig. 1 – "Space" of map use in terms of visualization and communication

BRISA ATLAS

The first approach to make a real implementation of those concepts in Brisa is based in a suggestion that information from the imaginary world is not like a continuous map, but is hierarchically structured – more like an atlas. The top level of an atlas provides information about the relative positions of countries, capitals, cities or districts with little detail. In this present case, the atlas gives information about motorways, regional support centres (CO's) and stretches of the infrastructure.

The Brisa Atlas starts as a concept map of the structure of knowledge without any graphical representation. Seemingly near the entity relation-model, this cognitive structure nodes are established with vertices, represent basic entities or concepts, and connections or links, represent the relationships between concepts (one-way, two-way or none). Both concepts and links may be categorized, and the concept map may show temporal or causal relationships between concepts.

With such a concept map fully in place, the graphical representation was developed in order to interpret and validate the structural model.

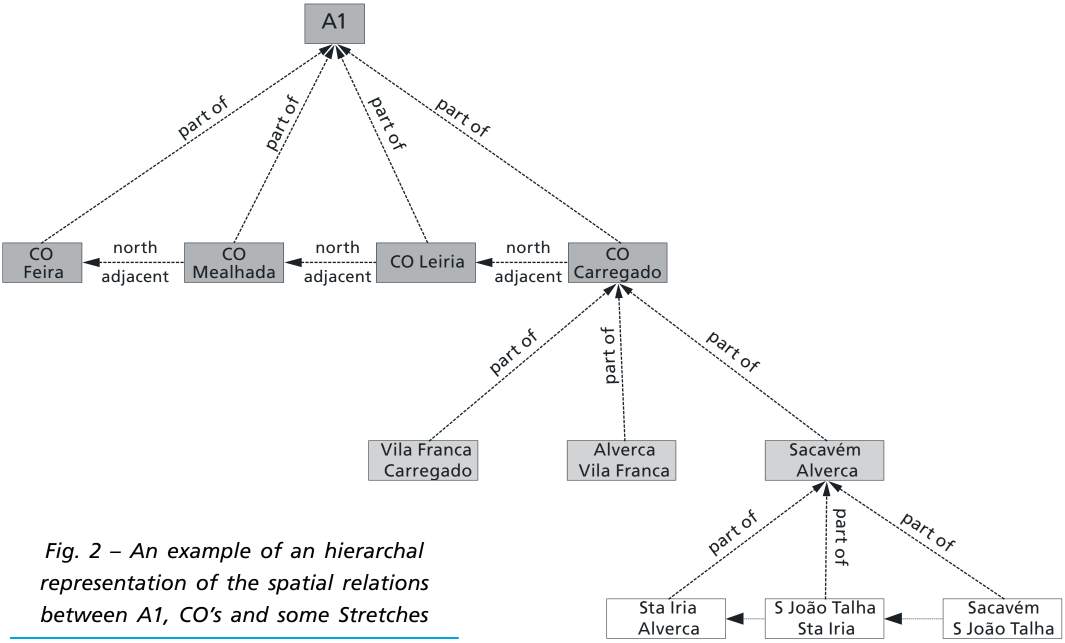

Fig. 2 – An example of an hierarchal representation of the spatial relations between A1, CO's and some Stretches

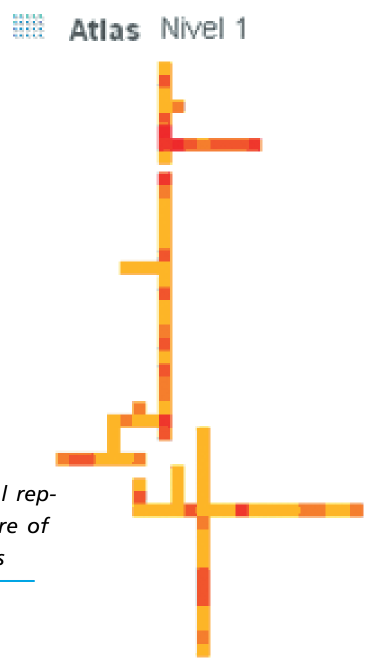

Fig. 3 – First-level graphical representation of the structure of knowledge Brisa Atlas

Behind the basic idea of building a global architecture of a knowledge domain and making existing expertise accessible through a visual interface, the Brisa Atlas aims also at providing a common framework through an explicit visual model to which different actors or users can relate to in their relevant competences.

Simply put, the Brisa Atlas is merely an enabler – a mean or a vehicle to express and release the expertise that lies within a handbook of procedures developed on top of more than thirty years of experience of motorways' operation and management.

