CO-102

PERSONALIZED MAP DESIGN BASED ON USER MODELING

CHEN Y.(1), XIE C.(1), YE H.(2)

(1) Zhengzhou Institute of Surveying and Mapping, ZHENGZHOU, CHINA ; (2) North China Institute of Water Conservancy and Hydroelectric Power, ZHENGZHOU, CHINA

ABSTRACT

Today's electronic maps are one-size-fits-all, and users with little programming experience have very limited opportunities to customize an electronic map according to their task, work habits and preference. Furthermore, users of electronic maps nowadays are both map designers and users sometimes, but most of them are non-specialist users who lack map design experience, and current GIS or CIS applications with map design functions are difficult to use for such kind of users. The solution to this problem is to build a personalized map design system with adaptive design function, and the emphasis is on the user modeling. In this paper, the authors firstly build the framework of personalized map design system based on user model, then put forward the concept of quaternary interaction user model, and discuss the process of user modeling, and lastly propose the user behavior database mining algorithm based on improved Apriori algorithm. Experiment proved that the algorithm is effective for personalized map design. The main purpose of our research is to provide personalized map service through personalized adaptive map design technique based on user modeling.

KEYWORDS

personalized map, map design, user modeling, adaptation, personalization

1 INTRODUCTION

In recent years, along with a vast increase in the amount of spatial data accessible online and popularization of electronic map, the needs for personalized maps are on the increase. However, GIS or CIS applications typically present default maps to users without personalizing both contents and visual appearance of maps. Today's electronic maps are one-size-fits-all, and users with little programming experience have very limited opportunities to customize an electronic map according to their task, work habits and preference. Furthermore, users of electronic maps nowadays are both map users and designers sometimes, but most of them are non-specialist users who lack map design experience, and current GIS or CIS applications with map design functions are difficult to use for such kind of users. How to take good care of the map users individually? Personalization is the best way, but designing personalized maps that are responsive to the individual needs of each user, is a challenging task.

Personalization is a process that changes the functionality, interface, information access and content, or distinctiveness of a system to increase its personal relevance to an individual or a category of individuals. Automatic personalization may greatly enhance user's productivity, but it requires advances in customization (explicit, user-initiated change) and adaptation (system-initiated change in response to routine user behavior). Personalized map service has two service modes: customization and adaptation. Fast and high quality map customization service is realized by parameterized template technology through the user configuration and modification template. Adaptive map service is realized based on user modeling by user behavior tracking and data mining which presents users with automatically and implicitly personalized map service. Both needs personalized map design.

Using user-oriented electronic map adaptive strategies to solve the problems in spatial information customized by customer, thus to provide users with various personalized electronic maps are currently a hot topic in the field of electronic map [1]. Adaptive electronic map design is more difficult than customized electronic map design; it is the advanced stage of adaptive map visualization research [2]. Taking adaptive mechanism as the core, the personalized map design system produces personalized maps, which accord with cartographic standards, according to user's background information, historical behavior records and personalized cartographic templates [3].

In the current technical condition, it is difficult to realize an adaptive electronic map design system; therefore it is an effective way to realize a personalized map design system with the combination of customization and adaptation. In order to improve the adaptability of the system and realize personalized map design, the authors discuss the adaptive mechanism of personalized map design, establish a quaternary interaction user model, and improved user behavior monitoring and data mining algorithm. The main purpose of this study is to improve the traditional map design method through adaptive technology.

2 ADAPTIVE DESIGN MECHANISM OF PERSONALIZED MAP

The basic idea of personalized map design by user modeling is to generate personalized maps that accord with cartographic standard, according to user's background information, historical behavior records and personalized cartographic templates, which adaptive mechanism is the core. The design process of personalized map can be described as that the system forms the function model of the current design object after obtaining maps designer's intent. In the subsequent design process, map designers will always get the interactive guidance from the system, which makes the design behavior automatically adapt to the function demand and cartographic specification of the current design, so as to realize the design goal of personalized map fast and efficiently.

2.1 Framework of Personalized Map Design System

Personalized map design systems can be defined as all map design systems that accommodate some user's characteristics into the user model and apply this model to adapt various aspects of the system to the user. Considering the component characteristics of an electronic map, the authors present a framework of personalized map design system based on user model, which is shown as Figure 1. The framework consists of four main parts: (1) user model; (2) context; (3) reasoning module; (4) template library (interface template library, color template library and symbols template library).

In the framework of personalized map design system, the user model is built based on the user's background information and operational information, the context is determined by environment and user's operations, and the environmental factors is acquired from the system environment, then the adaptive control module chooses the appropriate interface element, color configuration and symbols from interface template library, color template library and symbol template library, and combines them together, according to the user model, the context, the environmental factors, and lastly the system produces a personalized map.

