

DESIGN OF WEB MAPS FOR NAVIGATION PURPOSE

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ABSTRACT:

This paper discusses the design of web-map for navigation purpose. First of all, it provides an overview of the development of maps (from paper to web) and then some thought on the design of web maps for navigation purpose. It has been found that the functions of maps have changed from “display and storage” to “display and exploration” and “storage and linking”. The variables for visual presentations have been expanded from traditional set of visual variables to five sets of variables, i.e. visual variables, screen variables, dynamic variable, exploratory acts and web variables. The functions of map symbols are also enriched to include “indexing” and “pointing”. All these variables could be explored for web map design.

Because of its confined display environment, web map has to be carefully designed so that the graphics to be displayed will not be too dense. It is also discussed that the colour coding which has been in use for years for topographic maps may need to be modified for screen display. For example, different colour may be assigned to the road and building names according to the position of the location, and blinking symbols used to indicate direction restrictions. In addition, when incorporating with spatial analysis functionality, a selection of client-side or server-side Internet mapping systems has to be made to balance performance and functionality.

For the purpose of navigation, maps can be used for positioning (i.e. displaying current location on a digital map), navigation (i.e. displaying the current position and destination) and route guidance (i.e. displaying position, destination and route to destination). How the maps on web should be design for navigation purpose is a topic of this paper.

1. INTRODUCTION

Maps are not new at all to geo-information community. Indeed, maps have been regarded as one of the three ancient communication means, the other two being language and music. The issues on map design have been discussed in cartographic textbooks and one would wonder what’s new to talk here. The answer is that the environment considered in this project (i.e. the web) and purpose of this study (i.e. navigation) are quite specific although a book on web map design has been published recently (Kraak and Brown, 2001). There, there is a need of some special considerations on the design of such maps. In other words, the traditional theories need to be modified and/or expanded to accommodate the new development.

2. CHANGE IN MAP FUNCTIONS

Traditionally, maps were made on paper. On the making process, cartographers design the maps and users make use of the maps. However, in digital environment, this situation has been changed dramatically. Users of geographical information systems (GIS) and/or computer assisted cartographic systems

(CAC) can produce customised products without restriction. Therefore, the distinction between map designers and users diminishes (Su and Li, 1995).

After moving from paper map (hardcopy) to the web, the functions of maps have also changed. In analogue form, the map serves for two purposes, i.e. data display (visual communication) and data storage, (although some may also want to add another two: i.e. spatial index and data analysis tool). However, in digital form, these two functions, i.e. data storage and data display, have been separated. One could store the data in a database and display the map in a screen or plotted out in analogue form. At the stage of cartographic visualisation, visual analysis is emphasised, which is compared to numeric analysis. Other terms such as visual thinking and visual exploration are also in use (Jiang, 1986; Kraak, 1998; Kraak and MacEachren, 1999). In web-based visualisation, data storage is extended to include a new function, i.e. hyperlink to other sources. Such changes are summarised in Table 1 and a diagrammatic representation of such changes is shown in Figure 1 (Li, 2002; Li and Kraak, 2002).

Table 1 The role of maps in different environments (Li, 2002; Li and Kraak, 2002)

Stage of Development	Major Roles of Maps			
Paper Maps	Visual communication & data storage			
Digital maps	Visual communication		Data storage	
Cartographic Visualisation	Communication	Exploration	Data storage	
Web-based Visualisation	Communication	Exploration	Data storage	Data linking

