DESIGN AND IMPLEMENTATION OF SPECIAL-PURPOSE ELECTRONIC ATLASES

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Abstract

This paper presents a systematic approach to the design and implementation of special-purpose electronic atlases. The atlases design considerations include determination of purpose, information content and the user interaction with the information system, which are affected by user differences in cultural and social characteristics. This approach helps to determine system properties based on user criteria, information content criteria (*data, generalization level, symbology*) and user-interaction criteria. The design considerations have been applied in the system development of WERATLAS -- a Wave Energy Atlas.

1 Introduction

Electronic atlases have been the subject of serious concern and research for quite sometime [1,2]. This paper introduces a systematic approach to the design and implementation of special-purpose electronic atlases, i.e., atlases of general or specific content however which address special user groups. Three factors seem to affect the atlas design process: The intented purpose of the atlas, the information content, and the means of access to information. The atlas *purpose* is examined with respect to cultural and social issues [3,4] as expressed through differences in peoples' nationality, conceptual ability and cognitive level, which affect the overall interpretation of maps and atlases. The atlas *information content* addresses database issues with respect to cartographic components such as data content, generalization and symbolization. The design should take into consideration the need for model and cartographic generalization in order to operate and present information at different levels of detail. *User-interface* design must be based on simplicity and on support of the essential and most frequently used queries and operations. In a design process, the user-, content- and interface criteria should be expressed as a list of desired properties, to be used in the system implementation phase.

These considerations were employed and tested in the design and implementation of WEREATLAS - a special-purpose electronic atlas of wave energy resources along the European coasts.

2 Basic considerations on the design of electronic atlases

A conventional atlas is a special collection of maps in book form, conveying different aspects of one or more geographical phenomena in a specified geographical area. Contemporary technology provides more sophisticated means of expressing spatial and geographical themes. In CAD and GIS environments, spatial information can be dynamically portrayed by means of maps, images, graphs, texts and tables.

In an atlas design process three issues have to be addressed: the purpose (intention) of the atlas, the information content, and the user interaction with the information system.

With respect to *purpose* and the intended user, atlases can be distinguished to general-purpose and special-purpose (table 1). A general-purpose atlas, regardless of its content (general or special), is made to be used by many different groups of people. On the contrary, a special-purpose atlas, of general or special content, addresses the needs of specific groups of people (children, scientists,

tactuals, etc.). It is obvious, that conventional atlases cannot easily satisfy the needs of individual groups without making some compromises; while in the design of electronic atlases, there are many powerful tools to produce a final product tailored to the users' needs.

	GENERAL-PURPOSE (user) ATLASES	SPECIAL-PURPOSE (user) ATLASES
GENERAL CONTENT	world atlas	school atlas
SPECIAL CONTENT	tourist atlas	aeronautical atlas

Table 1. Examples of general-special purpose and general-special content atlases

General-purpose atlases are designed to be read by people of different conceptual ability and cognitive level, depending on their mental ability to understand images and on their education and experience in map reading. Those atlases having an international character, are meant to be used by people of different nationality, speaking different languages, having different traditions. Within nationalities, there are further cultural differences. The above characteristics (conceptual ability, cognitive level and nationality) constitute the cultural and social factors affecting the overall interpretation of maps and atlases. Depending on the general- or special-purpose of an atlas, its design is variably affected by these characteristics (table 2). A general-purpose atlas, e.g., an encyclopedia or a historical atlas, is read by people having a diverse range of conceptual ability, cognitive level and, not rarely, a different nationality. Considering these parameters, the atlas design must take into consideration the need for different types of information, generalized at various levels. At the same time, it must provide users with alternative ways of selecting and representing information of interest at the desired level of detail.

	GENERAL-PURPOSE	SPECIAL-PURPOSE
CONCEPTUAL ABILITY	diverse range	narrow range
COGNITIVE LEVEL	diverse range	certain
NATIONALITY	any	any but meaningless

Table 2. Cultural and social characteristics in general- vs. special-purpose atlases.

The design of special-purpose electronic atlases, for example a geographical atlas for high school students or a demographic atlas for humanities, differs from the general-purpose case for it addresses special user groups of more or less the same conceptual ability and cognitive level. The nationality parameter also has to be considered, especially as it pertains to the language issue.

	CONVENTIONAL ATLASES	ELECTRONIC ATLASES
DATA CONTENT	strictly defined	unlimited
GENERALIZATION	one pre-defined level	different levels
SYMBOLIZATION	one way	alternative ways

Table 3. Cartographic parameters in determining the information content of atlases.