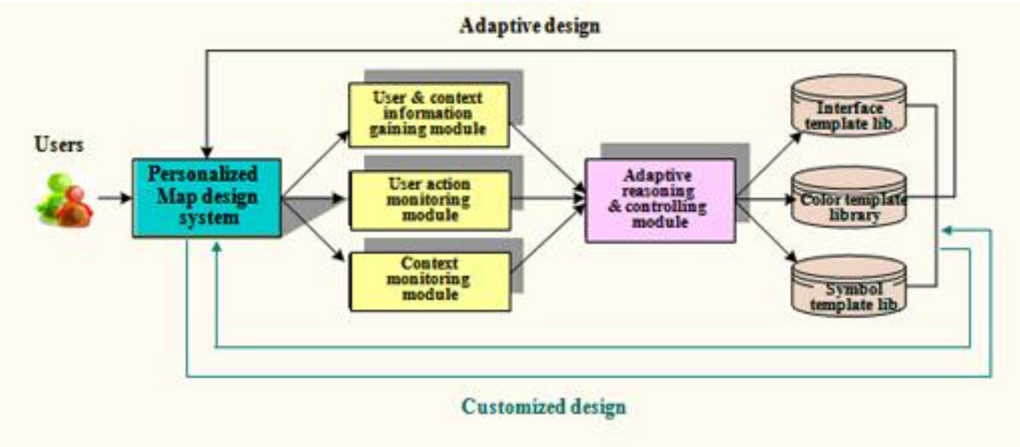

Figure 1 Framework of personalized map design system based on user model

2.2 Main Parts of Personalized Map Design System

From the framework of personalized map design system, it can be seen that the user model, the context and the reasoning module, the template library (interface template library, color template library and symbols template library), are key parts in the adaptive mechanism.

<u>*2.2.1 User Model*</u>

User model in a personalized map design system is used to describe the background, behavior, task, and preference of individual map user. According to the user model, the system can analyze and predict the user's knowledge and dynamic interaction, match user to relevant map contents and visual effects by reasoning, and meet the user's individualized map design demands. User model research in personalized map design includes the building, updating and matching of user model, and the main topics are user modeling and user behavior database mining.

<u>*2.2.2 Context*</u>

The context includes the following three aspects: the user types and behavior characteristic in user model; the historical records of user's interaction; the current electronic map forms, such as interface style, static elements layout, and color configuration. In the electronic map design process, the context related to user tasks is the basis, which the system actually provides services for users.

<u>*2.2.3 Reasoning Module*</u>

Reasoning module mainly refers to reasoning algorithm. Combined with electronic map features and technical status, the reasoning methods based on the production rules could be chose as the core technology to realize personalized map design.

2.2.4 Interface Template Library

It is necessary to make a comprehensive analysis of existing user interface elements (window, dialog box, icons), and then the result of the analysis is stored into the interface template library, which includes the interface conceptual layer, functional layer, representational layer and their relation structure. On the basis of the results analysis, the different types of user interface model are established; the map users can choose interface elements according to their preference and cognitive habits, at the same time optimize the structure, display mode and icons effect (text, graphics, animation) of interface elements. The interface template library currently is managed in the form of XML file or database.

2.2.5 Color Template Library

Map color template library is built based on the adjust processing for whole map tone, which forms various map overall display, and be chose by map users. These templates have their distinguishing features in symbols, label, color, and the overall style of expression, suitable for different purposes of data. The color matching schemes in color template library could be produced by taking the published paper maps and electronic maps as good examples.

2.2.6 Symbol Template Library

The map symbol template chooses the symbol in the symbol library and its articulation, then form various whole display of map and is provided for user to select by matching with the whole hue of map. Map symbol template includes the category, color, expressive mode, proportion of displaying, and graduation value. The design of map symbol template library includes four stages: the collection, classification and library building of all kinds of map symbols; the design and establishment of symbol's attribute; the metadata design and meta-database construction of map symbols; the knowledge base design and symbols user model design.

3 QUATERNARY INTERACTION USER MODELING

Traditional cartographic visualization systems, having no full consideration of the actual needs and personal background of different users, cannot adapt to different users. While in personalized map design system, users are subjects, and the system should adapt to the users, but the user adapts to the system. A personalized map design system is required to combine the information about the user, such as user background and operation behavior information, and can build a user model for each user according to these characteristics information. User model directly affects the adaptive effect of the system.

3.1 Quaternary Interaction User Model

Aiming at the existing problems in the user model of current adaptive cartographic visualization system, the authors put forward a more comprehensive and specific user model - a Quaternary Interaction User Model, which consists of four components: the user background information, user behavior information, target information (the task attribute), and interactive object information. The characteristics of "people" and "machine" in human-computer interaction are fully considered by the model, which can be formalized as follows:

$$UM = < UB, UA, TA, AO > \qquad (1)$$

In the formula (1), UB is user's background information; UA is user action information; $TA = \{ta_i \mid i = 1, 2, 3, \ldots, m\}$ is task attribute information set including purpose, environment, requirement and difficulty of task; and AO is interactive object information including the system function, user interface, and map information, etc.