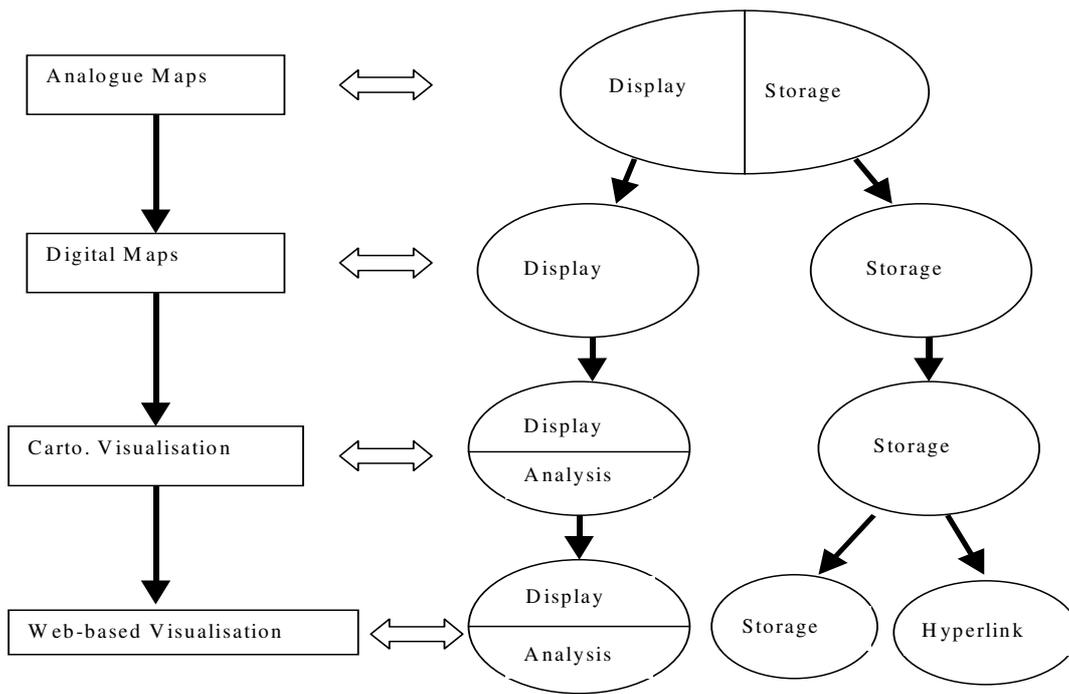


Figure 1 Functions of maps at played in different stages (Li, 2002; Li and Kraak, 2002)

3. ADDITION OF GRAPHIC VARIABLES FOR WEB MAPS

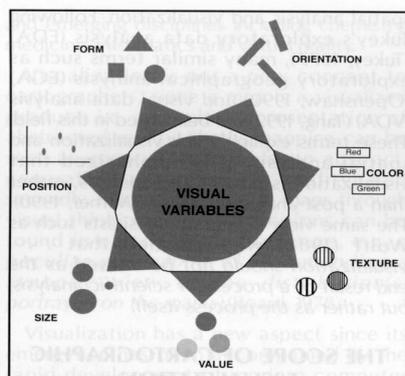
To make maps possess such roles, some kind of visual variables need to be employed. With web as a medium, the traditional cartographic variables as proposed by Bertin (1983) (Figure 2a) have been extended popularly. At digital map stage, theoretically, some variables particular to screen display (Kraak and Brown, 2001) may have been in use. At visualisation, dynamic variables (DiBiase et al, 1992) have been introduced and exploratory acts (Jiang, 1996) (Figure 2b) are widely used for visual analysis. At a stage of web-based visualisation, more exploratory acts are in use, particularly the hyperlink and plug-

in. Table 2 lists the sets of variables in use at such different stages as follows:

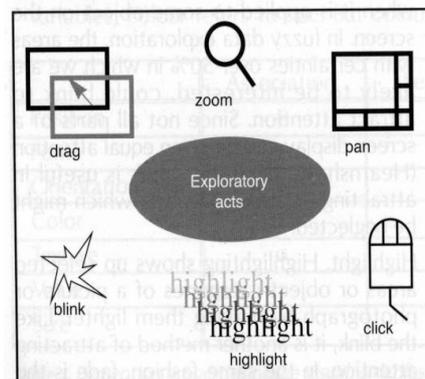
- Visual variables: Size, shape, orientation, hue, saturation, intensity, position, texture, arrangement (Bertin, 1983; Robinson et al., 1995; Jiang, 1996);
- Dynamic variables: duration, rate of change, order;
- Exploration acts: Drag, pan, zoom, click, blink, highlight (Jiang, 1996);
- Screen variables: Blur, focus, transparency (Kraak and Brown, 2001); and
- Web variables: Browse, plug in.

