

COGNITIVE EXPERIMENT ON USER INTERFACE FOR CARTOGRAPHIC VISUALIZATION SYSTEM

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ABSTRACT

Adaptive user interface can change characteristics of itself to adapt cognitive characteristics of different users, task conditions, and special demands. The starting point for designing the adaptive user interface is analysis of users, which involves in user's characteristics, such as age, gender, knowledge background, profession, spatial cognition ability, and computer operation level. According to users' analysis, users can be classified into some kinds, each kind with a certain interface type corresponds to like, understanding and cognition ability. Building a mechanism of adaptive interface needs rules of cognitive characteristics of users, and relationship between user's cognitive characteristic and style of user interface, which can be confirmed by user's cognitive experiments. In this paper, the author introduces two cognitive experiments about user interface on cartographic visualization system and explores the application of cognitive experiment in the user interface research.

1. INTRODUCTION

Cartographic visualization system (CViS) is a kind of computer system that provides users spatial information with cartographic methods. With advantage computer graphic technology, CViS aims to make digital map sever users better, and assist people's spatial cognition. In design and development of CViS, function is regarded as traditional center, many researchers effort to enhance functions of CViS, but ignore user interfaces of CViS. So, many powerful CViS are only used well by experts, while ordinary users use them with great difficulty. One system with only one professional style of user interface cannot meet the demand of ordinary users who have no geographical or cartographical knowledge. This problem restricts the development of CViS becoming a kind of popular spatial information tool.

Adaptive user interface for CViS is a new way to solve the problem existed in user interface. The goal of adaptive user interface is that the system has ability to change its user interface to adapt different users. Experts and novice have different cognition on CViS' user interface, so they cognize and understand CViS' user interface quite differently. It is necessary to find out what factors influence users' cognition on user interface and what relationship among different kinds of users and user interface styles of CViS.

Users' cognitive differences are evident in the operation process when they use CViS, so it provides researchers a valuable chance to observe the different cognitive characteristics among different users. In order to track these different characteristics of users' cognition when they use CViS, an experiment is built necessarily. With results of experiment and we can find what factor cause the different cognitive characteristics among users, and how these cognitive characteristics affect users using CViS.

Some relationships among user groups and user interface styles also can be found. The experiment introduced in this paper is based on computer. By this mean, some users' information and cognition concerned data can be tracked and recorded automatically with accuracy.

2. FUNCTIONS OF EXPERIMENT SOFTWARE

Cognitive experiment of user interface for CViS has functions as following: Recording users' basic information; Simulating a CViS' interface to support users' operations; Users' custom interface; activate associated CViS that have been installed in experiment computer; Tracking and recording users' experiment data with data base; Reporting of experiment results by charts and tables. Figure 1 is the flow chart of this cognitive experiment.

