

# Fundamental Research on Traffic Support to the Pedestrian

## by Route Guide Map based on the Space Perception

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**Abstract:** Recently, for the advance of information technologies, a pedestrian traffic support like navigation system with mobile phone is spreading. In pedestrian traffic, it is important to consider space perception. The city planning, the transport planning, mobile GIS and disaster prevention need to consider space perception too. In this research, we investigate how to make a hand-written map, to understand the feature of spatial perception for the pedestrian. Using the information obtained by the investigation, we made a model showing the type and position of landmarks that are important for the pedestrian traffic. Using the model, a system for making route guide map that is one of the methods to support pedestrian traffic is developed.

**Keywords** : GIS, Route Guide Map, Pedestrian Traffic Support, Space Perception, Landmark

### 1 . Introduction

In recent years, pedestrian traffic support systems, such as a navigation system using a personal digital assistant, are spreading with the development of an information technology. Expansion of maintenance of a digital map is mentioned as one of the background. Until now, utilization of the digital map has been restricted to public institutions, such as the government and local governments, and utilization by a general user was not considered. However, anyone can use a digital map now<sup>1)2)</sup> with development of information technology and data maintenance like geographic information clearing house. The digital map is utilized in various fields<sup>3)4)</sup>, such as in a car-navigation system, a city planning information system, and a route guide map. Moreover, there are two factors that pedestrian traffic support system spread. The first factor is improvement in accuracy of GPS (Global Positioning System) . The second factor is increase of the personal digital assistant with GPS for general users, such as a cellular phone and PDA (Personal Digital Assistants).

The service provided through personal digital assistants, such as “EZ Navi Walk”<sup>5)</sup> which KDDI Co. offers, and the service combined with search engines, such as “Google Map”<sup>6)</sup> which Google Co. offers are provided as a pedestrian traffic support system. With these services, diverse information is offered on the digital map. However, when using a digital map as a

route guide map, superfluous landmark information bars user’s space recognition<sup>7)</sup>. For support of pedestrian traffic, it becomes important to use the route guide map that has arranged landmarks appropriately. In order to arrange landmarks appropriately, it is effective to take a cognitive map into consideration. A cognitive map is drawn within a brain, when people perform spatial perception. As existing research on pedestrian support using a cognitive map, there is research<sup>8)</sup> that emphasizes landmarks near the destination on a route guide map, and research<sup>9)</sup> on automatic generation of a deformation map. In these researches, landmarks near destination are emphasized and landmarks are rearranged with accompanying modification of road data. However, in these researches, when arranging landmarks on a map, the importance of the landmark that a user needs is not taken into consideration. When a user looks at a map, an important landmark cannot immediately be grasped and a user’s cognitive map formation becomes difficult. In order to raise the accuracy of pedestrian traffic support more, it is necessary to arrange the landmark in consideration of the user’s spatial perception.

The investigation into making a hand-written map is conducted in this research. The feature of the landmark which people use for movement is modeled by the investigation. This research aims at a development of the system for making route guide maps which arrange landmarks appropriately based on the model.

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## 2 . Outline of Research

In this research, the system for making a route guide map for pedestrian traffic support is developed. The route guide map is based on the model of the type and position of landmarks. The outline of this research is shown in Fig.1. In this research, in order to clarify the landmark that the pedestrian uses for movement, investigation into making a hand-written map was conducted. From the results of the investigation, the model based on the kind and position of landmarks that are used by this research is created. Landmarks arranged from the created model on the route guide map generated by this system are edited. In editing landmarks, icon size, color, kind and label size are changed. Moreover, in this system, digital map 25,000<sup>10)</sup> which the Geographical Survey Institute has published is used as the basic data for a route guide map.

## 3 . Model Based on the Type and Position of the Landmark

.In this research, in order to develop the system for making a route guide map for pedestrian traffic support, the model of the landmark arranged on a map was created. The model is created by computing the kind of landmark and the appearance ratio of an arrangement position from the investigation into making a hand-written map. The created model is used in order to determine icon size, color, type and label size of landmarks that are arranged on a route guide map. In order to create the model, the cognitive map currently used when people move was taken into consideration. The image of modeling is shown in Fig.2. Students of Kansai University were set the task of the investigation.

The route guide map from Takatsuki station of Japan Railway to Takatsuki campus of Kansai University was created freely. The effective maps for a route guide map were chosen from hand-written maps, and the model of landmark arrangement was created from them.