Table 2 Variables in use at different stage of development (Li, 2002; Li and Kraak, 2002)

Map form	Variables in use				
Paper Maps	Visual variables				
Digital maps	Visual variables	Screen variables			
Cartographic visualisation	Visual variables	Screen variables	Dynamic variables	Exploration acts	
Web-based visualisation	Visual variables	Screen variables	Dynamic variables	Exploration acts	Web variables



(a) Visual variables for communication



(b) Exploratory acts for analysis

Figure 2 Variables for cartographic visualisation (Jiang, 1996)

Blur gives symbols a fuzzy appearance and can for instance be applied to visualise uncertainty, while focus will introduce blinking symbols to attract attention. Transparency can be seen as a kind of fogginess, by which part of map content is obscured or faded in favour of other information. Apart from the browsing, another particular interesting feature of web-based environment is the plug-in function. With this function, virtual reality technique could be integrated into web-based visualisation, via JAVA, JAVA-Script and/or VRML.

hydrographic features, green for vegetations, grey for settlements and red for transportation networks. Table 4 lists the use of colour in traditional maps, as well as some cultural meanings.

However, the use of colours for navigation maps displayed on screen may need a change. For example, Spiker et al (1986) has made a recommendation on screen maps for aeronautical navigation based on his empirical study (Figure 4). This is just a starting point and more study on this issue is very desirable.

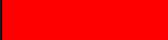
4. CONSIDERATIONS OF THE USE OF COLOURS ON WEB MAPS FOR NAVIGATION PURPOSE

In the set of primary visual variables, three of them are colour, i.e. hue, saturation and intensity. Traditionally, blue is used for

Table 3 The use of colour in traditional maps

Colour Names	Colour symbols	Cartographic features	Meanings in western culture	Meanings in Chinese culture
Blue		Hydrographic features	Advisory, status	Sky
Cyan				Mountain
Green		Vegetation	Go ahead, good, on, friendly, safe	Water
Yellow		Medium height, dryness/bareness	Caution, warning, standby	Sexual, noble
Brown		Higher lands	??	??
Red		Important features (e.g. roads)	Danger, stop, off, excitement, unsafe	Happy, fortunate, good
White		Ice/cold lands	tired	unhappy, lack of

Table 4 Recommended colour use for screen topographic maps for aeronautical purpose (Spiker et al., 1986)

Colour Names	Colour symbols	Recommendation for features on topographic maps for aeronautical purpose
Blue		Open water
Cyan		Streams
Green		Railway lines, obstacles
Yellow		Cultural features, bridges
Magenta		Cities, aeronautical data
Black		Contour lines
Pink		Roads
Red		Enemy point symbols and tactical overlay
White		Friendly point symbols and tactical overlay
Grey		Bare terrain surface (non forested terrain) (16 shades)

5. CONSIDERATIONS OF THE USE OF OTHER VARIABLES ON WEB MAPS FOR NAVIGATION PURPOSE

For the purpose of navigation, maps can be used for positioning (i.e. displaying current location on a digital map), navigation (i.e. displaying the current position and destination) and route guidance (i.e. displaying position, destination and route to destination).

The current position (of vehicle or a person) can be highlighted, e.g. using a small buffer (Figure 3). For navigation with planned route, different parts of the route can be highlighted in different colour according to the current position (Figure 4). An example of using perspective symbol for landmark was also shown in Figure 5 (circled in red), because of the importance of landmarks for navigation purpose (Burnett, 2000). The map provided flexibility to the users to customise their use by activating different layers such as car park and restaurants locations. Highlight of text symbols are also possible to create the difference in prominence. Figures 6 and 7 illustrate the highlighting of building names and road names by changing the colour and increasing the font size. Blinking system can be used for dangers.