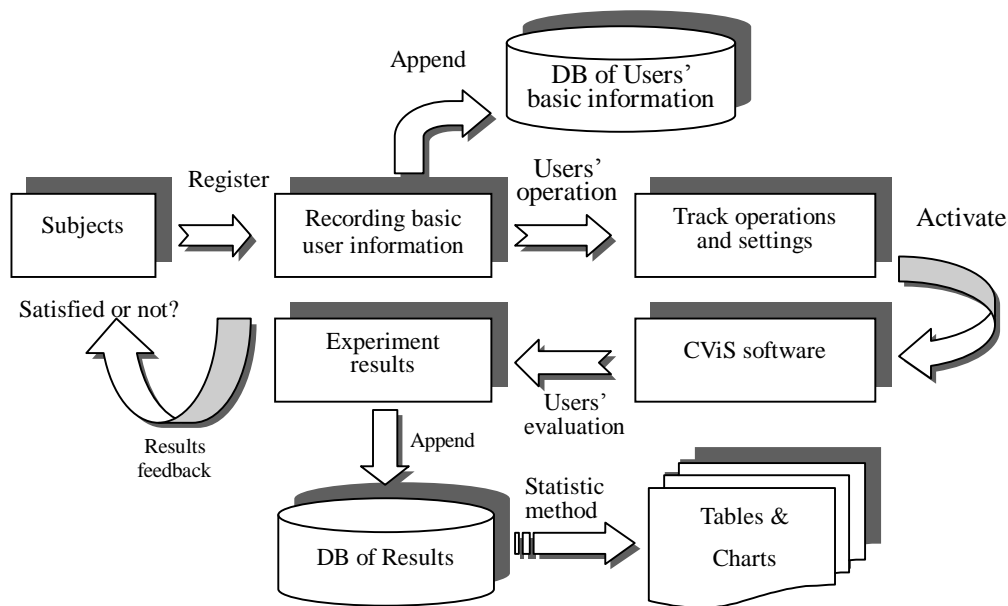


Figure 1. Flow chart of cognitive experiment

2.1 Registration of Subjects

This function obtains basic information of subjects. According to users classification factors, these basic information of subjects demanded by experiment software are: age of subject; gender of subject; computer operation lever of subjects; specialty of subjects etc. A welcome dialog box collects all these information. Subject inputs his or her basic information, then click "submit" button, this subject's information is appended to users' basic information database, and at the same time, this subject accomplishes registration. Every subject corresponds to an ID code in users' basic information database. This ID links subjects with their other experiment data.

2.2 Operation of Simulating CViS User Interface

This function is using VB Form's methods to change simulating user interface's states and appearances. When subjects make some settings in the simulating user interface, their operations and settings are recorded by software in time.

2.3 Activating CViS as Experimental Environment

Real CViS provide excellent conditions for cognitive experiment on user interface. The author installs six CViS software with different kinds of user interfaces in the computer for experiment. Subjects may use different CViS and be tested what kind of user interface adapt their cognitive characteristics. So, there is executive file calling function in experiment software. When subjects are asked to tryout different real CViS' user interface, they can activate different executive file of CViS.

2.4 Functions of Database

Functions of database are important in the cognitive experiment, other functions such as data recording; results analyzing; subject registration etc, depend on database. Because of the structure of data that used in the experiment is not very complex, Access 2000 is chosen as database tool. In experiment software, ADO (ActiveX Data Object) is used to access the database.

Users' basic information data table is shown as Figure 2, in which, the first field of the data table is ID of subject, and other fields are users' classification factors.

UserInfo: 表						
用户ID	姓名	年龄	性别	文化	计算机水平	专业
1	方继睿	23	男	3	4	制图
2	许远	23	男	3	4	制图
3	李季	22	女	3	4	制图
4	张春美	21	女	3	1	航测
5	刘薇	21	女	3	2	航测
6	宋爽	21	女	3	1	航测
7	王拴平	23	男	3	2	航测
8	马淑宇	21	女	3	2	航测
9	刘航治	21	男	3	2	航测
10	刘志超	21	男	3	3	航测
11	peony	22	女	3	2	大地
12	张婷	21	女	3	2	大地
13	王鸿桥	21	男	3	2	大地
15	王珍珍	21	女	3	2	大地
16	何峰	20	男	3	2	大地
17	薛宏	20	男	3	2	大地
19	王晨燕	22	女	2	4	制图
20	刘芳	28	女	4	4	制图
21	lingyun	23	男	3	4	制图

Figure 2. Data table of users' basic information

In this cognitive experiment, subjects' ID links basic information and other experiment data. By this mean, the results of experiment can be administrated in orders, and can be analyzed effectively. If the kinds and amount of subjects are plenty, the relationship among users' kinds and the user interface that adapt to them can be found more definitely.