### ( 1 ) Cognitive Map

A cognitive map is a memory about the space structure and the place that were accumulated by human activity. There are various methods in forming a cognitive map. Generally, there are ways to memorize a map, ways to change direction many times and to form a cognitive map by linguistic description<sup>11)</sup>. However, since there is a limit in memory of human, geographic information was efficiently simplified and it has been memorized as a cognitive map. A difference arises between the geographic information in the real world and the cognitive map in the brain. Moreover, since person forms different cognitive map in order to create a route guide map intelligible for a pedestrian, it is necessary to take a cognitive map into consideration.

### ( 2 ) Landmark

A landmark is one of the factors of a cognitive map, and it is the target subject or place considered as a symbol when people move. As an example of landmarks, the signboard, the building, the park, the station, etc. are mentioned. The target subjects differ from every individual. In this research, the investigation to create a hand-written map is conducted, and the feature about the landmark in a cognitive map is extracted and modeled. The route guide map is created based on the model that supports pedestrian traffic.

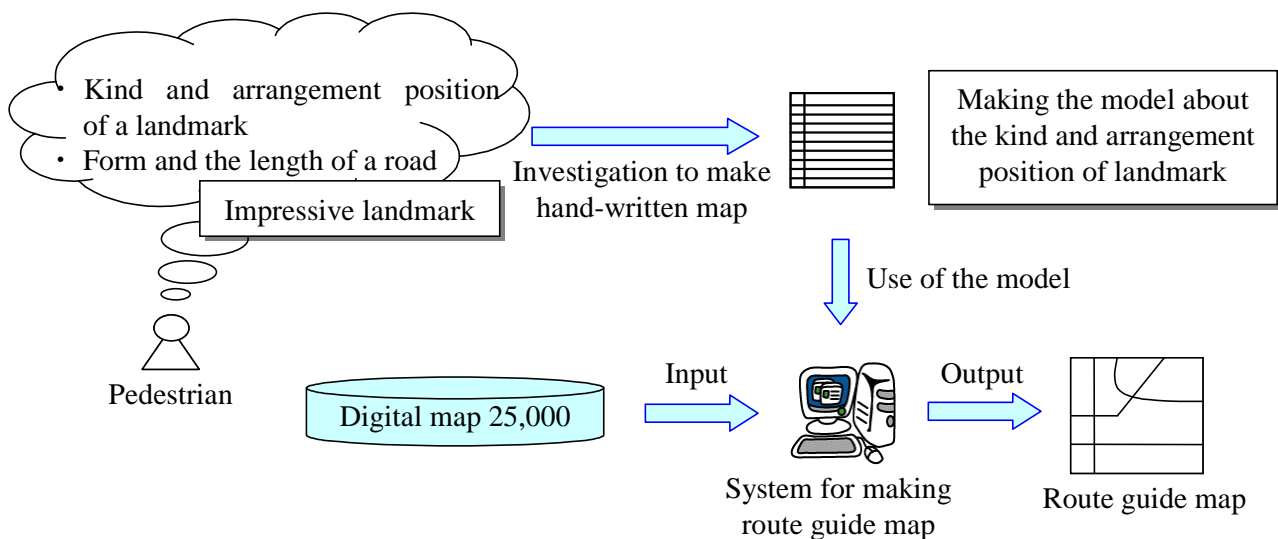


Fig.1 Outline of this research

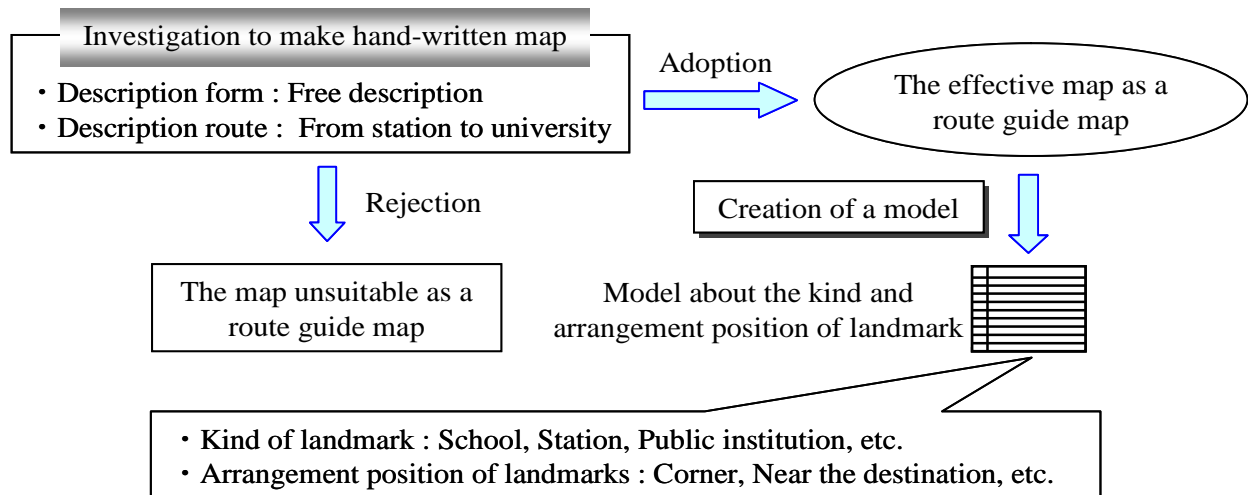


Fig.2 Image of modeling