MANAGING ITS SERVICES THROUGH BRISA ATLAS

Basically, the Atlas is a schematic map that consists of two main parts: a ground layer which represents the context for real mapping, and the individual elements that are mapped within this context. With the aim of providing a mutual context that different observers with diverse backgrounds at multiple level of detail can understand and relate to, the ground layer is based on the visual representation of the basic entities, concepts and relationships that describes the motorway and the involving environment, such cross intersections, service and resting areas, toll plazas, Brisa regional units and many more. In a passive way, each entity can be inquired to obtain some of its details and, in some cases, to link with other specific services.

Onto such ground context, the individual items are dynamically mapped and enabled in order to provide the necessary ability and expertise required for the user to deploy its core competences. In the first stage, the Atlas was planned to support the coordination of Brisa's motorways operations, and includes access to the telematic services infrastructure, such as video cameras (CCTV), variable message signs (VMS), environmental stations (ES), SOS call boxes, tunnel device controllers, and so on. From the symbolic link, linearly located along the motorway stretch, and representing the functional and operational status of the equipment, there is direct access to the visualization and management of the corresponding device, according to the user's privileges. A very important and thoroughly used feature, is provided by a second layer of individual items that consists of the real-time information about events and assistance vehicles, also linkable with the cognitive map.

In addition to the background infrastructure and the dynamically mapped interactive individual elements, there is a third layer of effective knowledge: based on the event location context (e.g. SOS call box, GPS located vehicle) and thematic context (e.g. SOS call, Video processing alarm), the Brisa Atlas redraws the interactive map, highlighting the eligible resources according to the availability and suitable competence. Individual symbols are coloured in yellow and dully enlarged.

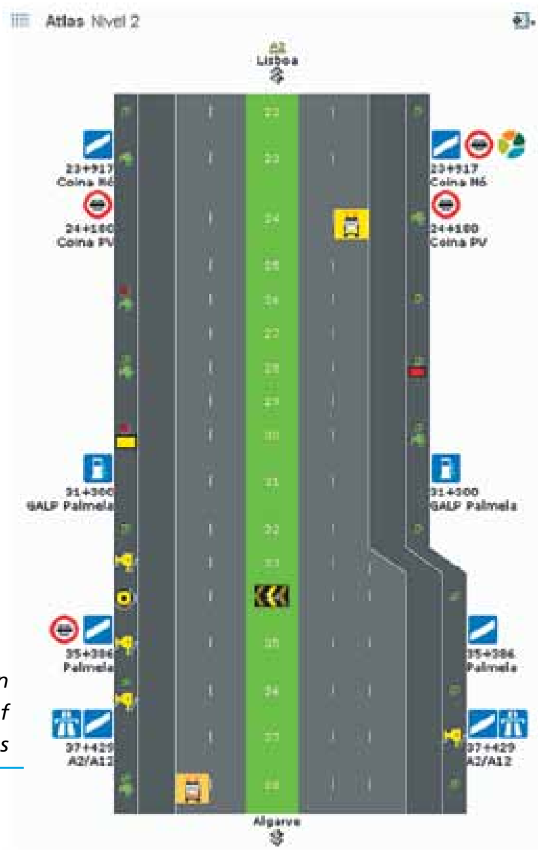

Fig. 4 – Graphical representation of the structure of knowledge Brisa Atlas

The figure above prompts a real-time map in accordance with a particular event (SOS emergency call). The event location is dynamically framed with the motorway schema (kilometre stones, lanes geometry, cross intersections, etc.). In such schema, the individual elements (CCTV, VMS, SOS) and other resources (e.g. assistance vehicles) are mapped, highlighting the appropriate use for a response planning.

In addition to the schematic mapping, the Brisa Atlas provides all functionalities necessary to create and manage event processes, integrating all events and actions as facts.

CONCLUSIONS

The large majority of problems facing ITS services and data possess an inherent geospatial nature. Following the dramatic increase of relevance of such knowledge domain, there were significant scientific and engineer progresses directed at providing a wide range of applications and solutions to face the community needs. Although the availability of methods to transform this data into information and, subsequently, into knowledge, derived from the integration of disparate sources, there is a lack of ability to prompt instantaneous changes in maps. Such is the case for pointing out quantifiable differences in maps, for the number of things a user can make visible is limited, but such is also the case for the more qualitative differences associated with the way users think and, consequently, in the way maps should function.

In the heart if this challenge, geographic visualization move from the sense of "making visible" to "making visible and understandable on-fly", as the intersection of representation methods, cognition and analysis.

Conceived as a structure of knowledge about Brisa's Motorways, Brisa Atlas rapidly grown to be a real-time mapping interface to understand and support operations management.

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