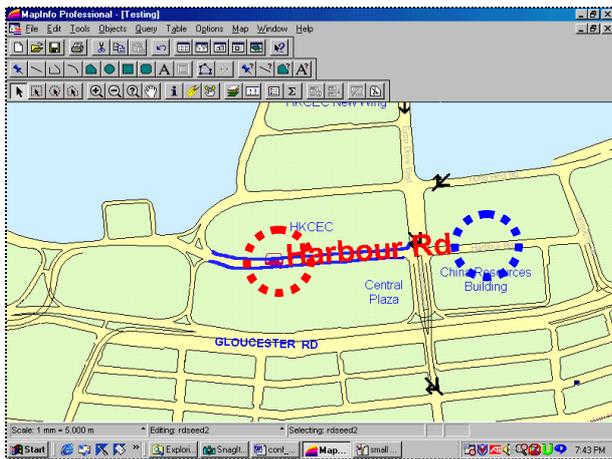


Figure 3 Feature highlighted by small buffer zone

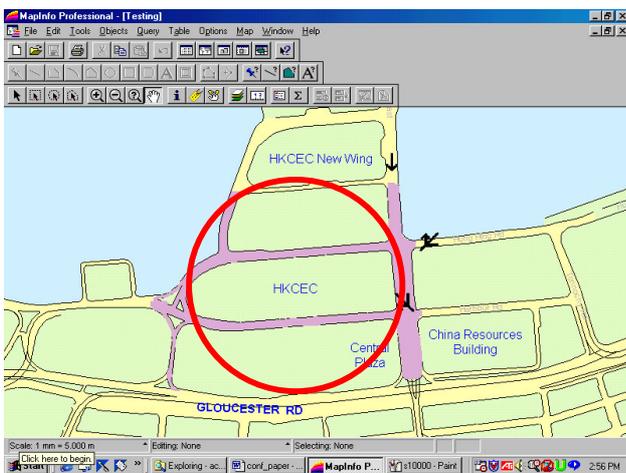


Figure 4 Road segments highlighted by large buffer zone (circled in red)