### ( 3 ) Investigation in Making a Hand-Written Map

In order to clarify the kind and the rate of an arrangement position of landmarks that are used for the cognitive map, an investigation concerning a hand-written map was conducted by 125 students of Kansai University. Subjects freely created the map of the distance from Takatsuki station of Japan Railway to Takatsuki campus of Kansai University. An example of a hand-written map is shown in Fig.3. Various maps were created by every subject. As for Map A, the landmark is thought of as important, and the landmark is arranged at the corner of a street used as the key point and other places. Although the accuracy of the road shape is missing, if landmarks in a course are followed in order, arriving at the destination is possible. On the other hand, the road form of Map B corresponds with the real world mostly. However, although the station front has many landmarks, they are not indicated in the sketch. The

place of a family restaurant is correct, but a store name is wrong. The features of landmarks effective in guidance are extracted from these various hand-written maps.

Among the created hand-written maps, those map effective in guidance was judged by whether the position of the arranged landmark is correct and the number of landmarks is three or more. The feature about the type and arrangement position of landmarks was (computed for 86 peoples' maps) that was effective as a route guide map among the created hand-written maps.

### ( 4 ) Modeling

As a result of the investigation into making hand-written maps, the feature of 86 maps which was most effective as a route guide was extracted, and a model of the type and position of landmarks which are used by the system for making route guide map for pedestrian traffic support was created. In creating a

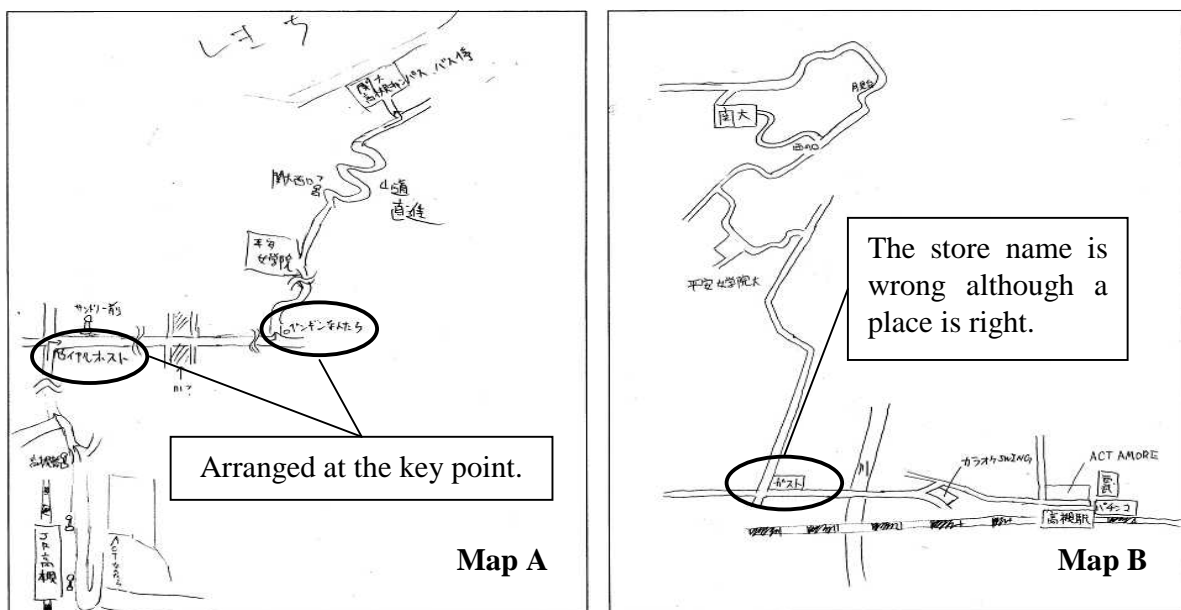


Fig.3 Example of the hand-written map by the investigation for making route guide map

