A Study on the Navigation System for User's Effective Spatial Cognition

- With Emphasis on development and evaluation of the 3D Panoramic Navigation System-

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Abstract: We live in the day of information Society and the seeking of the information is very important in these days. The designer's role is to give the suitable information to the right person in proper time most effectively and efficiently. However, because of getting too much information, information-users often feel like "lost in cyber space." Like a cyber space, people get information to find a right way and get lost in real world. Problem solving is the goal of design. So finding and suggesting the new method from existing studies for navigation is meaningful.

So this study, which is based on the studies about existing navigation literature, user cognition, and spatial cognition, found problems in navigation, which are spatial cognition, representation gaps, load of memory and the problem of control. To solve these problems, this study suggested some solutions, which are providing 3D experience & multiple views, proper quantity of information, point-by-point navigation and tool for affordance and suggested the new navigation method in concrete. The ideas give the images applying the panoramic view at any crossing points for effective spatial cognition and provide immersive views, fly-over views and map view for spatial cognition by 3D experience. In case of external aids, this study suggested the map interaction tool by electromagnetic induction for efficient 3D navigation.

For development of navigation system, the existing technologies about VR and interaction tools were studied. After that electromagnetic induction technology for interacting with map was adopted. Finally the special lens for collecting panoramic images and a program language to spread collecting images for interaction was used.

To verify the new navigation idea, the system was developed and the experiment was done with it. The validity and problems were found through the experiment and the findings in the study will be useful for the related studies.

***Key words*:** *Navigation, Wayfinding, Panorama VR, Spatial Cognition*

1. Introduction

Because we navigate in space, we need effective spatial cognition. For effective navigation too many methods and tools are developing. But a lot of developers provide the 2D map and audio communication and don't use 3D image for 3D spatial navigation. In many cases it is proved that spatial memory is useful to memorize the space. Therefore we provide space cognition environment through 3D spatial experience with the panoramic VR and multiple-view concept. By those environments, user can recognize 3D space effectively, efficiently and accurately.

2. Related Research

2.1 Navigation and user cognition

Rudy Darken defines “Navigation is combination of wayfinding and locomotion” and standard aspects of Navigation are locomotion, decision-making, processing and condition. Navigation is complex cognitive process and when we are moving, it happens. Cognition happens in human brain and attention, memory and decision making among process of cognition is important for navigation. Especially in case of memory, we consider that too many burdens cause to reduce effectiveness of memory ability. To help memory problem we use external cognition. It reduces the burden of memory. External memory means using diary, calendar, calculator and other tools for effective working. The type of wayfinding is naive research, primed research and exploration. And according to the situation, we apply appropriate research method to navigation. Existing navigation method by using spatial ability is efficient, but providing too many information reduce efficiency because of cognitive process. The important point of planning navigation control unit is natural, easy of use and understandable according to whether users are skillful or not.

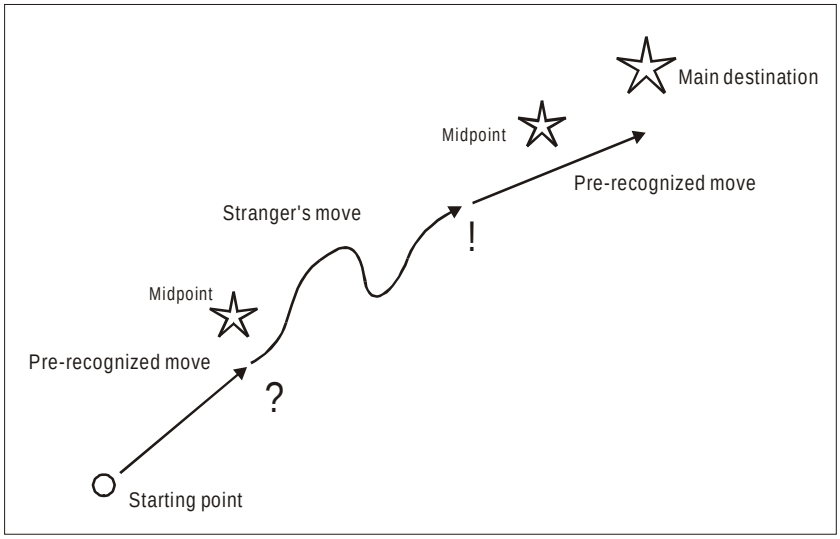

Fig. 1. General Structure of Wayfinding in urban space

Table 1 Navigation elements

Classification	Contents
Navigation	Orientation, deciding route, checking route, destination cognition Relationship of sign and environment is important There are 3 type of wayfinding. Considering situation and human state
User cognition	Improve power of memory by external cognition Appropriate use of experiential cognition and thoughtful cognition Complementary use of route knowledge and survey knowledge Clearness of orientation and sight for spatial cognition Use survey knowledge for understanding total situation
Navigation system	Natural and easy control Consideration about skillfulness Simple, understandable and easy tool

