Schematic Maps as an Alternative to Point Coverages When Topographic Maps are not Available

Elissavet Pontikakis, Florian Twaroch
Institute for Geoinformation and Cartography, Vienna University of Technology
{pontikakis,twaroch}@geoinfo.tuwien.ac.at

Abstract

This paper describes the visualization methods of point related spatial information used in geo-portals for tourism and recreation. We examine the issue of visualization of points of interest when base topographic maps are not available. We compare the schematic map approach to point coverages. In our hypothesis, we suggest that the schematic map approach offers the best alternatives for assisting the tourist in taking decisions during the planning phase of an excursion when detailed topographic map information is not available. We use algebraic operations to evaluate the visualization approaches.

Keywords: **visualization, points of interest, national defense, schematic map, cost, weights, metro map metaphor, tourist portal, GIS, web map services, military sensitivity**

1. Introduction

Web portals are widely used by Internet gurus and novice alike. We observe a rapid increase in the data which is available to these portals, specifically to geo-referenced data. Google Earth, MapQuest, Map24, Via Virtual Earth present popular examples. As the data availability increases, so do the demands of the user. The Portals represent the gateways to a plethora of sites and their supported data. In addition, they represent the emergence of new business ideas. In this paper, we present the case of a tourist portal and we focus on the issue of visualization of spatial information in sensitive areas near borders or military installations. We draw our example from a tourist portal developed under the eTen EU program. We address the issues of visualization for military sensitive areas. Thus we improve the opportunities of the individual tourist providers of these regions for exposure. We examine the solutions as answers to individual questions which are asked by the tourist [1].

Section 2 of this paper discusses in detail our use case. The background theory is reviewed in section 3. In section 4, we describe the proposed solutions and in section 5 we present our conclusions. Section 6 provides an outlook to future research.

2. Use case and hypothesis

Let us imagine the following case, first for the portal and then for the potential traveler and user of the portal.

2.1 The tourist portal

A tourist portal provides a gateway to municipalities and the activities they offer for a tourist. The activities cover a wide range of recreational tourism such as hiking, bird watching, water rafting, skiing, etc. Dynamic maps are displayed through a standardized web mapping service. The portal manages the display of points of interest (POIs) and the content associated with each POI at each municipality. Special focus aims in instituting a uniform way of managing content for all participating municipalities.

The above paragraph summarizes the set up of the GEOCOMPASS portal supported by the E-Ten project of the European Community. The GEOCOMPASS portal implements technical solutions on visualization. In addition, the project addresses the issue of content management from the provider's side and decision making from the tourist's perspective.

2.2 Restrictions for consistent performance

The description of GEOCOMPASS as presented here could fit many other tourist portals. The parameters emphasized in Figure 1 are derived from the above description printed in italics. We refer to them as "hidden concepts". We suggest that the hidden concepts hinder the visualization efforts in a portal. In most projects, these issues are realized much too late and alter the expected performance. Often, these issues affect one another. In this paper, we are motivated by the military sensitivity of a location which also offers tourist attractions. The problem is the lack of topographic data for civilian use in these regions. We suggest ways to harmonize the performance of a portal when an issue like this arises. There are additional reasons which hinder *data and information availability* such as fear for abuse by unwanted groups, and financial and technical limitations. Google Earth provides a hot topic for discussion on the area of fearing potential abuse of its uses [2]. On the other hand the issues of financial and technical limitations are known to smaller, economically depended localities. In these cases, data can not be acquired at all levels. There is a cost pyramid associated with the different levels of the GIS data acquisition [3].

One of the municipalities which participate in the GEOCOMPASS portal is located in Northern Greece. Topographic maps issued by the Greek government are generally restricted by the Greek military and are not always available [4]. In his search for topographic maps the user often encounters responses such as "*We are pleased to announce that we have received the 1:250,000 topographic maps*" [4]. The soviet military-issue series often provide an alternative.

