COGNITION THEORY-BASED RESEARCH ON ADAPTIVE USER INTERFACE FOR GEO-VISUALIZATION SYSTEM

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Abstract

Geo-visualization system becomes more and more useful in now days. However, current geo-visualization systems only can be used by experts. The main reason is that geo-visualization systems, especially their user interfaces are not designed according to the user-centered rules. Adaptive user interface is a powerful method to solve this problem, and through researches on human’s cognitive characteristics, a mechanism of geo-visualization system adaptive user interface can be established.

INTRODUCTION

Technology of geo-visualization is now developing faster and faster. Desktop GIS, web GIS, mobile GIS, multimedia electronic atlas are changing their roles from expert’s tools to public’s tools. However, the design of these products does not sever public users well. Numerous functions and complex user interface that only can be manipulated by experts always make people confusion. One important reason is related to these products’ user interface. User interfaces of some geo-information systems are equipped with poorly structured and unnecessarily intricate operations (Wang et al., 2001). Therefore, badly designed user interfaces became obstacles in geo-visualization system’s way to popular. The author applies human’s cognition theory for designing user interface, and tries to find a way of designing adaptive user interface for geo-visualization system.

This article consists of seven parts: 1. Introduction. 2. Cognition based methods of adaptive user interface of geo-visualization system. 3. Analyzing of user interface in current geo-visualization systems. 4. Methods and standards of user classification. 5. Establishment of adaptive mechanism for geo-visualization user interface. 6. Introduction of the experiment. 7. Conclusions and Prospects.

COGNITION-BASED METHODS OF ADAPTIVE USER INTERFACE FOR GEO-VISUALIZATION SYSTEM

Adaptation means that biology can change its characteristic to adjust the change of environment, which it lives in. Adaptation theory has been used in many fields of science. Adaptation’s kernel meaning is that one system can change its characteristic actively to adjust other systems when they react each other. User and the user interface can be looked as two systems that react each other. Adaptive user interface should be adapted to user’s characteristic, especially user’s cognition characteristic.
Human’s cognition factors of memory in designing geo-visualization user interface

Characteristics of human’s memory are important to design user interface. Human’s memory can be divided into two parts: short-term memory and long-term memory. In designing user interface, if we use these two kinds of memory reasonably, we will avoid the common phenomena of commands forgotten or tools missing, e.g. using chunking information to increase the users’ short–term memory capacity (Dix et al., 1997). In this way, users remember new commands and tools’ functions more easily.

Human’s cognition factors of vision in designing geo-visualization user interface

Geo-visualization system shows user the geographic information by means of visualization. This information is shown to user by user interface, so cognition factors of vision is especially important in designing user interface. With the direction of visual cognition principles, the user interface will be not only beautiful but also effective, and the finite visual resources will be used more effectively.

Principles of visual cognition that can be used in designing user interface:

1. Concision of user interface
   Every tools and menus in user interface without any choices, only makes user confusion and system’s low efficiency.

2. Color harmony in user interface
   Harmonic colors make user interface pretty, and makes user comfortable. Contrast colors can be used in warning and fatal important tips.

3. Effective use of display space
   The display space of device and user’s optic zone are limitary, therefore, important information should be shown in important place.

4. Three principles of visual information combination
   User interface design should follow three principles, that is, neighborhood combination law, similarity combination law and closes combination law. With these laws interface tools can be organized well.

5. Visual attention & visual search law
   Those objects with moving or changing colors will attract users’ attention, thus, it can be used to show objects that user searched in geo-visualization system’s user interface.

Personal cognitive factors to be concerned in designing user interface

Users in different cultural background or religion beliefs may have some different cognitive factors. Our goal is to design a geo-visualization system that can be accepted by public users. Therefore user’s personal cognitive factors must be concerned.

ANALYSIS OF CURRENT GEO-VISUALIZATION SYSTEMS’ USER INTERFACES

Adaptive user interface of geo-visualization system is designed to overcome immanent deficiency of traditional geo-visualization systems’ user interface. However, traditional user interfaces’ excellence elements should be inherited. Because of these two reasons, Analyzing of current geo-visualization systems’ user interface is an important pre-task.
Find design problems from current geo-visualization systems’ user interfaces
The authors analyze some current traditional geo-visualization systems’ user interfaces, and found some design problems that is listed as follows:

Firstly, Most of geo-visualization systems use WIMP (Windows, Icon, Menu, Point) style interface. This kind of interface has good interaction, but quite blankness. Current GUI/WIMP meets the user’s need to implement and master the geo-visualization systems in a certain time (Chen et al., 2003). However, this interactive method makes user feel tired after a long time operation, and user wastes time on looking for the tools she/he needed in many buttons and icons. Secondly, traditional geo-visualization system designer look experts as expected user, and terms are used without any explaining. To public users, this style of interface is quite unfriendly, even can’t be accepted. Thirdly, current geo-visualization system’s user interface is lack of consideration for user’s requirement. Fourthly, current geo-visualization system’s user interface can’t inspect and analyze user’s operations, interface has no foresee ability.