2.2. Navigation design in 3D space

2.2.1 Spatial cognition and representation

Human work and recognize not by natural thought, concept and event, but by sign and symbol which coincide with his cognitive process. They are called “representation”. Representation is substituted for real event, but

inevitably is made abstract. Because of the abstraction, people concentrate on the representation and misunderstand that event. To protect misunderstanding, three principles are suggested and there are principle of nature, cognitive and appropriateness. In figure 2 there are original structure and changed structure and when gap of two structures is the smallest, cognitive map is close to original one. The roles of representation and cognitive artifacts have to make two ones closer.

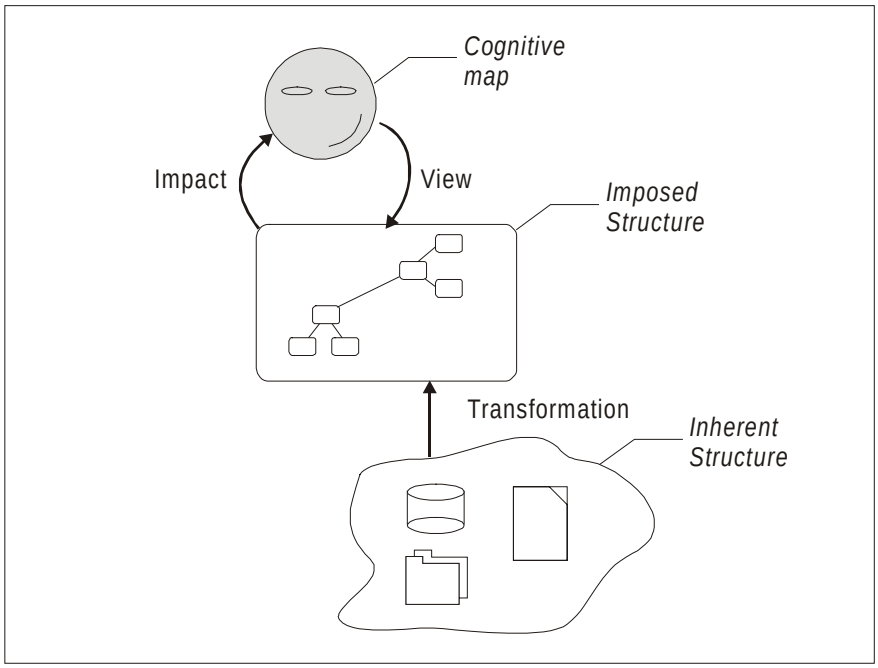

Fig.2 Level of structure

2.2.2 Principles of navigation design

The principles of navigation design are related to effective navigation in space and there are three principles. First, it is designed that user know his location easily in space. Second, it is designed that user find the way to reach his goal easily. Third, user accumulates the experiences of route finding in space and next time use his experiences. Also in wayfinding, a sign, which is important as visual clue is different from other things. A signal as useful clues is used for memorizing the direction and location. One of important principles is that to give user too many choices is dangerous. The reason is burden of memory reduce efficiency as we told before. To recognize the space, using character of three views in cyber space is beneficial. Immersive view, fly-over view and map view have merits and demerits. Therefore if it is used merits well, it is useful to make user cognize the 3D space easily.