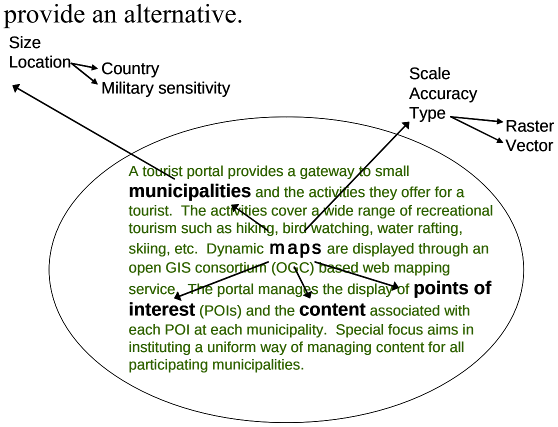

Figure 1. Hidden concepts in portal description

Figure 1 provides an example of the issues faced by the web mapping designer when dealing with data availability and compatibility. In our paper we seek solutions which will provide a chance for such regions to promote themselves. We link these solutions to visualization methods.

2.3 The case of a potential hiker

A casual hiker is going for a Sunday trip. His interest for a specific hike depends on criteria such as a) the difficulty and length of the path, b) the estimated time to the next service facility based on his physical condition, c) the list of alternatives offered along the way, and d) his personal taste for the surroundings as seen on pictures and described in text.

2.4 Hypothesis

Our hypothesis is that in the areas where topographic data is not available, schematic map representations communicate better information in geo-based web portals than representations that are solely based on geo-referenced assembly of points namely point coverages. We define "information which better communicates" as information which allows the user to take decisions which fit his goals. Detailed topographic data is not available in regions where we encounter legal, military, or financial impediments.

3. Background theory

Visualization is defined as the formation of mental visual images and as the act or process of interpreting in visual terms or of putting into visible form [5]. Visualization is linked to mental image and visual perception. Edward Tufte suggests that the methods used in presenting quantitative evidence are directly linked to the results of the decisions taken based on this evidence [6-8]. Although geo-spatial information does not clearly fall in the realm of quantitative information, the authors of this paper share the above position between information presented and assistance in intended decision. In our specific context of a web portal for tourists, information visualization is a tool for communication. We observe that geo-portals often capture point data and enrich them with as many attributes as possible. However, more data is not necessarily better information. A concise and clean design is attractive. Google provides an example of frugal but effective design. In the geo-portal, the relevant information has to be on the map. This fact on its own, adds to the complexity and misrepresentation of the information and contributes to the often observed compromised performances of web sites with maps. Map data is expensive and often requires regular maintenance. A rough cost estimate for the data is that it is an order of magnitude more costly than the software used to visualize it and two orders of magnitude than the hardware [3].

3.1 Communication process via portal

Portals express communication processes previously expressed by real-experienced contacts. Portals too, employ the basic steps in the communication process encountered among target groups namely 1) orientation, 2) building trust in the information, and 3) experiencing the feedback of their decisions [9]. The differences between the real-experienced contact and the contact through portal lay in the "when" and "where" the outcome is observed for the target group participant [1]. This outcome is observed for each of the steps of the communication process. This is of importance for the current research as it imposes additional limitation to possible technical solutions. For example, due to delayed feedback time, solutions provided by low end providers, i.e. the tourists, are considered inadequate.

3.2 The main questions a tourist portal answers

Tourist information systems should help a tourist to manage his holidays. There are two main questions answered by a tourist portal namely "where can I perform an activity?" and "what types of activities are supported by a certain area?" [1].

In the literature, three planning phases have been distinguished: the pre-trip planning, the on-trip and the post trip phase [10] . Research relates this to the level of detail involved in each phase [11, 12].

In the *pre-trip planning* phase consumers like to get a rough overview to decide where to go. This decision process is influenced by various factors like the financial, family, or physical condition of the participants and the activities carried out in the tourist region. Maps support the decision process by giving information about the surroundings of the chosen location.

In the *on-trip phase* the consumer is "in situ" and often assisted by a mobile device or an information checkpoint. Ad-hoc queries need to be answered to support the consumer's decision, i.e. "Where is the next restaurant?". The demands, in terms of data granularity and up-to-dateness, are much higher than in the pre-trip planning phase. Very detailed information is required in real time.

In the *post trip phase*, users give feedback to the web portal and share their experiences about the holidays online. They give a rating of the overall performance and usability of the tourist information system comparable to online selling systems.