Select interface’s original styles and elements for adaptive interface
Current geo-visualization system user interfaces are not all defects. For some skillful users, the familiar interface is the best interface. So, it is necessary to gather some representative geo-visualization system user interface styles as a part of adaptive interface. This method can make adaptive user interface be accepted by skillful users as their familiar interface. With a long-term development, some GUI elements are well designed. Adaptive interface also can take advantage of them.

METHODS AND STANDARDS OF USER CLASSIFICATION
User classification is necessary
In designing user-centered geo-visualization system’s user interface, there is a need to acquire user’s characteristics. As a kind of information service system for public, geo-visualization system will face innumerable users, and it is impossible that build different user interface style for each individual user. So, it is quite necessary to classify users into some quantifiable groups. Users can be classified by their same characteristics, and then it’s possible building geo-visualization system user interface styles to adaptive these groups’ characteristics

Factors influenced upon user’s classification
Because there is not a very clear standard for users classification, when we begin classifying users into groups, many factors should be concerned. In current reaching stage, the authors concern some important factors that can affect users’ cognitive ability for understand user interface. One factor is users’ age. Different age causes users’ different requirements of user interface style. For example, children like graphic better than letters, adults’ interfaces can be like normal software’s user interface, but for elder, user interface should provides some assistant functions such as magnifier tool, larger font or contrast colors to adjust old people’s possible situation of vision decrease. User’s education degree is another factor should be concerned. Different education degree makes users have different ability of comprehension. Geo-visualization system adaptive user interface should have different styles for different educated users. The task that users want to accomplish is the third factor. Different users have different tasks when they using geo-visualization. In the users’ viewpoint, the best interface is the interface that can help them to accomplish
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their tasks. Because of this, user interface should provide different styles for users who have different tasks. And help them accomplish their tasks easily and rapidly. Users’ computer operation lever is the fourth factor should be taken into account. Computer system is the hardware foundation of geo-visualization. Users who can operate computer skillfully may have quite many knowledge on how to operate a user interface. But users without such knowledge will have difficulties to operate geo-visualization system user interface. Therefore, users’ different computer operation levers should be concerned in designing a user interface.

The factors mentioned above are not complete yet. Standards of user classification are flexible. New standards will be appended when new characteristic is found. And several standards may be used at the same time when estimating which user group should an individual user belong to.

Quantification of user classification standards
Some software also use simple user classification standards like “advanced ”,”normal ”and ”primary”, however, these software’s quantification of user classification are too simple. Such quantification method is not fit the demand of geo-visualization system’s user interface. In geo-visualization system adaptive user interface, user classification is based on factors that mentioned before. And each classification standard can be quantified as several degrees. For example users’ age can be quantified as “below14”, “15 to 18”, “19 to 30”, “31 to 50”, “more than 50”. Others standards also can be quantified. Then every individual user’s characteristic concerned above corresponds to a certain lever. And gather different levers of different characteristics’ standards can be used to represent a certain user.

ESTABLISHMENT OF ADAPTIVE MECHANISM FOR GEO-VISUALIZATION ADAPTIVE USER INTERFACE

Geo-visualization system adaptive user interface can change it self’s styles correspond with changing of user’s characteristics. How dose this wonderful thing happen?

Adaptive mechanism

Acquire user's basic information
Before geo-visualization system adaptive user interface begins to work, an initial state is needed. Because that if the interface doesn’t know any information of user, it can’t work well. On other word, if user input some of his or her basic information, the interface can adjust to this basic information as the first step of adaptive changing.

Mechanism in adaptive process
After user inputs basic information, interface still need to know what user changes in his operational process. To inspect user’s operation becomes important in this step. Use’s skill and user’s goal can be conjectured by analysis user’s operation. For example, when user clicks here and there meaninglessly, maybe this user is a novice or need more help. And if a user uses some tools frequently then the user’s main task maybe can accomplish with those tools’ functions. User’s operation characteristic can be conjectured by capture interactive devices’ messages such as keyboard’s messages and mouse’s messages.

Estimation of user’s type and characteristic
Estimation of user’s type and characteristic is through obtaining user’s basic information and capturing user’s operation characteristics. By estimating user’s basic information and
operation, user’s characteristics can be found out. Then interface compares these characteristics with user’s classification standards, and decides which group the user should belong to; at last, interface shows user adapted style. Abstraction of user’s characteristics can simplify the express methods of user’s characteristics. Certainly, user’s age can be express by number, user’s education degree also can be abstracted as numbers: “1”-primary education, “2”—secondary education and “3”— higher education. By this means a user’s characteristics can be express as (14<age <18,2,2…), it means a user whose age between 14 and 18, education degree is secondary education and can use computer simply…with this method, computer can process user’s characteristics data easily. And now, user’s characteristic can be estimated by mathematic expressions. In the same way, user’s operation characteristic also can be abstracted, and be estimated by mathematic expressions.