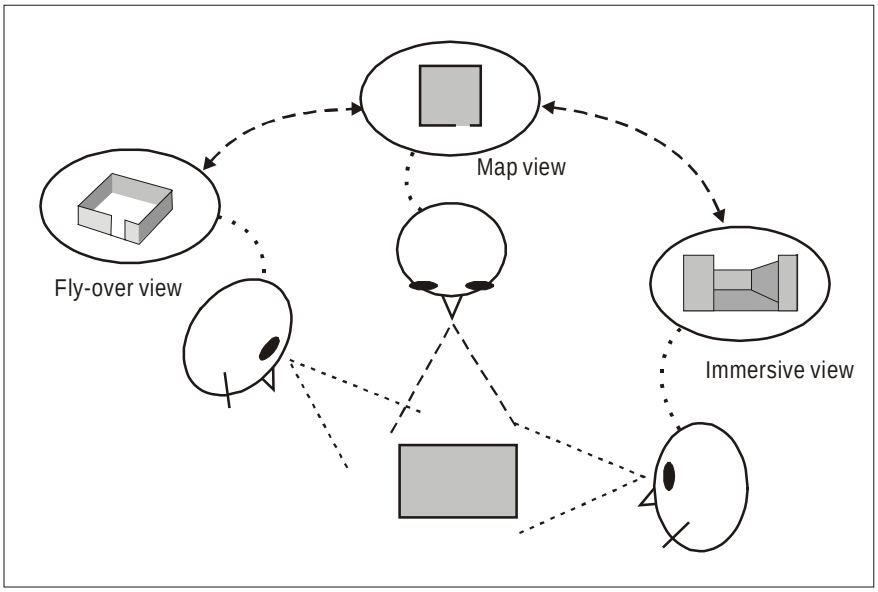

Fig.3 3 views in cyber space

2.2.3 Navigation in 3D space

To choose appropriate technology is very important in navigation in 3D space. There are several technologies for providing 3D experience and among them VR (Virtual Reality) technology is powerful. There are panorama VR for providing experience of VR environment and object VR for providing 3D experience about objects in this technology. Because VR making technology by using real image is efficient, it is used by a lot of people. In table 2 there are comparative results of two fields by using photo realistic images. In addition to visual part, control part is important. Users have effective spatial experience by controlling 3D images easily. Terms, which are needed are making absolute coordinate system signal and giving user affordance. For this reason we investigate mimio Xi's infrared and ultrasonic technology, and electronic induction technology of WACOM "Graphire2" tablet.

Table 2 Comparing Real VR technology

Classification	Real VR panorama	Real VR Object
Purpose	Space experience	Observing objects by 360 degree
Features	Providing views, scene and distance feeling like real space	Observing real product by 360 degree and providing real feeling about product working
Use	Tour some place, embodiment and experience of space	Product simulation at Internet shopping mall

2.2.4 The direction of navigation design development

Through the principles of navigation and embodiment method we find developing directions of navigation design and they are in table 3. There are spatial cognition, principles, technology and method of navigation in development.

Table 3 The direction of Navigation design

Classification	Contents
Spatial cognition	Using navigation assistant Helping to make appropriate representation Providing user feeling like reality Expressing perceptual and spatial representation by apt abstraction Minimizing memory burden
Principles of navigation design	Design easy to find and memorize his location and path Choosing and using apt view among virtual views Immersive view, fly-over view, map view Providing map for survey view, providing signs at decision points Providing quick feedback for preventing user's faults
Technology and method	Using panorama view for view, scene and distance like reality Using exclusive control tool for interaction

2.3 model development for 3D navigation system

When we study navigation elements and direction of design, we can divide navigation, cognition, technology and method part. On the basis of that, we extract function elements as figure 4.