With respect to the *information content* (table 3), the atlas design mainly depends on the determination of three fundamental cartographic components: the *data content*, the *generalization*

level and the *choice of symbology*. While in conventional atlases the data content must be strictly defined, the data content of electronic atlases can be theoretically unlimited. The generalization level of a conventional atlas has to be pre-defined, while an electronic atlas can be a product of different generalization levels. Data symbolization in a conventional atlas has to be the "best" choice after a rigorous analysis of user's conceptual level. On the other hand, electronic atlases can satisfy the user's special preferences by designing various symbol sets.

The electronic atlas must provide visual information to users who are not necessary specialists in CAD, GIS or other information technology. This *Human Computer Interaction* (HCI) objective is accomplished with appropriate development of the Graphical User Interface (GUI).

3 Design criteria

The design of an electronic atlas considering the above aspects has to satisfy certain criteria. These criteria can be grouped into three main categories. The first category is based on *user criteria*, that is, differences in conceptual ability, cognition level and/or nationality. These criteria can be satisfied by a system having the following properties:

- multi-linguality
- multi-symbolism

The second category is based on *information content criteria*, such as, the thematic variation and the required level of detail (generalization level) of the atlas information. These criteria are expressed by the following properties:

- theme variation
- scale variation
- seasonal variation
- temporal variation

The third category relates to *user-interaction criteria*, that is, the technological capabilities provided to users for accessing the atlas. The resulting properties are:

- browse - query
- data transferability
- on-line analysis
- modeling - simulation

Electronic atlases may have dynamic and static characteristics with respect to the way the atlas is updated and the way users interact with the available information. Due to current technological limitations, information updating of atlases is rather static, while user interaction with the electronic atlas can be dynamic.

4 Implementation of a special-purpose atlas

4.1 Background

Wave Energy Resource Atlas (WERATLAS) is a user friendly, PC-based computer environment, for the control, retrieval and presentation of wave-energy and wave-climate data along the European coasts by physical scientists. The wave-energy and wave-climate information is calculated for a set of data points distributed off the coasts of the study area. Data primarily comes from hindcasting analysis using the WAM model (The WAMDI Group 1988). For areas where the applicability of WAM is questionable as in Norwegian Sea, measured data is used. Parameters to be retrieved and displayed utilizing WERATLAS, refer either to single sites (pointwise presentation) or to a number of geographical areas (global presentation). In case of pointwise presentation information refer to a single data point and will be either in tabular or graphical form. In the case of global presentation,

information refer to the portion of the data delimited by the selected geographical area, and will be in graphical form [5].

For the pointwise presentation the following parameters will be displayed:

Histograms/tables

- Mean wave power
- Histogram of significant height
- Histogram of energy period
- Histogram of peak period
- Exceedance distribution of wave power
- Histogram of sea-state

Graphs

- Probability density of significant wave height
- Probability density of energy period
- Probability density of peak period
- Exceedance distribution of wave power
- Seasonal variability of mean value and standard deviation of wave power
- Directional distribution of wave power

For the global presentation the geographical distribution of mean value and main direction of wave power will be displayed. For both kinds of presentation there will be different values of the parameters for the winter and summer due to the temporal variation of the relevant phenomena.

The above mentioned characteristics classify WERATLAS to the category of special- purpose electronic atlases. The inherent spatial nature of the entities involved on the other hand and the digital representation of the data (positions - attributes) lead at first place to a Geographic Information Systems application. As will be shown later this is debatable due to the users background and the resources required which led to an alternative and - according to the authors - more efficient approach for the implementation of the atlas.

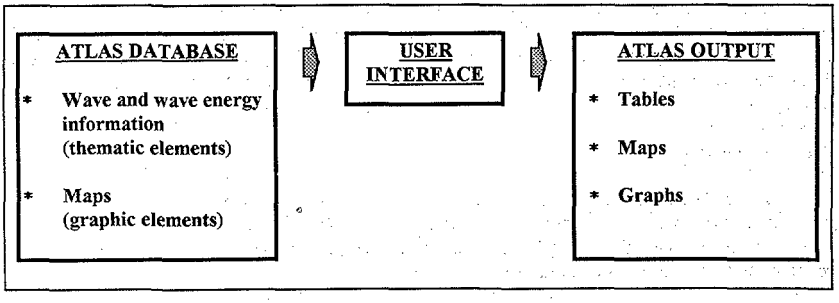

Figure 1. The operational schema of WERATLAS.