The model summarized user's characteristics mainly from two aspects: the user background information and user interaction behavior. The former describes the background information of users, and the latter reflects the user's interactive behavior in operating personalized map design system. The organic combination of them could quite comprehensively reflect user characteristics when he uses a personalized map design system. And task attribute determines the user behavior information; interactive object information provides the necessary guarantee for users effectively completing their tasks. The combination of them more meticulously describes the user model.

From the formalized description of the model, it is known that the realization of this user model needs to survey the user background information parameters and to count user behavior information parameters, and the task attributes and interactive objects depend on external conditions and system itself, these are data needed to be acquired in the prophase. So when a user login the system at the first time, he is asked to fill the relevant registration information with user model including his name, gender, educational level, profession, computer knowledge and operation ability, purpose, interest, preference and so on, then the system produces an initial user model according to production rules. With user's interacting with the system constantly, through tracking and recording user behavior, the system constantly updates user model using relevance feedback technology to modify user model repeatedly, which makes the user model truly close to the user; meanwhile, the user model as a user example stored in user model library and as the basis of other user model matching.

3.2 User modeling

In the application of the system, the authors used the object-oriented thought and VC + + programming language to build the quaternary interaction user model: establish for the AdaptiveUser classes of objects, and constitutes the methods and properties of AdaptiveUser, respectively are defined as different methods and properties of AdaptiveUser classes.

User Class CadaptiveUser can be defined as;

```
class CAdaptiveUser //adaptive user base class, responsible for all user parameters
{
public:
int UserID;//User ID
CUserAge UserAge;//user's age
CUserGender UserGender;//user gender
CUserEducation UserEducation; //user's culture degree
…
CModifyUserModel ModifyUserModel;//user model modification
…
};
```

Various subclasses contained in AdaptiveUser, such as ModifyUserModel and UserEducation can also use the same class to describe, for example, ModifyUserModel can be defined as class CModifyUserModel:

```
class CModifyUserModel
{
public:
int UserModelID;//User Model ID
void MonitorUserAction ( );//Monitoring User Action
void ReadUserActionDataBase ( );//Reading User Action Database
void MineUserActionDataBase ( );//Mining User Action Database
…
};
```

In addition, in order to facilitate the acceptation and expression of the computer, some fuzzy attribute information need to express in the quantified way, such as variable name UserGender, using 0 and 1 to represent male and female users respectively.

4 USER BEHAVIOR MONITORING AND DATA MINING

User behavior monitoring module is a critical part of the personalized map design system, which determines the adaptive effect of the system, and its main function is to monitor user's activities including keyboard keystrokes and mouse activity, application state analysis and user local resources analysis. User behavior data itself can't be directly used by system so as to realize adaptive service, only through user behavior database mining and analysis, and after the establishment of user model, adaptive service can be realized by the system.

4.1 User Behavior Monitoring

User action monitoring is an important means to help the system modify automatically individual user model, determine the proficiency of user operating system, reflect user's habits and hobbies, and speculate the using objective of user. User action monitoring method by using the mouse and keyboard to track and record user action is used. Its principle is mapping the messages of the mouse and keyboard that user operated into the user operation capture function that designer defined when user interacts with the system, through the message mapping of the system.

When establishing the system framework, the hook installed can intercept and deal with the appropriate messages, for example, a keyboard hook can intercept keyboard messages, the mouse hook can intercept the mouse messages, the shell hook can intercept start-up and close program messages, and the log hook can monitor and record the input event. These hooks can dynamically retrieve the user operation information. These operation messages are numeric data, which are constantly adjusted during the interactive process of the user and the system, and should be stored in database form in order to facilitate the storage and management.

Obtaining basic user operation message is not the ultimate aim, what the system needs is to mine the user relevant information about the skillful degree and purpose of using the system from these messages. So it is necessary to mine and analyze these data on the basis of gaining messages, and provide operational data for speculating user behavior so as to adjust the user model.

4.2 User Behavior Database Mining

User behavior database mining includes: the statistics of behavior frequency and retention time, the mining of behavior association rules, the mining of behavior sequential rules and the mining of behavior clustering. The mining of behavior association rule is mainly discussed in this paper.