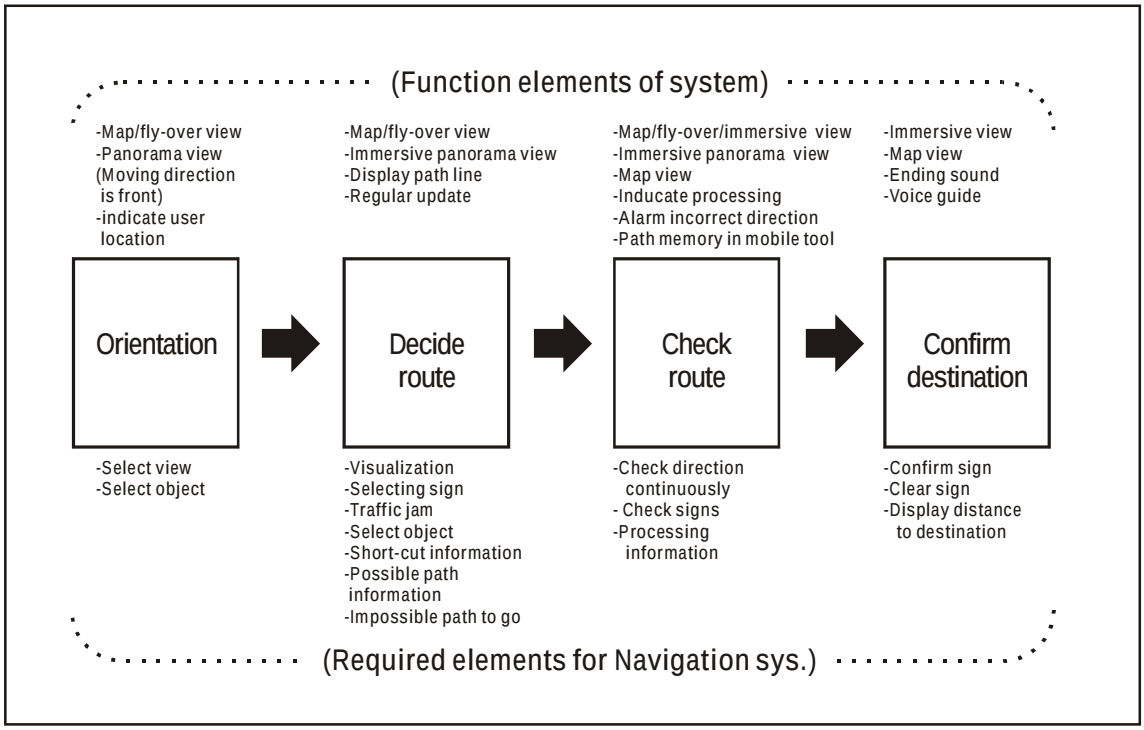

Fig.4 Function model for development

We make elements of function on the basis of orientation, route decision, route check, and arrival cognition, which are 4 steps of navigation through relation of naïve researcher, primed researcher and exploration and delivery service, theme park and campus. There are in figure 5.

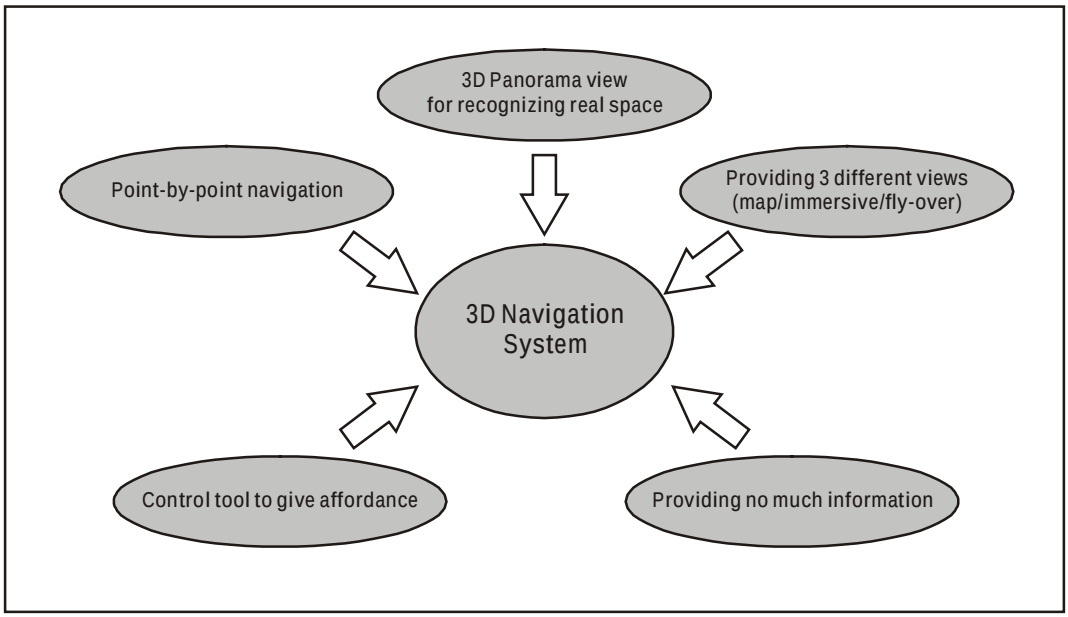

Fig. 5 Structure of navigation system

We get model like figure 6 by linking function in this function model and 4 steps to using process of navigation system. And then to decide the embodying method of navigation system we divide 8 elements of function to

display control and hardware part and map the function. We suggest navigation method including function element and evaluate according to the orientation, route decision, route check, cognizing goal, spatial cognition, too many burdens, representation, and control problem.