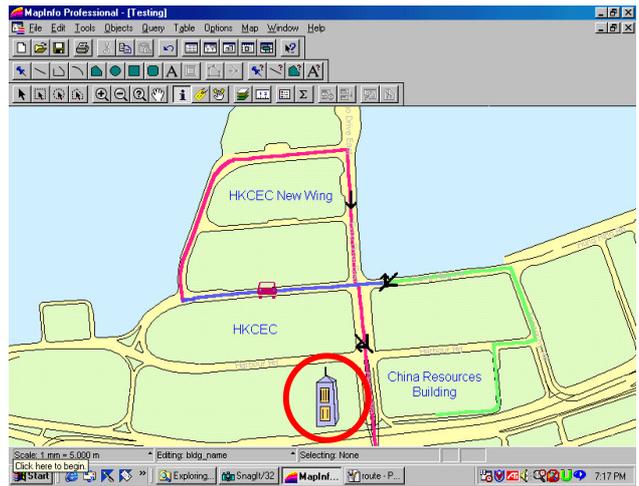


Figure 5 Mode of navigation with planned route and use of perspective symbols

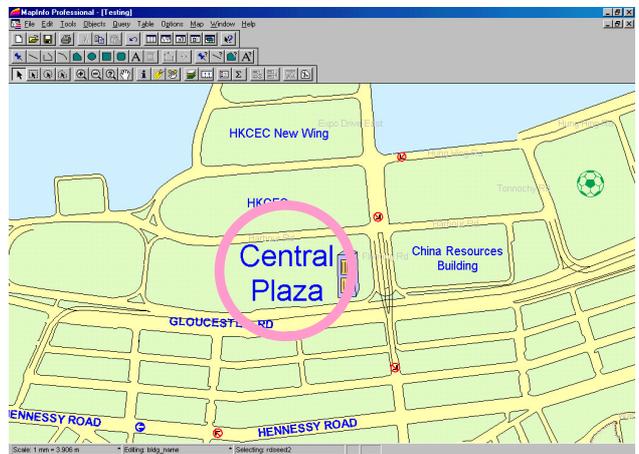


Figure 6 Highlight by enlargement of text symbol

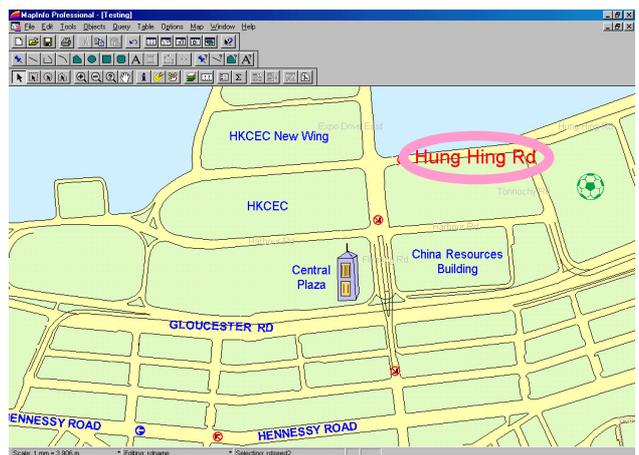
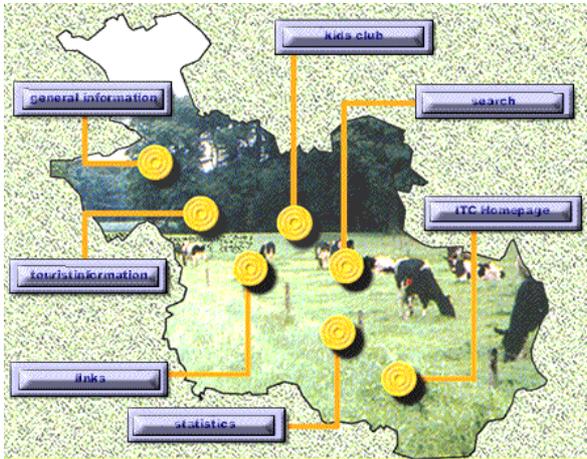


Figure 7 Highlight by changing the colour of text symbol

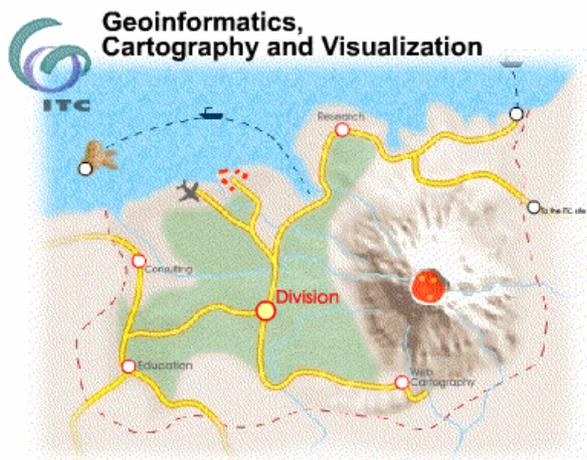
6. CONSIDERATIONS OF THE FUNCTIONS OF MAP SYMBOLS FOR NAVIGATION PURPOSE

Traditionally, maps are static and for views only. However, in web environment, maps could be either static or dynamic, each then being subdivided into view only and interactive (Kraak, 2001). On static view only maps, the function of map symbols is to indicate location and thematic meanings. On the other hand, for interactive maps, map symbols offer additional

