

A PROTOTYPE OF A NATIONAL ATLAS INFORMATION SYSTEM OF CHINA BASED ON ARC/INFO™

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Abstract

This paper summarizes the results of a research project aiming at the development of a prototype of a National Atlas Information System of China with the help of ARC/INFO software (UNIX version). First, a conceptual scheme of the prototype of a NAISC is presented, which is partly based on the analysis of the requirements of the prospective users. After this, attention is paid to the implementation phase along three main lines: the creation of a sample database, the functionalities of the system and the user interface. Finally we arrive at some general conclusions with respect to the suitability of the software applied.

1 Introduction

A National Atlas Information System (NAIS) is a special kind of electronic atlas. A NAIS as we conceive it is a:

Computerized geographic information system with an additional narrative function in which maps play a dominant role. The geographical database, which is interactively accessible through the system, refers to a certain nation and -in connection with a given purpose- to one or more themes [1,2].

In the past few years a lot of NAIS development activities have taken place in many countries, for instance in Sweden [3,4] and in Canada [5,6]. Some five years ago, also in China it was decided to investigate the possibilities of setting up a NAIS (NAISC) [7]. Since then, a lot of effort went into the definition of the concept and the formulation of the required functionalities. But now the time seemed ripe for more concrete follow-ups.

As a possible contribution to these developments a M.Sc. research project was formulated at the International Institute for Aerospace Survey and Earth Sciences (ITC) in Enschede, The Netherlands. The purpose of this research project was to develop a prototype of a NAISC with the help of ARC/INFO software (UNIX version on a HP workstation). The reason for choosing this software (and the hardware configuration) is that it has been used for a while in China already for the production of various national and regional atlases and that it is a well-known and frequently used GIS software package in many other countries in the world as well. Therefore, a derived objective of this research project was also an evaluation of the suitability of ARC/INFO (Rev. 6.1) for the development of a NAIS. This paper summarizes the results of this research project. A full report is given in Ms. Wanhong Mao's M.Sc. thesis [8].

2 NAISC user investigation

In the nature of things, the conceptual scheme of the NAISC prototype is first of all based on the analysis of the requirements of the prospective users. To this end, a user investigation was carried out in May 1994. Prospective users in China -scientific researchers and planners, teachers and other professionals with a need for geographic information at a national level- were interviewed on the basis of the following questions:

- ▶ What kind of studies could or would you do with national geographic data?
- ▶ If a NAISC would be available, would you use it?
- ▶ Which functionalities do you expect from a NAISC?
- ▶ Do you have any suggestions on a prospective NAISC?

Unfortunately, in view of the limited time available a more thorough user investigation was not possible. However, the interviews led to some meaningful starting-points for the design of the prototype.

From the reactions to the first question the significant regional variations within China came to the fore, particularly those in connection with the complex physical geographical conditions. Therefore, up to now researches mainly focussed on regional and not on national scale problems. As a consequence, on the one hand the potential users of a NAISC would very much appreciate a national line of approach, but on the other hand within the system they would also want to be able to descend from the national to the regional level. In any case, they would like to use an operational NAISC.

As far as the functionalities of a NAISC are concerned, the following wishes were expressed during the interviews:

- ▶ It should be possible to *browse* all the data which are stored in the database, in order to find out what is in it.
- ▶ It should be possible to *retrieve* data from the database in searching for answers to specific geographical questions (for example: all provinces with a population density greater than 100 people per km²).
- ▶ It should be possible to *analyze* the relationships between several features (visually, but, for instance, also statistically).
- ▶ There is a distinct need for ways, which are as simple as possible, to generate responsible and correct *cartographic displays*. At the same time, the possibilities for visualization need to be as flexible as possible.
- ▶ It should be possible to *input* own or other data into the system in a simple way.
- ▶ The system should offer various possibilities for data *output*: on screen, on paper and in digital form. It should be possible to export digital data to other software packages, e.g. (carto-)graphic packages.

In addition to all this it was suggested emphatically to realize -in setting up a NAISC - a recognizable and gradual transition from the conventional (paper) national, regional and thematic atlases which are already available in China to a fully functional information system.

3 Design and implementation of a NAISC prototype

Together with literature studies and an analysis of the PC Atlas of Sweden and the Electronic Atlas of Canada the results of the user investigation led to the conceptual scheme of a NAISC prototype which is presented in *Figure 1*. Some of the elements of this concept were actually implemented: a sample database, some functional modules and a user interface.