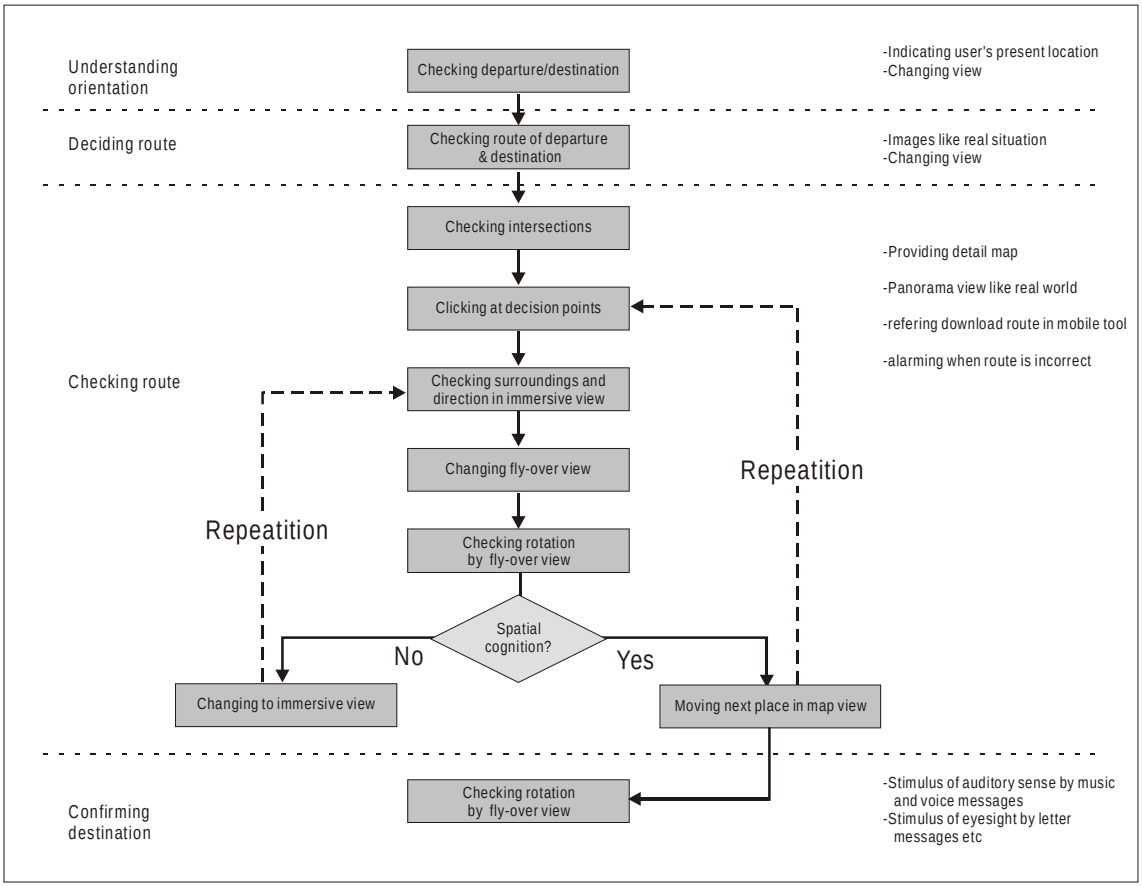

Fig. 6 user process model

And figure 7 is final system structure. Basic concepts of suggested idea are providing panorama view like real environment.

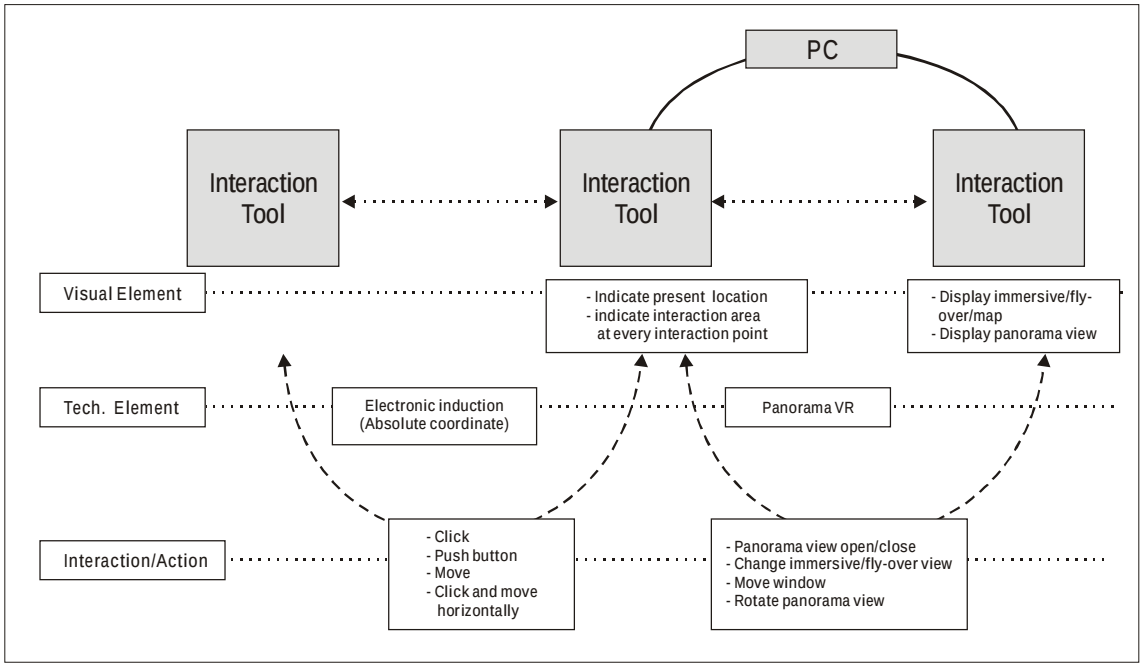

Fig. 7 Structure of navigation system

Figure 8 is the concept drawings of navigation system including the idea of point-by-point and integration of 3 different views.