Association rules algorithms are mainly Apriori series algorithm [4] and FP - tree algorithm. FP - tree algorithm will produce a lot of nonsense rule, and the efficiency of Apriori algorithm is deficient, but simple and easy to realize [5]. The procedure of Apriori algorithm is as follows (in order to use Apriori algorithm to mine user behavior database, some changes has made in this paper, the contents after the symbol • are increased by the authors):

1） L1 = {large1-items};•M1 = L1;

2） for(k = 2; Lk-1≠ ; k+ +) do begin

3） Ck = apriori-gen(Lk-1);

4） forall transactions t∈D do begin

5） Ct = subset(Ck,t);

6） forall candidates c∈Ct do

7） c.count++; •if Apriori-con(c), then c.realcount++ end if

8） end

9） Lk = (c∈Ck | c.count ≥ min_sup) •Mk = (c∈Ck | c.relcount ≥ min_sup)

10） end

11） Answer = Uk Lk; •Answer = UkMk;

The role of function apriori-gen (Lk-1) is to generate candidate k categories set Ck, this function is divided into mergers and pruning. In the part of merger, through a merger of two k-1 categories set Lk-1p, Lk-1q , a possible k sports set can be got. The algorithm is as follows: insert into Ck

select p.item1, p.item2,…, p.itemk-1, q.itemk-1 from Lk-1p, Lk-1q, where p.item1 = q.item1,…, p.itemk-2 = q.item k-2, p.itemk-1 = q.item k-1;

In the part of pruning, the candidate k categories set in Ck will be cut off if (k-1) -dimensional subset of Ck is not in Lk-1. The algorithm is as follows:

forall itemset c∈Ck do

forall（k-1） subsets s of c do

if (s Lk-1) then

delete c from Ck.

Apriori algorithm is one of the most influential mining Boolean association rules algorithms of frequent itemsets [6]. Since user action information in database is dynamic, time factor is very important. The importance of time factor mainly manifested in two aspects: one is time duration of user having an operation, which explains this user’s interest to the operation; the other is that the user action database is updated constantly with the passage of time, which explains the user’s interest may change with time passing by. So an improved Apriori algorithm that adds time factor in it is presented, which is shown as formula 2.

$$\Delta WA => B = \sigma D^{days} \bullet time \bullet Association(A => B) \qquad (2)$$

Two time parameters are added in formula (2): one is time representing the duration of operation, another is days representing the days of using the system. ∆WA=>B is the weight changes of association rule $Association(A=>B)$

.

Among them,σis the factor less than l.

Combined with static user basic information, formula (2) can easily establish user model with association rules for each user, so the system can provide adaptive map design for each user according to the user model. Formula (2) is actually a learning algorithm, the user model will be more precise with the passage of time, and adaptive service will become more and more close to the needs of the users.

Through association rule mining of user behavior database, the system can obtain the correlation between the operations when users use an personalized map design system, and also can predict the other operation that the user may have, thus can provide an personalized map for the user.

5 CONCLUSIONS

Personalized map design system based on user model, which overcame some drawbacks exist in previous electronic map design system, through departing the description and implementation of user interface, the map color matching and symbol grading, make map design more humanization, individuation, also will greatly improve the efficiency and effectiveness of electronic map design. Of course, the design method proposed in this paper has yet to be perfected, a personalized map design system with the functions of complete self- processing, self- explanation, and self- guiding, is just a system in ideal state. Electronic map design is a complex activity, it involves semiotics, aesthetics, cartography, psychology and cognitive science, the research on electronic map design is still an open multilateral exploring problem. With the improvement of people's aesthetic conception, and the development of modern science and technology, it is necessary to explore and create new map design theory continuously, and create a simpler perfect map design method.

REFERNCES

1. Wang Hong, Ai Tinghua, Zhu Guorui. Adaptive Strategy on the Visualization of Electronic Map [J]. Geomatics and Information Science of Wuhan University, 2004, 29 (6): 525-528. (in Chinese)

2. Wang Yingjie, Yu Zhuoyuan, Su Ying, Chen Xiaogang, Chen Yufen. The Main Frames and Achievements in Adaptive Geo-visualization System Research [J]. Science of Surveying and Mapping, 2005, 30 (4): 92-96. (in Chinese)

3. Wang Yingjie, Liu Yue, Chen Xiaogang, Chen Yufen, Liqiu Meng. Adaptive Geo-visualization: an Approach Towards the Design of Intelligent Geo-visualization Systems [J]. Journal of Geographical Sciences, 2001, 11(S):1-8.

4. Agrawal R,Imielinski T,Swami A.Mining association rules between sets of items in large databases[A]. Proceedings of the ACM SIGMOD Conference on Management of Data [C]. New York: ACM, 1993: 207-216.

5. Dai Zhen, Fei Hongxiao, Li Jun, Xie Wenbiao, Xiao Xinhua. The Algorithm of Users Behavior Associate Rules Mining Based on Specific Pattern Tree [J]. Computer Systems & Applications, 2007, (5): 56-59. (in Chinese)

6. Yu Zhuoyuan. Studies on Individualized Map Design Based on Adaptive Spatial Information Visualization [D]. Institute of Graduate Student, CAS, 2008. (in Chinese)