3.1 A sample NAISC database

A NAIS normally includes a database, which allows users to conveniently access large amounts of data stored in digital files. A database management system is needed to provide a series of functions to efficiently search specific data, to manipulate thematic data, and to facilitate such operations as data entry, updating and the integration of graphic and non-graphic files [5]. To a large extent, the design of the NAISC database should be related to the requirements of its users.

For the prototype an incomplete geographical database of China was built based on the ARC/INFO

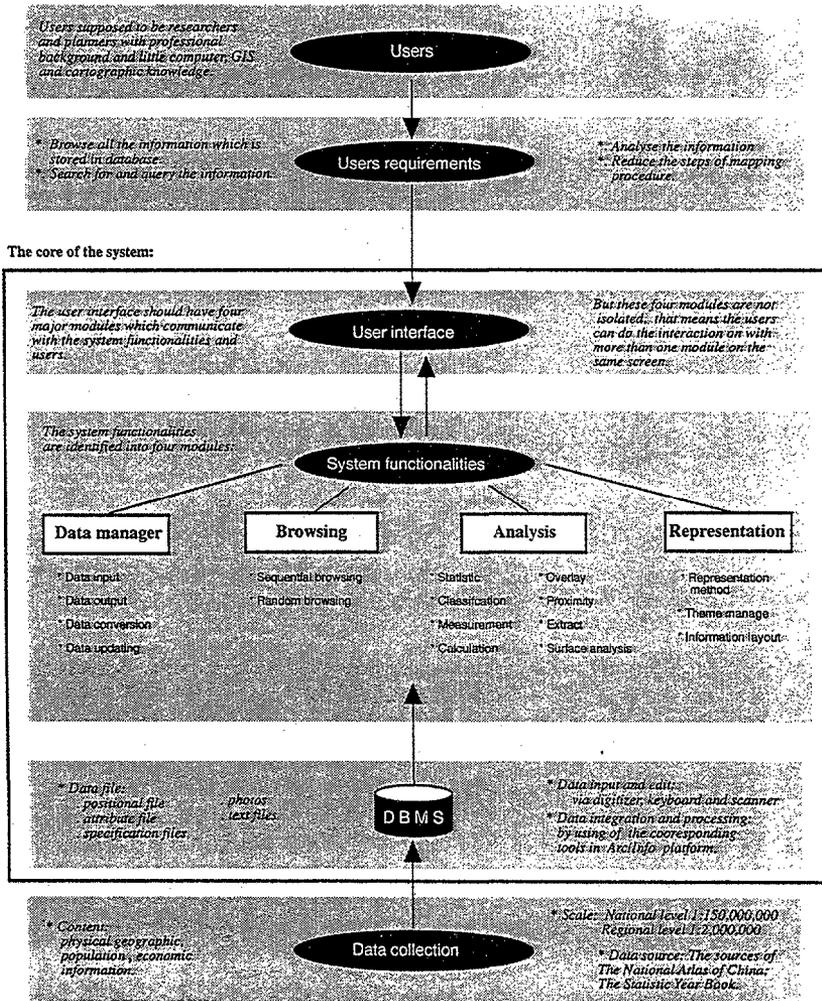


Figure 1. Conceptual scheme of the NAISC prototype

database management system. The data selected are related to the geomorphology, the hydrography, the physical geographical conditions, the administrative division and the population of China in several years (also in the future) and at different levels of aggregation (national, provincial, district). The data originated from the same Chinese sources that were used for various recent conventional national, regional and thematic atlases. The base map data were digitized at the scales 1:10, 1:12 and 1:15 million. Next to cartographic digitizing, other input methods were applied to import text, photographs and statistical data into the sample database.

The data are stored, manipulated and processed with the help of several ARC/INFO tools and concepts: *coverages* (defining the location and thematic attributes of geographic features in a given area), *map libraries* (mechanism for the management of large coverages by means of layers and tiles), *map composition files* (predesigned maps created by the map composition tool in ARCPLOT), *map and graphic commands files* (commands written in the ARC Macro Language (AML) which invoke a mapping or graphic procedure) and a *geographic data files library*.

3.2 System functionalities

An ideal NAIS should have functionalities in three main categories: analytical, cartographic and narrative. Geographical Information Systems normally provide ample possibilities for the exploration, manipulation and analysis of the geographical data stored in the database. But often they are less flexible in terms of cartographic visualization. A narrative functionality is most special to a NAIS and takes care of the navigation through the data. The narrative functionality is particularly important for educational purposes and it is a starting-point for accessing the system and the data.

According to the conceptual design, the NAISC prototype has four modules: *Data Management*, *Browsing*, *Analysis*, and *Representation*. A *Read-Me* module is added to introduce the users to the system and to provide on-line help.