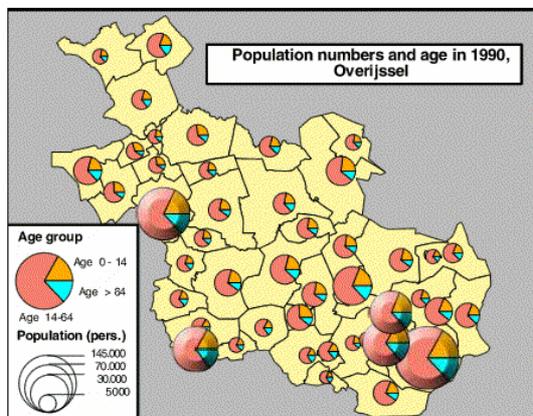
functions, i.e. to serve as index to further information by making the symbols "clickable" (Figure 8) and to provide extra information by "mouse-over" (Figure 9). By using the clickable symbols, photographs, drawings, texts, sounds or other maps can be linked. This makes web mapping a more and more popular way of providing information to a large group of users, country-wide or even world-wide.



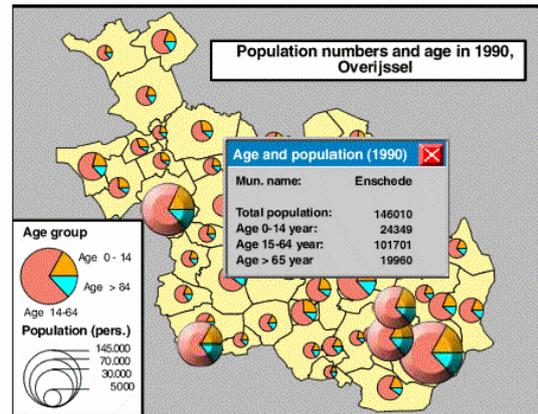
(a) "Clickable" map symbols as index



(b) New map pop-out after clicking a key
Figure 8 Map symbols as index to further information (van de Worm, 2001)



(a) "Mouse-over" map symbols with highlight



(b) Extra info displayed when mouse is over a symbol
Figure 9 "Mouse-over" map symbols to reveal extra information (van de Worm, 2001)

In the case of maps for navigation, such information as traffic condition, landmarks, bus station, taxi station, road signs, larger scale maps, and so on can be linked by using clickable symbols.

7. CONSIDERATIONS OF THE EFFICIENCY OF SPATIAL ANALYSIS OF WEB MAPS FOR NAVIGATION PURPOSE

When incorporating with spatial analysis functionality, a selection of client-side or server-side Internet mapping systems has to be made to balance performance and functionality. For example, in the multi-modal public transport enquiry system by Pun-Cheng et al (2004), some spatial analysis functions have been implemented as follows:

- whether there is a direct route given the origin and destination as depicted on a map or by textual input;
- whether one or more transfers are needed and what the options are;
- how to get to the pick-up and drop-off locations (the stops/stations/piers) from the user's chosen origin and destination; and
- how much the trip will cost, when and how frequent the routes are, and so on.

An Internet Mapping System (sometime referred to as a Web-enabled GIS or an Online GIS application) is a Web application fully charged with GIS functionality. Usually, the applications emerge when traditional GIS packages are extended to support the Web technology. Basically, an Internet Mapping System follows the Client-Server Model with Web browsers as the clients and the Web site serving the application as the server. There are two variations to the basic Internet mapping application: (a) client-side; and (b) server-side applications (Gifford 1999). In the former, the client machine takes up all of the responsibilities of processing analysis functions. In the latter, on the other hand, the server platform handles highly process-demanding requests from clients

In general, the client-side solution provides a better working environment with powerful functions for analysis. This approach is favourable for a smaller group of sophisticated users who are looking for complicated analysis functions. To achieve the best performance for this approach, additional add-on components (or *plug-ins*) for the Web browser need to be developed and extra effort to maintain software and plug-ins is also required. On the other hand, the server-side solution offers

a standardized and economical GIS solution to a wider group of infrequent users who do not require a highly responsive GIS server. As all of the processing is done by the server and all of the processed information is returned to the client in the form of HTML documents, the server-side solution demands a better and more powerful hardware configuration for the server.