The operational schema of the atlas is the one depicted in figure 1. It consists of three distinct elements: The *atlas database*, the *user interface* and the *atlas output*. The above mentioned design criteria influence WERATLAS elements in the way shown in table 4. This table must be used as a guide for the implementation of the atlas.

4.2 Implementation

As it was pointed out earlier, the inherent characteristics of the WERATLAS call for a GIS environment. This is due to the fact that any GIS environment can implement all three elements of

the operational schema. This approach although straight forward has a basic weakness, the requirement for the user to purchase the GIS package along with the atlas package. This would reduce drastically the number of users due to the expense of purchasing the GIS package and the reluctance in working in a GIS environment. On the contrary, if the atlas does not require any specific software platform, the total cost of the atlas would be kept to a minimum and the number of users would increase. The approach followed by the authors was a combination of the above, resulting to a package which runs on off-the-self equipment without any specific software requirement.

PROPERTIES	DATABASE	USER INTERFACE	OUTPUT
Multi-linguality		*	
Multi-symbolism	*		
Theme variation	*	*	
Scale variation	*	*	*
Seasonal variation	*	*	*
Temporal variation	*	*	*
Browse-query		*	
Data transferability		*	*
On line analysis		*	*
Modeling - Simulation		*	*

Table 4. Influence of design criteria on WERATLAS.

The development, the population of the data base and the compilation of maps required for the atlas were carried out in a GIS environment. The maps were then transformed to graphics files (bitmaps) and stored along with the other data in the data base. Utilizing the capabilities of Microsoft Visual Basic for Windows (ver. 3.0) which is a programming language manipulating database contents (maps and related data) and developing a friendly and full-proof user interface that satisfies users needs, the application is available in object code requiring minimum storage space (two floppy disks).

4.3 The Database

DBase IV was used as the database management system for the implementation of the database containing the wave and wave-energy information. Considering the future addition of new data points and/or quantities, special care was taken during the design process for the normalization of the relations and the minimization of the required storage space.

4.4 The User Interface

The user interface controls the use of the atlas and performs the retrieval of the wave and wave-energy information from the database and its display in tabular or graphical form. The design of the user interface is influenced by the content of the atlas and the user community it is addressed to. It consists of a number of menus (Main, Area, Season, Quantity, Mode, Help and Exit). Pointing to a menu name, the menu is activated and the corresponding submenus are displayed. The menus are fool-proof allowing the user to proceed only if the required selections have been done (ie. users cannot select the quantity if area and season have not been selected). Experiments carried out by the development group shown that there is no need for user training as long as he/she is aware of basic PC-computer operation.

4.5 Output

Special consideration was given to the cartographic part of the atlas i.e. cartographic background and symbolization. In order to facilitate the user in the identification of the geographic area and point of interest, the area covered by the atlas was subdivided into five (5) sub-areas. The delimitation of these sub-areas was not based only on the distribution of the data points but on the inherent characteristics of the projection used and the output medium, the computer's monitor. As far as the projection is concerned, the Mercator projection was adopted with latitude of zero distortion at 66° N in order to distribute the scale distortion evenly throughout the area covered by the atlas.

A basic characteristic of computer monitors is aspect ratio. Aspect ratio is defined as the ratio between the number of vertical and the horizontal pixels used to display lines of equal length at the two dimensions of the screen. It represents the scale difference in the horizontal and vertical axis of the screen resulting to the deformation of shapes displayed. Most computer monitors have aspect ratio 3 to 4 i.e 600 X 800 or 768 X 1024. Thus, when a map whose dimensions have a different ratio is displayed on the screen, is deformed in order to cover the largest possible area resulting in deformation of the characteristics of the symbols something misleading for the user.

As it was pointed out above, the geographical background of the atlas will be in the form of graphic files. Map scale is defined by the ratio between the bitmap dimension and the length it represents on the earth's surface. In order to achieve a standard scale for all maps (and the symbols they portray) without noticable deformations, the limits of each map were defined in order to comply with the ratio 3:4.

5 Conclusions

Design and implementation of special-purpose electronic atlases must undergo through a number of stages depending on the purpose and the content of the atlas. The design must satisfy a number of criteria which apply variably on the various kinds of atlases. Cartographic considerations play a critical role in the design and implementation of a special-purpose atlas. Thus, dispite the "system oriented" character of the electronic atlas the cartographer is a key-member of the design-implementation group of the atlas. In order to achieve a correct and functionally efficient environment the human computer interaction is a key factor to a successful atlas and is accomplished through the graphical user interface. Although a GIS approach would be the "natural" way for the implementation of the atlas, alternative approaches resulting to stand-alone and lower cost products are considered as more appropriate.

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