The *Data Management* module is designed to have functionalities for the input, output, storage, retrieval, conversion (including vector to raster and raster to vector) and updating of data. Besides there are possibilities for merging graphic, text and image files. The *Analysis* module is designed to include the usual analytical tools which are present in many GIS softwares (e.g. overlay, neighbourhood and connectivity analysis, measurement, simulation modelling, etc.). Due to time limitations both the *Data Management* and the *Analysis* module could not yet be implemented in the prototype. However, it is expected that the GIS functions (like OVERLAY, NETWORK, GRID and TIN) and the database management functions of ARC/INFO may easily be transplanted to these NAISC modules.

The *Browsing* module and the Mapping Function of the *Representation* module are actually implemented as they represent the most striking differences between an 'ordinary' GIS and the NAISC. The implementation is mainly done in ARCPLOT, whereby options offered by ArcTools are partly incorporated in the Mapping Function of the Representation module. AML (the ARC Macro Language) was used:

- ▶ to group frequently used ARC/INFO command sequences as one option;
- ▶ to standardize procedures, such as creating map command lines;
- ▶ to prompt user information, validate user input and provide meaningful error messages;
- ▶ to automate frequently performed and repetitive tasks, such as sequential browsing;
- ▶ to automate database access, e.g. in getting files, coverages, or items from the database; and
- ▶ to create a user interface.

The narrative faculty of the NAISC took shape in the *Browsing* module. The functional architecture of this module, which could be considered as the gateway to all information in the system, is shown in *Figure 2*.

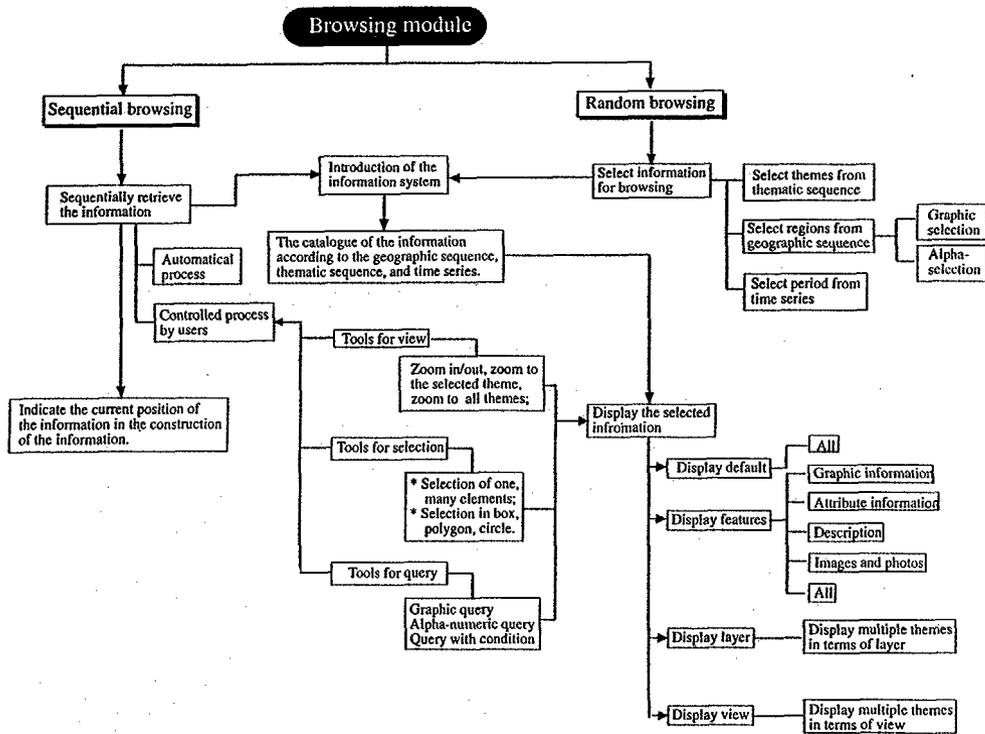


Figure 2. Functional architecture of the Browsing module

Your special attention is asked for two possible ways of browsing the information: random and sequential. The narrative faculty of the NAISC is reflected by the possibilities for sequential browsing, following either a thematic, geographic or time sequence. In the random browsing mode NAISC users may select the subjects they are interested in from the system's thematic catalogue and define the wanted time period and may graphically or alphanumerically select the level of aggregation, i.e. the geographical region. In both the sequential and the random browsing modes the information may be presented in several pre-edited ways, both analytically and synthetically: maps, graphs, statistical tables, text, photos and other images (sound and video are possible in principle as well).