2.5 Reporting of Experimental Results

The experiment software records subjects' information and other operational data, the results of experiment are worthful. The experiment software can output results in tow methods. One is reporting table, the results can be shown with accuracy, another method is chart. When the number of subjects becomes large, result table will have too much content, this problem brings tester difficulty to analyze the results, chart can show experiment results with graphic method, the characteristics of results can be found out directly.

2.6 Assistance Functions of Experiment

These functions can provide subjects some helps about how to accomplish the experiment. Subjects with less experiences of using computer can accomplish the experiment by themselves. The help changes its content in the process of experiment to make subjects know how to go on with the experiment. "Video help" is used in the experiment also. Most subjects can understand video help better than textual help.

3 PREPARING OF EXPERIMENT

3.1 Conditions & Subjects Selection of Experiment

The hardware of cognitive experiment is a personal computer with PIII CUP at 800MHz; 256 RAM memory, 17" CRT displayer (1024×768) in 24 bit color model, standard keyboard and mouse. The supporting software of experiment are six different kinds of CViS with different styles user interfaces.

The subjects of experiment are 21 students of Zhengzhou institute of surveying and mapping. 9 are males, 12 are females. 19 subjects are under graduate students, 7 of them are major in surveying and positioning, 5 of them are major in cartography, and the other 7 are major in remote sensing. 2 subjects are postgraduate students major in cartography. Subject has experiment one by one, during 9:00-11:00 am, computer records some experiment data that needed to record in time and with accuracy, 3 observers of experiment are arranged to record other phenomena such as subjects' mood changing and operational mistaken rate.

3.2 Registration of Subjects

At the first step of experiment, subject is required to register, subject input his or her basic information in a welcome dialog box as Figure 3, and submit it, then they may enter the next step of experiment.



Figure 3. Subject registration dialog

4 EXPERIMENT ABOUT USING DIFFERENT STYLES OF USER INTERFACES

4.1 Purpose

In the experiment, tester provides subjects some different kinds of CViS, subjects' cognition characteristics can find out in the process of using CViS. According to time that subjects spent on accomplishing tasks, relationship among different users and the user interface models that adapt to them can be found.

4.2 Experiment Design

In the computer that experiment based on, has installed six different styles CViS software with different user interface. Experiment software activates different CViSes for subjects, every subject required to accomplish 3 using tasks with each CViS, when he or she accomplishes using tasks, the time that they spent will be recorded

by experiment software.

4.3 Procedure

As Figure 4 shows, subject observes each user interface, and observes one of them in full screen by clicking their index picture. Subject double clicks one of the user interfaces' index pictures, and activate associated CViS software. After a tryout of 5 minutes, each subject is asked to accomplish 3 tasks: (1) loading a digital map data, and shows it on computer screen. (2) Searching an object on the electronic map that shown on screen. Subject can use the tools provided by CViS to accomplish the task. (3) Query attribute of the object that subject has searched. After subject accomplished these 3 tasks, 5 minutes was given to go on using each CViS freely, subject decides whether using the CViS for more time, according to their using experiences. The time that is spent to accomplish tasks is recorded by experiment software. And experiment observers record other phenomenon when each subject fulfils tasks, such as subject's mistaken rate in operation and mood changing etc.