Maps and visualizations of points of interest used in pre-trip planning are a useful assistance in this phase. In the use case of a tourist web portal with maps the focus lies on the pre-trip planning phase. In the presented region in Greece, data are not available due to military restrictions. Our aim is to support the user with alternative visualization forms to improve the communication process.

4. Proposed Solutions

The previous section has shown that tourists are involved in an asynchronous communication process with a web portal. An asynchronous communication process is observed when the sender and receiver of the information experience the consequences of each others actions with a time delay. Considering just the pre-trip planning phase a user states two spatial questions to the information system: *1) Where am I?* and *2) How to get to points of interest?* Golledge proposes a set of questions asked through a cognitive map such as: "is it there?", "how can I go there?", "what is the shortest way?" etc. [13]. The concept of cost is thus added to the above two main questions in the form of effort. The additional spatial question states: *3) How much effort does it take to reach a point of interest?*

A cognitive map can be described as a mental representation of an environment. There is an increasing interest in the cognitive aspects of map representations, especially schematic maps [14]. A schematic map is a linear abstraction of a functional network, such as networks of roads, railways or footpaths. Metro maps are schematic maps that maintain just line and point features [15].

We consider that there is an algebraic morphism between the operations described through a cognitive map and those described through a map on a computer. An algebraic morphism preserves the structure of objects and operations in different domains and ranges.

We propose a schematic map solution which visualizes the connection between POIs. We introduce a set of algebraic axioms for each of the operations used in the evaluation of the proposed solution namely the schematic mapping. We compare this visualization with the geo-referenced point coverage.

The above questions are connected to algebraic operations such as "is it there", "find shortest path", "access" etc. Hofer suggests three classes of topographic map use operations namely, measurements, terrain interpretation, and navigation [16]. Schematic maps address the measurement and navigation classes.

4.1 Algebraic Operations

We consider that the POIs are points and the map extent is a closed region. The axioms describe the relation of a point and a region or the relations between two or more points. All points of interest are elements of a tourist region A. All links L between these points are elements of the tourist region A. The three questions defined in section 4 namely *1) Where am I?* , *2) How to get to points of interest?*, and *3) How much effort does it take to reach a point of interest?* lead to the following five operations:

Operation 1: *Is POI_1 there?*

Operation 2: *Is POI_1 linked to POI_2?*

Operation 3: a) *Is line segment POI_1 POI_2 shorter than line segment POI_1 POI_3 ?*

Operation 3: b) *Is traveling line segment POI_1 POI_2 faster than traveling line segment POI_1 POI_3 ?*

Operation 4: *Is POI_1 geo-referenced?*

Operation 5: *Is there freedom to infer for a POI which does not belong to the set of POIs?*

Operation 3 is split in two sub operations that are both related to cost. Operation 3a is related to cost in distance while operation 3b is related to cost in time. We consider that topographic maps contain a subset of the links, while schematic maps contain a subset of links found in a topographic map. We use a formal model to validate the algebras of the operation arguments. In the Appendix of this paper we attach the executable implementation of the above algebraic axioms with the use of the functional programming language Haskell [17]. Extended information on the Haskell language is found on the web (www.haskell.org).

4.2. Schematic maps, the "Metro map metaphor"

Mathematically schematic maps are straight planar line graphs consisting of a set of nodes and edges. They provide topological information such as "which points are neighbors to each other", or "which points lie on the same sequence". Figure 2 provides an example of a schematic map.

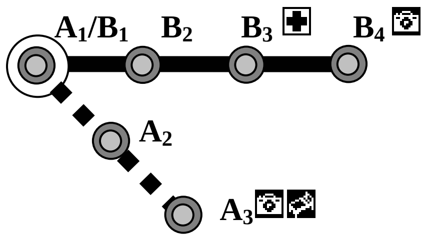

Figure 2: A schematic map

Metro maps are schematic maps. They provide information with the use of symbols such as "which metro line connects two stops" or with the use of weights such as "what is the frequency of the passing metros" or "what is the estimated travel costs from one location to another". In public transportation, given a starting point and a destination, it is easy for a passenger to determine which transportation means to use to reach a goal. Recently the "metro map metaphor" has been used in virtual guided tours. [18]. The "metro map metaphor" is well known to people who move in the city and use public transportation. These are also the potential clients of a web portal that promotes mountain and countryside tourism.