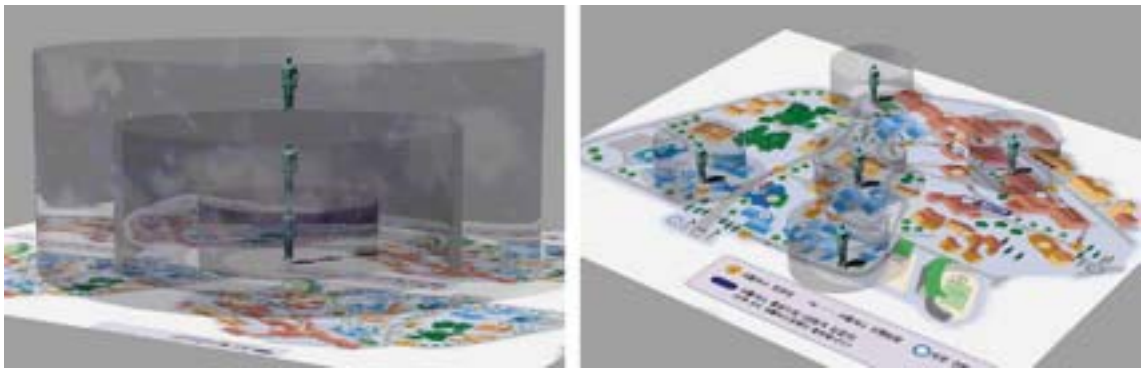

Fig. 8 Concept drawing of system

3. Development and evaluation

3.1 Purpose of development

Through former literature study of case studies and user studies we find important elements of navigation and suggest method of embodiment. To maximize 3D experience we are about to develop the tool, which gives multiple views and using 3D panorama view, panorama event, which happen at every point, interaction, which is similar to real situation. On the basis of extracting elements we develop the 3D navigation system and by evaluation we are about to investigate benefits of navigation method and tool.

3.2 Selecting the object to develop

Because in campus there are a lot of naïve search, we choose the campus as object to develop. Among the campus we develop the navigation system for KAIST campus.

3.3 Process for system development

Process for system development is in figure 9. For the part of system display, we collect panorama images according to the collecting process as in figure 10. For collecting images we use special lens in egg solutions. Panorama images consist of immersive view and fly-over view. Immersive view gives the immersion to user and is collected at 1.8m. For fly-over view we choose 7 locations in campus according campus situation and collect the images by using crane. We collect the images for immersive view at 11 crossing points. Fig.11 shows area of fly-over images and correlation of them. Collecting images have a donut shape and change the donut images to panorama images by programming through proportion of each edge. And by interaction map which adopt electronic induction technology in WACOM panorama images are called and are given spatial cognition experience to user. System image is as follows. Figure 13 is the images of screen display and instruction. By interaction of pen and map panorama image is opened and is interacted with pen.