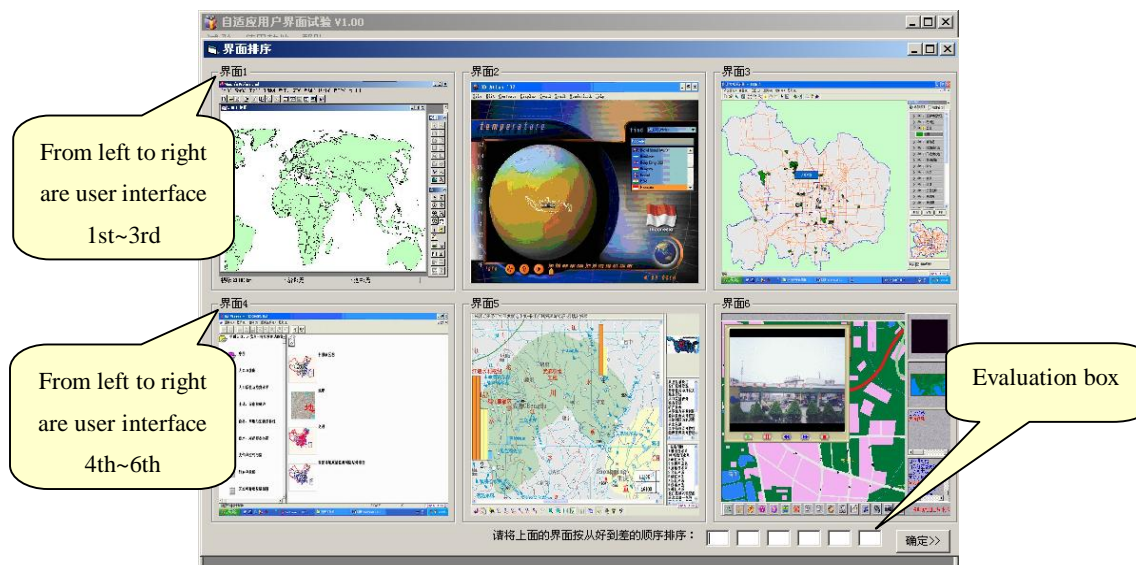


Figure 4. Application experiment about different style user interface

4.4 Experimental Results & Analysis

By analyzing the results, time that cost subject to accomplish tasks, of this part of experiment, we can find that computer lever is the main factor affecting subjects' tasks accomplishment. The experiment records several groups of time results (from first UI to sixth UI, the unit is second):

Accomplishment of the first task (loading a digital map, and showing it on screen), subjects with novice computer operation lever, averagely spend time: 116,29,34,133,41,48; subjects with a middle computer operation lever averagely spend: 15,10,12,21,14,19. Subjects with experiences of using GIS software spend: 8,6,9,11,9,7.

Accomplishment of the second task (searching a object on map that shown on screen): this task also affected by maps color, area and information quantity. In this task, subjects without GIS using experiences spend time averagely: 18,9,12,23,21,16. However subjects with GIS using experiences averagely spend time: 7,5,9,12,14,8, and they use tools help themselves to accomplish this task. According to the results of this part of experiment.

Accomplishment of the third task (find object's attribute): subjects with high computer operation lever averagely spend time: 7,5,5,9,7,6. Subjects with novice computer operation lever spend: 16,10,14,25,17,15.

CViS' professional user interface as first one in experiment, need subject decide the format, path and display model of a digital map, so these operations make subjects with novice computer operation lever accomplish the task with difficulty. Adaptive user interface designers should design simple novice user interface model with usually used tools in evident places. The time spent to accomplish tasks may enlighten designers of adaptive user interface that using these averagely spent time by different kinds of subjects as threshold to judge user's skill of CViS' operation, and adaptive user interface may according to this provide associated user interface that adapt to current users.

5 EVALUATION EXPERIMENT OF CViS' USER INTERFACE

5.1 Purpose

In this part of experiment, we can obtain subjects' evaluation of six different styles of CViS' user interfaces, and analyze experiment results to discover subjects with different cognitive characteristics like to accept what styles of CViS' user interfaces.

5.2 Experiment Design

Based on previous experiment, subjects according to their using experiences and favors, evaluate six styles CViS' user interfaces from the best to the worst.

5.3 Procedure

Every subject has this part of experiment just after accomplished previous part of experiment. According to the using experiences and impressions of each CViS' user interface, subjects rank these user interfaces form best to worst then inputs number of each user interface in evaluation box, input the number of the user interface in first box means subjects consider this is the best one, and so on, the last box filled with the worst user interface considered by subjects. And at last click button "confirm" to submit their evaluations, end the experiment.