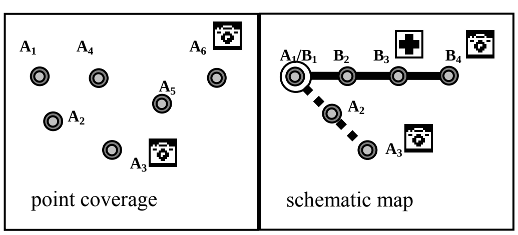

Figure 3: Point coverage vs. schematic map

We would like to take this idea a step further and transfer the use of the "metro map metaphor" to tourist maps for mountain and country side. The regions of interest do not have access to detailed topographic maps, but have *geo-referenced datasets of point of interest* (like churches, museums, restaurants, bars). In a content management system, the owner at a point of interest can insert text and photographs of his own location and *links* to other points of interest. With the use of the "metro map metaphor" we try to exploit this additional *link* information, instead of providing the user with a geo-referenced point coverage. Figure 3 provides a visual comparison of the two representations.

We hypothesize that metro maps communicate better in the pre-trip planning phase than available presentations based on point coverages. Here, cartographic variables like color, size, shading, patterns, and symbols are exploited. When a tourist is interested whether he can carry out a certain activity in the surrounding of his accommodation, he just "enters a fictional metro" on the schematic map. He subsequently follows the line until he detects the symbol for the desired activity. Based on specific weights he can decide whether the "nearness" of the activity is satisfactory or not.

Hence, schematic maps are used to provide overview when entering the information infrastructure by showing *what you can access*, *from where* and with *what cost* over all specified routes. This relates to the first and second aspect of communication through portals where the user orients and builds thrust in the information.

4.3. Real path and airline distance

We define as air-line distance the straight line segment which connects two points when ignoring all obstacles in between them. Figure 4 provides an example of a situation of two POIs located at points *A* and *B* on the hillsides of a region. The figure also depicts the contour lines sketched on the hillsides. The line segment *AB* is the air-line distance while A′B′ is the projection of the air-line distance on a planar map.

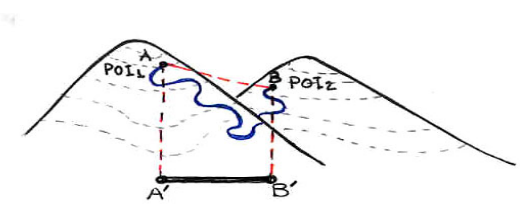

Figure 4: Projected air-line distance vs. real path

The real path a hiker has to walk is depicted by the snake-like line in Figure 4. On a point coverage the line segments inferred by the user are projected air-line distances. The projected air-line distance is not indicative to the actual path.

4.4. Costs on a schematic map

Cost is represented by weights on a schematic map. We encounter cost based on money, time, covered distance, effort, alternatives, etc. A weight corresponds to a *line segment* or to a *node* on a schematic map. Travel time between two nodes for example constitutes weight for a corresponding line segment while possible alternatives for connections constitute weight for a node. Cost and its corresponding weights can be defined in connection to the goal of the route. For example, in an area intended for bird watching, the weight of a line segment can be linked to the number of water fountains and bird baths which are found along the way. We assume here that water baths attract more birds.

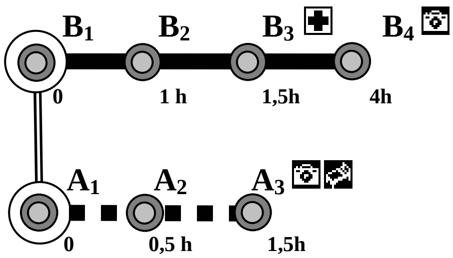

Figure 5: Schematic map with time weights

Figure 5 shows a simple schematic map which embeds the cost in time. The nodes on this map are equally spaced along a route. This map is often seen in bus stops. Such maps are generally too condensed to be fully deciphered by the passenger [11], however, travelers are for the most part familiar with the general design. On Figure 5, A1 and B1 corresponds to the same point in space.