Fig. 9 Process of system development

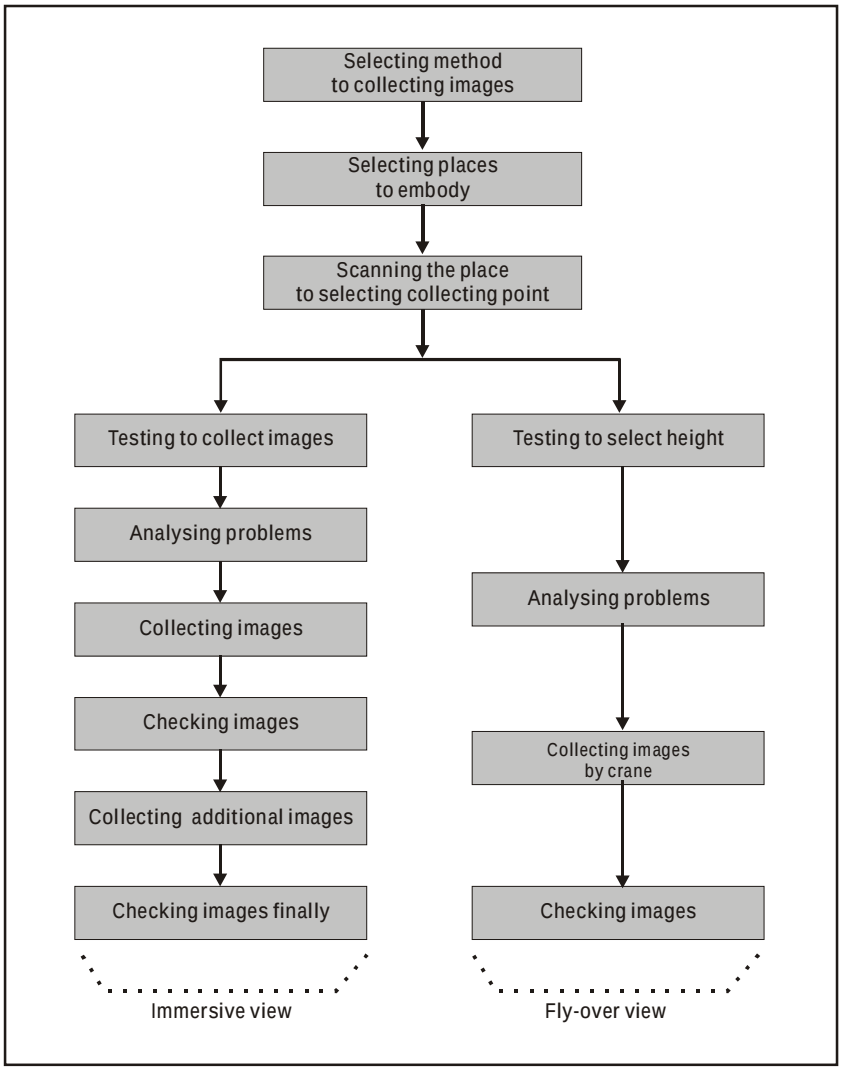

Fig. 10 Process of collecting images

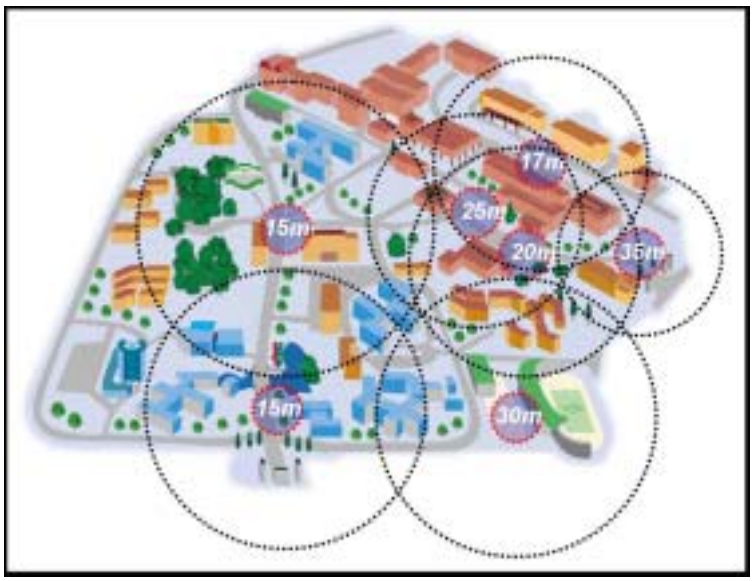

Fig. 11 Collecting places for fly-over views

The navigation system images and system screen images developed according to the concept are in Fig.12 and 13.

Fig. 12 System images

Fig. 13 System screen images

3.4 Usability test for verification of navigation system

For verification of usefulness in navigation system, we make an experiment. The goal is checking whether navigation system is available for effective spatial cognition and better navigation and finding problems. Procedure of experiment is in figure 14. Subjects are 6 high school girls and 16-18 years old. They don't have any experience to visit in KAIST campus. Experiment conditions are 1. using map 2.carrying map and pre-learning by navigation system 3. pre-learning location with navigation system and carrying navigation system. At each case there are two subjects and missions are finding two places, which is visited by many people. In fig.15 subject A,B

are using map, subject C,D are pre-learning and subject E,F are pre-learning and carrying navigation system. Processing is recorded for transcription. Through experiment and interview we know that use of navigation system is helpful for spatial cognition. From short time and stable data of subject C, D and interview we know that. We know that subject F feel difficult because of too many burden. It looks like Using in mobile situation gives a burden to subject. Problems to get from transcription are as in Table 4.