8. CONCLUSIONS

This paper provides an overview of the development of maps (from paper to web) and particular emphasis is on the design of web maps for navigation purpose. It has been noted that many factors should be considered in the design of such maps. In this paper on the following issues have been discussed:

- functions of maps;
- graphic variables;
- colour codes;
- functions of map symbols; and
- efficiency of spatial query

It has been found that the roles of maps have changed from "display and storage" to "display and exploration" and "storage and linking". The variables for presentations have been expanded from traditional set of visual variables to five set of variables, i.e. visual variables, screen variables, dynamic variable, exploratory acts and web variables. Using these variable, various special symbols can be designed. It is also discussed that the colour coding which has been in use for years may need to be modified for such purpose. The function of map symbols is also enriched to include "indexing" and "pointing". In addition, when incorporating with spatial analysis functionality, a selection of client-side or server-side Internet mapping systems has to be made to balance performance and functionality

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REFERENCES

- Bertin, J., 1983. *Semiology of Graphics*, The University of Wisconsin Press. Wisconsin.
- DiBiase, D. W., MacEachren, A. M., Krygier, J. B. and Reeves, C., 1992. Animation and the role of map design in scientific visualisation. *Cartography and Geographic Information Systems*, 19: 201-214 & 265-266.
- Dodge, M. and Kitchin, R., 2000. *Mapping Cyberspace*. Routledge, 296pp.
- Gifford, F. 1999. Internet GIS architectures – which side is right for you? *GIS World*, vol. 12, no. 5.
- Jiang, B., 1996. Cartographic visualization: Analytical and communication tools. *Cartography*, 25(2): 1-11.
- Kraak, M.J., 2001. Settings and needs for web cartography. In: Kraak, M.J. and Brown, A. (eds.), *Web Cartography: Developments and Prospectus*. Taylor & Francis, London. 1-7.
- Kraak, M.J. and Brown, A., 2001. *Web Cartography: Developments and Prospectus*. Taylor & Francis, London. 231pp.

Li, Z.L., 2002. Some Considerations on the Design of Web Maps. *Proceedings of the International Workshop on Mobile and Internet GIS*, August 15-16, 2002, Wuhan. (CD-Rom)

LI, Z.L., and Kraak, M.-J., 2002. Web-based exploratory data analysis (Web-EDA): Visualisation meets spatial analysis. *Proceedings of the ISPRS Commission II Symposium -- Integrated Systems for Spatial Data Production, Custodian and Decision Support*, August 20-22, 2002, Xi'an, China. 281-286.

Pun-Cheng, L. and Shea, G., Design parameters for interactive web mapping systems. In: *Advances in Spatial Analysis and Decision Making*, edited by Li, Z., Zhou, Q and Kainz, W., A.A. Balkema, Lisse. 299-306.

Robinson, A.H., Morrison, J.L., Muehrcke, P. C., Kimerling, A. J. and Guptill, S. C., 1995. *Elements of Cartography* (6th edition), John Wiley & Sons, Inc. 674pp.

Spiker, V.A., Rogers, S. P. and Cicinelli, J., 1986. Selecting colour codes for a computer generated topographic map based on perception experiments and functional requirements. *Ergonomics*, 29: 1313-1328.

Su, B. and Li, Z.L., 1995. Expert system for automated map design and production: A review and some considerations. *Cartography*, 24(1): 33-42.

Van den Worm, J., 2001. Web map design in practice. In: Kraak, M.J. and Brown, A. (eds.), *Web Cartography: Developments and Prospectus*. Taylor & Francis, London. 87-108.