**Dynamic reaction of user interface**

Adaptive interface changes its style on the basis of user’s characteristic estimation results. The dynamic changing includes changing style, changing position or filtrating interface’s elements. When some important changes will happen, the interface gives user right of decision. This method ensures interface’s changes are acceptable, and under the user’s control. Flow of how geo-visualization system adaptive user interface adaptive user’s characteristics can be shown as the Figure 1 below.

![Figure 1: Design of geo-visualization adaptive user interface.](image)

**Data structure and data administration of geo-visualization system’s user interface**

Geo-visualization system adaptive user interface is different with current user interface. The different aspects not only exist in styles but also in structure. Adaptive user interface acquires user’s characteristic information and has the function of data process. For an adaptive user interface, data structure and data administration is important. In order to support interface’s adaptive changes, data structure and data administration methods must be designed. The authors use the object-oriented method to structure user’s characteristics data. Building classes in programming to express user’s groups, and each user’s characteristic can be express as data elements in the class. Using the inheritable attribute of class, different user group can be derived.

Database can be used to administrate user’s characteristic data and interface’s data. Different kinds of data can be administrated by different database. So, three databases are
needed by adaptive user interface. First of them is user’s basic information database. It uses users classification standards as fields, and different user’s information as data elements. Each user has a unique ID number. Second one is user’s operation database. Every interface’s element that can react device message is this database’s fields, their state as data elements. Time is a special field of this database because by comparing user’s current data and historic data, user’s change of characteristics can be found. The last one is interface’s database it administrate different elements of interface such as tool bars, icons, graphics and pictures that may be used by adaptive changes.

**INTRODUCTION OF USER INTERFACE COGNITION EXPERIMENT**

Cognition experiment of user interface is an attempt that uses cognitive experiment method to discover interface design rules. The experiment’s goal is find out the relationship between user’s characteristic and interface’s characteristic. In the reaching of geo-visualization system adaptive user interface the author makes experimental software.

**Experiment design**

As experiment’s subjects, some students of the college where the author works in attend the experiment. They come from different departments and have different computer operation levers. Firstly the experiment software inquires subject’s basic information, secondly subject is asked to do operation and set interface’s elements as they favorite, and choose the interface style that they like best. The user’s information and the interface information that user liked are recorded in databases. After enough subjects are tested, there are enough data and by analyzing this data, the relationship between user’s characteristic and interface’s characteristic can be found out. The blue print and flow chart of the experiment that mentioned above can be shown as Figure 2.

![Figure 2: Experiment’s blue print and flow chart.](image-url)
The contents and steps of experiment
Before the beginning of the experiment, the subject is asked to input his basic information. With the help of software’s tips this work can be done easily. At the first step of experiment, subject can operate interface element as their favorite, this step test content include change the size of main interface, set the position of tools, choices colors used in interface, sets the button style and make favorite icons. When subject is doing these jobs, his operation and favorite interface style is recorded by experiment software. The second step of experiment is sorting the current geo-visualization system user interface styles. Subject is given some interfaces of different current geo-visualization, these interfaces are some representational ones that chosen from many current geo-visualization system user interface. A subject sort these different style interfaces from the best to the worst, the result also is recorded by software. By this step, subject’s favorite of interface’s macrocosm style can be discovered. In the third step of experiment, subject is shown different detail layout state of same interface, as what she/he does in previous step, subject sorts these detail layout styles from best to worst, meanwhile, result is recorded automatically. After this step of experiment, subject’s favorite of interface’s detail layout styles also can be found. After all subjects finish testing. Tester can use experiment software’s analytic function see the test results charts.

CONCLUSIONS AND PROSPECTS
Geo-visualization system adaptive user interface is a new theory to solve current geo-visualization system problem that in the way of geo-visualization systems’ popularization. Human’s cognitive characteristic play a key role in designing user interface. By the means of cognitive experiment, user’s cognitive characteristics of user interface can be found, and based on these cognitive rules adaptive mechanism of geo-visualization system adaptive user interface can be built.

There is wide field in researching of geo-visualization system adaptive user interface. The author’s current researches are just the first step toward the application of adaptive theory in geo-visualization. And the adaptive mechanism mentioned in this article is also a primary model. In the further research the author will concern other sense cognitions, and discover their characteristic. The experiment’s contents should be increased. And the ability of results analysis should be enhanced.

REFERENCES