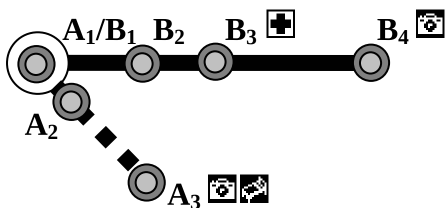

Figure 6: Schematic map with distance information

Figure 6 shows a schematic map where the length of the line segments corresponds proportionally to the distance of path traveled. In combination, Figure 5 and Figure 6 can show the difficulty of the path.

Depending on the application cost can be positive or negative. The way uphill is usually not the way downhill in terms of costs. Considering the weights, there is an asymmetry in the path and the cost of the path from point A to point B is not equal to the cost of the path from point B to point A ($Cost_{AB} \neq Cost_{BA}$). Schematic maps have the ability to convey such weights and thus cost information to the user.

4.5 Testing of hypothesis

We use three different visualizations of POIs to test our hypothesis. a) geo-referenced POIs overlaid on a topographic map, b) geo-referenced POIs on a point coverage without support of topographic map, and c) POIs on a schematic map. We examine the five operations described in section 4.1 Algebraic operations. We define that a visualization method communicates better information if it supports more operations.

	POIs on a Topographic map	POIs on a Point coverage	POIs on Schematic map
1. Is POI_1 there?	✓	✓	✓
2. Is POI_1 linked to POI_2?	✓	-	✓
3a. Is $POI_1POI_2 < POI_1POI_3$?	✓	-	✓
3b. Is POI_1POI_2 faster than POI_1POI_3 ?	✓	-	✓
4. Is POI_1 geo-referenced?	✓	✓	✓
5. Is there freedom to infer for a $POI_n \mid POI_n \notin \{POIs\}$	✓	-	-

Table 1: Summary of testing the hypothesis

Table 1 provides a comparison between the three listed visualization methods. The "✓" indicates that the visualization method supports the corresponding operation while the "-" indicates that there is a potentially negative aspect associated with the operation within the specific visualization method. For example, the distance between points inferred by a geo-referenced point coverage can be misleading for the user and lead to wrong decisions. Distances on a geo-referenced point coverage do not reflect actual distances.

The above table shows that a visualization of geo-referenced POIs on a topographic map is the preferred solution because all defined operations can be carried out. However, when a topographic map is not available the coverage of geo-referenced points on its own communicates less information than an enhanced presentation of a schematic map.

4.6 Other aspects

Besides the technical there are legal and economic aspects to be considered in spatial communication processes [19]. An example of a legal issue can be dealt with a disclaimer such as "Location A shows HotelX located on the boundary between LandY and LandZ. Due to military restrictions, we can not offer a detailed map of the surrounding, and location A on this representation is not geo-referenced. However, location A offers a great variety of activities and services and links to other locations".

An economic issue arises when the community promoted through the tourist portal is big enough and the feedback works well. In this case, the owner at a POI who maintains advanced web presentation generates a new market force. Additional owners at other POIs will want to improve their presentations and a new market niche may open up.

We expect similar marketing effects from using schematic maps. The schematic maps shall be there to promote the area. The idea is that the web presentation shows the most scenic or popular routes. Implementation of schematic maps by a locality presented through a tourist portal may also generate a new market force. We propose that other regions presented through tourist portals which have detailed topographic maps will also include the schematic map solution as an alternative.

5. Conclusions

We encounter cases where web mapping in tourist portals is hindered due to limitations imposed by financial, technical and national defense reasons. The desired "topographic base map display" is simply not available. Thus, the web portal designer faces compatibility issues when including point spatial data from diverse regions. Some regions have topographic maps and others do not. Hotels, information centers, restaurants, huts, etc. constitute points of interest on the web map of a tourist site commonly known as POIs. What is the preferred visualization solution for POIs in the cases where a topographic map is not available? We focus on the needs of a tourist during pre-trip planning phase.

In our paper we examined three visualization methods namely a) an overlay of the geo-referenced POIs and the topographic map of the region, b) an assembly of geo-referenced POIs namely a point coverage, and c) a schematic map representation of the POIs which utilizes the "metro map metaphor". We examine the three visualization methods with the use of algebraic operations. These operations refer to the three main questions included in the literature, namely *1) Where am I?* , *2) How to get to points of interest?*, and *3) How much effort does it take to reach a point of interest?*

We conclude that the schematic map representation for a tourist portal is the preferred solution when a topographic map is unavailable. Although a schematic map does not provide any geo-referenced POIs it maintains the topological relations among the POIs. In our paper, we demonstrate that the schematic representation of the POIs shows the accessibility routes among POIs. It also indicates the cost which is linked to the specific goal of the tourist e.g. "Which way is fastest?" or "Which way is the shortest?" This is achieved with the use of weights.