But with the help of the information *Representation* module users may also modify the ways in which the information is presented, depending on their specific needs and applications. Depending on the characteristics of the information and the purpose of the representation the system first proposes some potential solutions and ranks them in terms of suitability. But, where possible, the user is also free to change the images, graphs, tables or maps as he or she likes. As maps are the most suitable means to explore, analyze and represent the geographical data stored in a NAISC, the Representation module of the prototype focusses on the mapping functionality. The design of this functionality is shown in *Figure 3*. It is not just like a map design package, but it also contains libraries, in which symbol sets, map types and elements of map composition are brought in relation to the information to be represented and are made available to help NAISC users to make their own cartographically justified map products. In this way, the NAISC actually functions like a knowledge-based mapping system as well, as the user is guided through the process of map design and construction according to the rules of cartographic semiology and thematic cartography. For instance, to this end the measurement levels of the geographic information (nominal, ordinal, interval and ratio) and the dimensional characteristics are already stored with the attribute data. When the NAISC-user wants to retrieve certain data, the system presents (visually, by means of icons) different, alternative, but cartographically correct, ways of representation or map types (see e.g. *Figure 4*). When a particular method of representation is selected, in several ways it may still be adjusted to the specific needs of the user (for instance in terms of data classification, symbolization, choice of colours, map text, etc.). But in offering, for example, symbolization parameters in relation with certain map types, the system only allows design solutions which are not wrong from a cartographic point of view. Partly to that end user friendly interfaces are designed for every possible map type.

3.3 NAISC user interface

A user interface is a set of tools provided to users to interact with a NAIS. The objective in designing a user interface of a NAIS is to minimize the steps needed to initiate and accomplish a particular operation, so that users can easily use various functions and conveniently switch between them without in-depth knowledge of computers, digital data processing and the software. A user interface has the task to [9]:

- ▶ inform the user of the state of the system;
- ▶ present choices of action to the user;
- ▶ receive the user's input and translate it to commands to the processing software and database management system; and
- ▶ translate the required information from the database's internal representation or language to a language understood by the user.

The interface is of utmost importance for an efficient and correct use of a NAISC and has to be adjusted to the potential users and to the different modes of use. Graphical interfaces, designed according to the Window-Icon-Mouse-Pop up menu (WIMP) approach, have proved to be very successful in the past few years. Such an interface prevents that the user should know a lot about ARC/INFO in order to be able to work with the NAISC. In other words, the 'buttons' on the screen that are 'pressed' with the help of the

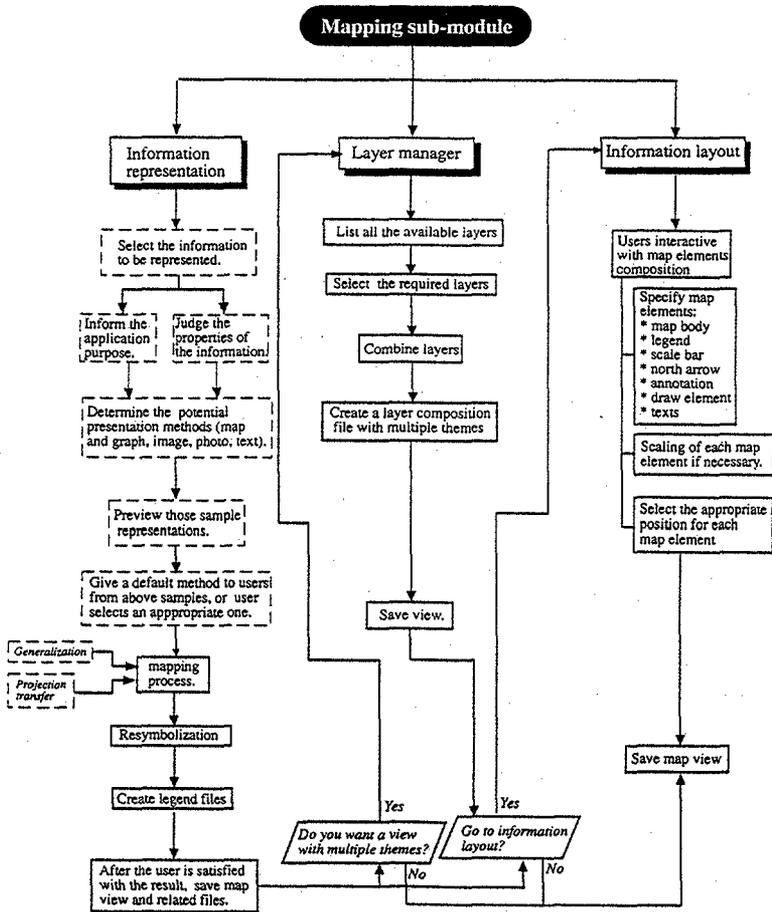
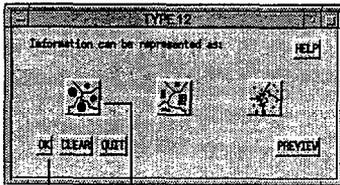


Figure 3. Functional design of the mapping function of the Representation module



Select the left icon and press OK button, a sub-menu will appear, user can change parameters which are listed on the menu.