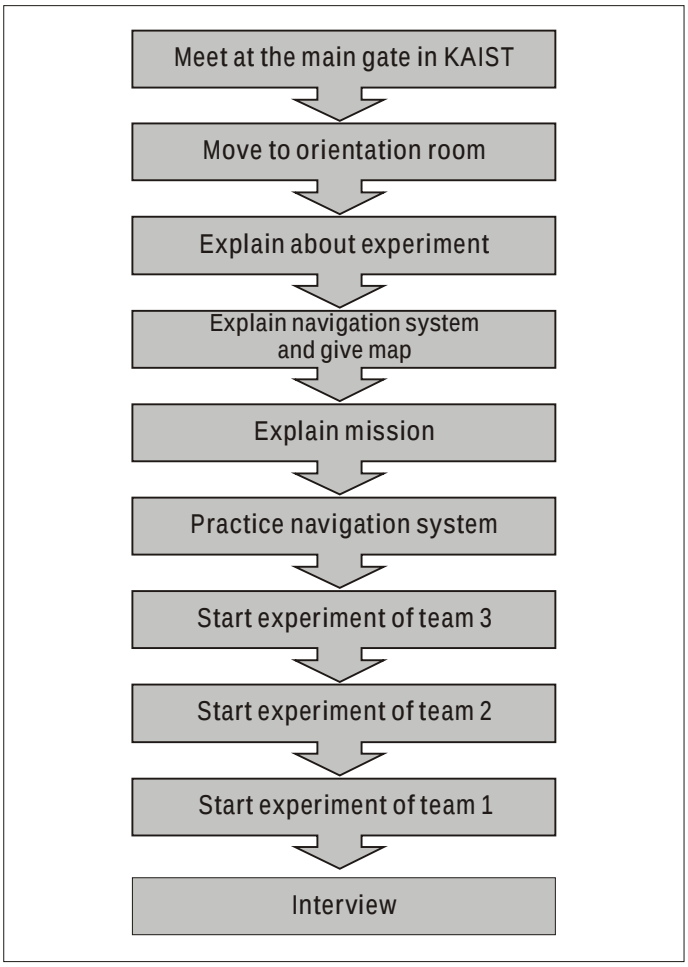

Fig. 14 Experiment procedure

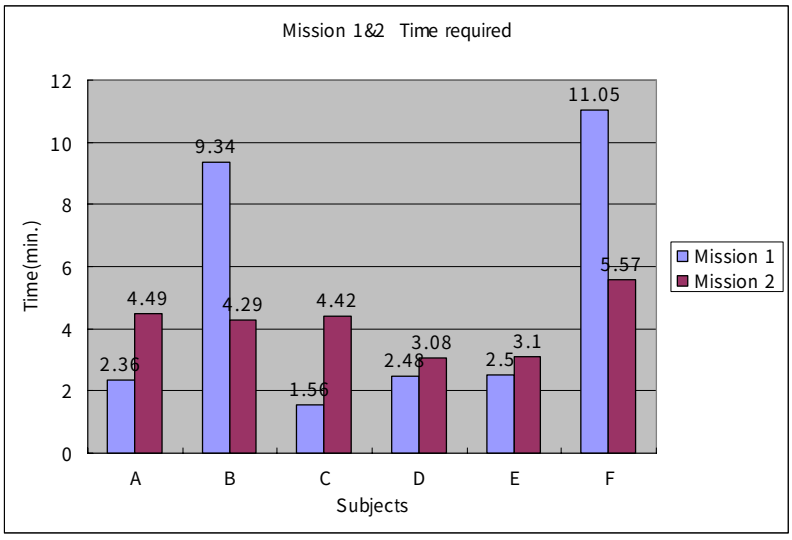

Fig. 15 Experiment result

Table 4 problems through transcription

Classification	Problem list	Method to improve
Navigation	Difficult to match Map, panorama view and real situation	• Improving image quality (proportion, clearness etc) • Removing unnecessary object in images Minimize difference between center of immersive view and center of user
	Difficult to know present location	Put sign and number etc in views and map for helping to match
	Difficult to matching map and real situation (distance)	Improving accuracy of map
Spatial cognition	Difficult to understand orientation	Put the start point sign in the panorama view
Too many burden	Difficult to check map view, immersive view, fly-over view and real situation simultaneously	• Making understand immersive view and fly-over view at the same time • Separate map from system
	Difficult to see screen	Improving method to use
Representation	Lack of detail information (need fast update)	Including detail facts in the map

4. Conclusions and future study

The effectiveness of spatial cognition through the experiment about the navigation system to be made by the concepts to get from this study is verified. But, we find some problem to improve. In navigation to recognize direction is important as we refer before. Also to improve image quality is important. When we collect images for immersive view, we consider that gap of the center of user location and the center of immersive view is minimized. Experiments about efficiency evaluation of interaction tool, evaluation of system condition when carrying, comparison of efficiency according to whether users are skillful or not, and efficiency evaluation according to screen angle will be carrying out for future study.

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