5.4 Results & Analysis

	best	worst
First UI	11.8%	17.6%
Second UI	41.2%	11.8%
Third UI	11.8%	0%
Fourth UI	11.8%	35.3%
Fifth UI	5.9%	17.6%
Sixth UI	17.6%	17.6%

Table 2. Best UI considered by all subjects

All subjects' evaluation on six different styles user interfaces as table 2. This result shows, if take all subjects as a whole user group, by age between 20 to 25, they more like colorful and vividly user interfaces as second UI, but not like a user interface lack of colors and graph as fourth UI.

The table3 and table 4 above show, more than half of female subjects consider the second UI is the best one, however, male subjects consider the first user interface is as good as the second one, and the others almost have same evaluation rate. For this result, female users maybe are more sensitive to user interfaces' color, and appearance of CViS' user interface.

	Male	Female		Male	Female
First UI	12.5%	22.2%	First UI	25%	0%
Second UI	12.5%	11.1%	Second UI	25%	55.6%
Third UI	0%	0%	Third UI	12.5%	12.5%
Fourth UI	25%	44.4%	Fourth UI	12.5%	12.5%
Fifth UI	25%	11.1%	Fifth UI	12.5%	0%
Sixth UI	25%	11.1%	Sixth UI	12.5%	25%

Table 3. Worst UI considered by subjects

Table 4. Best UI considered by subjects

The table above shows that subjects with novice computer operation level consider simple user interface such as the second one and the fourth one is adapt to them. But not like professional user interface. Subjects with middle computer operation level consider ordinary software like user interface, and multimedia user interfaces are also acceptable. And subjects with high computer operation level or with GIS using experiences can accept almost all of the user interfaces. However, colorful, beautiful user interfaces are also more attractive to them.

	novice	middle	Veteran	Have GIS experiences
1st one is the best	0%	12.5%	14.3%	16.7%
2nd one is the best	50%	62.5%	14.3%	16.6%
3rd one is the best	0%	0%	28.6%	33.3%
4th one is the best	50%	0%	14.3%	0%
5th one is the best	0%	0%	14.3%	16.7%
6th one is the best	0%	25%	14.3%	16.7%

Table 5. Best UI considered by subjects with different computer operation lever

As table 6 shows, different specialty also causes subjects' different cognition of user interface. Subjects major in cartography evaluate different user interfaces averagely, because they usually use different kinds of GIS software, they can accept different styles of user interfaces. Subjects, who major in Remote Sensing, consider the second user interface and the fourth one are much better than others. And the subjects major in surveying show favor to the first, second and sixth one. These results illuminate that adaptive user interface of CViS should provide simple user interface with usually used tools for users who aren't major in cartography, to make them use CViS effectively.

	Cartography	Remote Sensing	Surveying
1st one is the best	16.7%	0%	16.7%
2nd one is the best	16.7%	60%	50%
3rd one is the best	30%	0%	0%
4th one is the best	0%	40%	0%
5th one is the best	16.7%	0%	0%
6th one is the best	16.7%	0%	33.3%

Table 6. Best user interface considered by subjects with different specialty

6. CONCLUSIONS

By the two cognitive experiments above, we can draw conclusions as following:

Users' cognition on CViS' user interfaces is exactly affected by some factors such as their age, gender, computer operation lever and specialty.

Different computer operation lever affects users using CViS, users without skills of computer operation should be provided simple interface in adaptive user interface of CViS.

Adaptive user interface should provide different styles of user interface for users who major in different specialty. Users who have cartography and GIS knowledge like professional user interfaces, and other users like some simple and vividly user interfaces, such as multimedia style user interfaces more.

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Biography

Ling Yun (1980-), master graduate student of department of cartography and GIS, in Zhengzhou Institute of Surveying and Mapping, P.R.China. His specialty is cartography and GIS. His research subject is theory of cartography, cartographic visualization system and adaptive user interface for cartographic visualization system.