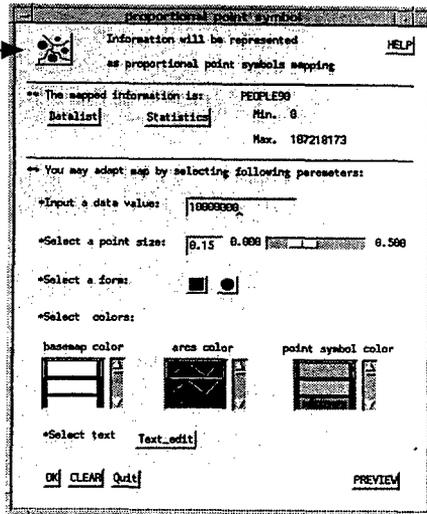


Figure 4. Methods of cartographic visualization and possibilities of adjustment thereof as presented by the NAISC prototype when a user wants information about absolute population numbers and their distribution

mouse, have to activate series of ARC/INFO commands which eventually lead to the desired result.

On the basis of these considerations a user interface has been created with the help of ARC/INFO's FORMEDIT: a graphical tool to create AML form menus with full functionality. The user sets all the parameters required on the form menu in order to execute a complex operation. The BITMAP tool in the UNIX environment was employed to create the icons which appear on the form menus. Naturally, in terms of organization and logical flow the interface is directly related to the conceptual structure of the NAISC prototype. So, the user may access the four main modules of the NAISC via the main menu of the interface. Within such a module, series of sub-menus may be activated which are threaded together in hierarchical and parallel ways. Other points of attention in the design of the user interface were the visual appearance, user-friendliness, simplicity, consistency, error control and reporting mechanisms and on-line help and feedback.

4 Conclusions

The aim of this research project was to develop a prototype of a NAISC: a computerized GIS, related to a sample geographic database of China, with knowledge-based representation functions and a narrative faculty in which pre-edited documents play a guiding role. New and unique features of the prototype, compared to already existing electronic atlases in China, are the narrative faculty and knowledge-based information representation functions. In this sense, the map orientation of the NAISC concept formulated some five years ago [7] has evolved into a data and information orientation with an additional narrative faculty.

Due to the limited time available for this research project the conceptual design of the NAISC prototype could not yet be fully implemented. For instance, the Analytical, Data Management and Read-Me modules are not yet operational and the Representation module only partly. In addition, some more attention need to be paid to problems like the exchange of data between ARC/INFO and other software (via the Data Management module) and aspects of cartographic generalization and map projections. However, the prototype can already provide a good image of the usefulness, operation and functionalities of a potential NAISC and it may therefore serve as a good starting-point for the further development and operationalization of the system.

It also demonstrates that ARC/INFO appears to be well suited for setting up a NAIS. However, a clear disadvantage of this software are the limited standard possibilities for diverse cartographic presentations, especially for the visualization of socio-economic data. The ways in which several thematic map types have to appear now on screen (or on paper) are sometimes rather long-winded and the results flatly meagre. Other limitations of the application of ARC/INFO for building a NAIS are the impossibility to invoke more than one graphic window at a time and the difficulties in creating an optimal user interface for this application. Although ARC/INFO is or can be made much more user friendly than a couple of years ago, the user interface still leaves a lot to be desired. Although it is found that AML is flexible and powerful enough to develop most of the user interfaces for NAIS applications, at the same time it is not a simple language and it costs a lot of time to generate the interfaces. Besides, the flexibility in the graphic design of the user interfaces is too restricted.

In all these respects, the new version (Rev.7) of ARC/INFO and, in particular, the new version (2.0) of the ArcView™ software package seem to be more promising. Therefore, one of the first tasks in the further development of the NAISC prototype, next to implementing the remaining functional modules, may be to investigate the effects of the application of ArcView™ (perhaps in addition to the latest version of ARC/INFO) on the efficiency and the use of the system.

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