6. Future Work

We propose that further research be done on the issue of accessibility. For example, a hotel owner can enter a) accessibility links to other POIs and b) parameters related to the generation of the weights for the various types of cost. A link can be defined if both POIs desire the link or if only one suggests it. International law of the web should also be considered. Further map operations have to be identified and linked to the visualization method. Again algebraic axioms can assist in the refinement of the operations.

Data acquisition is a sensitive issue and has not been addressed in this paper. If data is captured by layman we have to deal with diverse data quality and to some degree also with data abuse. The data quality varies because different devices can be used to capture the data, like hand held GPS, digitized maps and simple rough point placement on a map. The "service" can be abused by owners at POIs by placing their facilities in the vicinity of advantageous locations e.g. hotels close to the beach.

These disadvantages have to be overcome in the near future. Major impediments are the slowness of the feedback cycle in portals, which additionally requires a reasonable number of users. Until feedback is given by the tourist the reliability of the produced results can not be checked.

Methods to automatically generate map representations based on the "metro map metaphor" are a topic of future research as well as other cartographic beautification issues.

In this paper, we conjecture that people living in the city making holidays on the countryside will readily accept schematic maps. The reason is their familiarity with this form of map representation. Empirical research is needed to determine if schematic maps are accepted by tourists planning their holidays via the web.

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Appendix

Executable implementation in Haskell of the algebraic axioms used in the evaluation of the visualization methods proposed in this paper.

```
module GeoVIS where
-- Title: overcoming diversity in visualization
-- Authors: Pontikakis, Twaroch

type Weight = Int
data POI = Point (Maybe (Int,Int))
data Link = NULL |
            Link (POI,POI) Weight
data PointRegion = PointRegion [POI] [Link]
data MapType = PointCoverage |
               SchematicMap |
               TopographicMap

-- Operations for comparing visualization methods
--                     1. Is POI1 there ?
isPOIthere :: POI -> PointRegion -> Bool
```

```
isPOIthere p1 (PointRegion pointlist linklist) =
elem p1 pointlist
--                      2. Is POI1 linked to POI2
-- a link expresses an accessibility in the real
world.
areLinked::PointRegion->POI->POI->Bool
areLinked (PointRegion pointlist linklist) p1 p2
= (elem link linklist) where
       link = Link (p1,p2) w
       w = 99
-- weight w is arbitrary and indifferent for this
operation
--                     3a. Is line segment
POI1POI2 shorter than POI1POI3
isShorter :: Link -> Link -> Bool
isShorter l1 l2 = (distance l1) < (distance l2)

distance::Link->Weight
distance (Link p w) = w
--                     3b. Is traveling line
segment POI1POI2 faster than POI1POI3
isFaster :: Link -> Link -> Bool
isFaster l1 l2 = (traveltime l1) < (traveltime
l2)

traveltime::Link->Weight
traveltime (Link p w) = w
--                  4. Is the POI geo-referenced?
isGeoRef::POI->Bool
isGeoRef (Point Nothing) = False
isGeoRef (Point (Just (x,y))) = True
--             5. Is there freedom to infer about
a POIn which does not belong to the list of POIs

--freedom :: Region ->
freedomToInfer::MapType->
                PointRegion->
                POI->POI->Link
freedomToInfer (PointCoverage) r p1 p2 = NULL
freedomToInfer (SchematicMap) r p1 p2 =
       if (isPOIthere p1 r) &&
          (isPOIthere p2 r) &&
          (areLinked r p1 p2)
      then
           Link (p1,p2) w
      else NULL where
       w = 99
-- weight w is arbitrary and indifferent for this
operation
freedomToInfer (TopographicMap) r p1 p2 =
       Link (p1,p2) w where
       W = 99
-- weight w is arbitrary and indifferent for this
operation
```

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