**Table.1** Model about the kind and arrangement position of landmark

	School	Station	Public institution	Famous building	Natural object	Others	Sum (Position)
Corner	6.70%	8.20%	0.33%	14.06%	7.87%	2.18%	39.34%
Straight line road	5.86%	7.18%	0.29%	12.31%	6.89%	1.90%	34.43%
Departure point	2.70%	3.30%	0.13%	5.66%	3.17%	0.88%	15.85%
Destination point	1.77%	2.16%	0.09%	3.71%	2.08%	0.57%	10.38%
Sum (Kind)	17.02%	20.85%	0.85%	35.74%	20.00%	5.53%	100%

model, the landmark that people use to move was extracted. First, the total of the specified landmarks was computed from 86 persons' map. Next, the number of the type of landmark and their positions to the total landmarks is computed. Finally, the appearance ratio was computed from the product of the rate of a kind and an arrangement position, and the model was created. The landmark with the highest appearance ratio is treated as the important landmark for a route guide map. The model rated by their appearance ratio computed during the investigation to make the hand-written map is shown in **Table.1**.

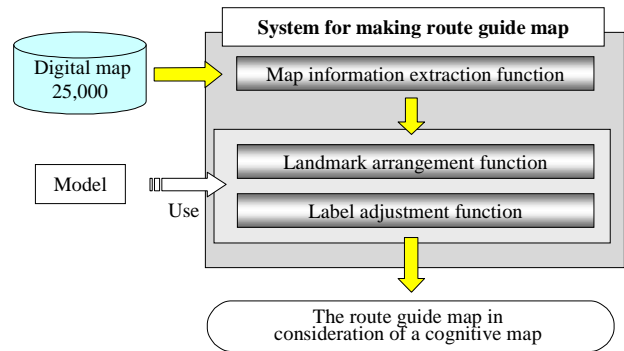
**a) Features of the Type of Landmark**

Various landmarks are used when people move, but used landmarks are different. The landmarks that used by people who has an excellent sense of direction is immobility, conspicuous even from a distant position, easy to memorize, and used as the point in a course. On the other hand, landmarks that used by people who does not have a good sense of direction is feature that changes with time, or an inconsistent thing.

The maps which subjects were drawing have various kinds of landmarks. And, in this model, landmarks are classified into six kinds, such as “school” and “station”. In this research, landmarks with appeared several times are treated as landmarks of the kind of “a famous building”. “A famous building” targets chain stores, such as a convenience store and a supermarket, a building famous for the area, and the building that appeared 20 times or more in the experiment. Since especially the appearance ratio was high, “school”, “station”, and “natural object” are treated as independent the landmark. Since “public institutions”, such as a police station and a post office are buildings which stand out easily, they are treated as independent landmarks. The number of landmarks is calculated for every type.

**b) Feature about the Arrangement and Position of Landmarks**

When people move, there is a tendency to memorize the landmark that easily impresses like the corner of a street<sup>12)</sup>. The tendency to have memorized the landmark of the corner appeared in the result of the investigation.



**Fig.4** Outline of the system

Moreover, there was also a tendency for a landmark along a straight line road to be memorized. It is important for supporting guidance to emphasize landmarks near the destination<sup>13)</sup>. This model classifies the place of landmarks into four kinds: “corner of a street”, “straight line road”, “near a destination point”, and “near a departure point.” And the number of landmarks is extracted for every place.

**4 . System for Making a Route Guide Map**

The system for making route guide maps can make a route guide map where landmarks and labels were arranged at the best positions based on the model. For the base data of route guide map, digital map 25,000 is used in this system. The outline of this system is shown in **Fig.4**. This system consists of the following three functions:

- 1) Map information extraction function
- 2) Landmark arrangement function
- 3) Label adjustment function

First, map information is extracted from the data of digital map 25,000 by the XML form. Second, landmarks are arranged and labels are adjusted on extracted map information using the model. Finally, the route guide map for the pedestrian traffic support based on the model is outputted.

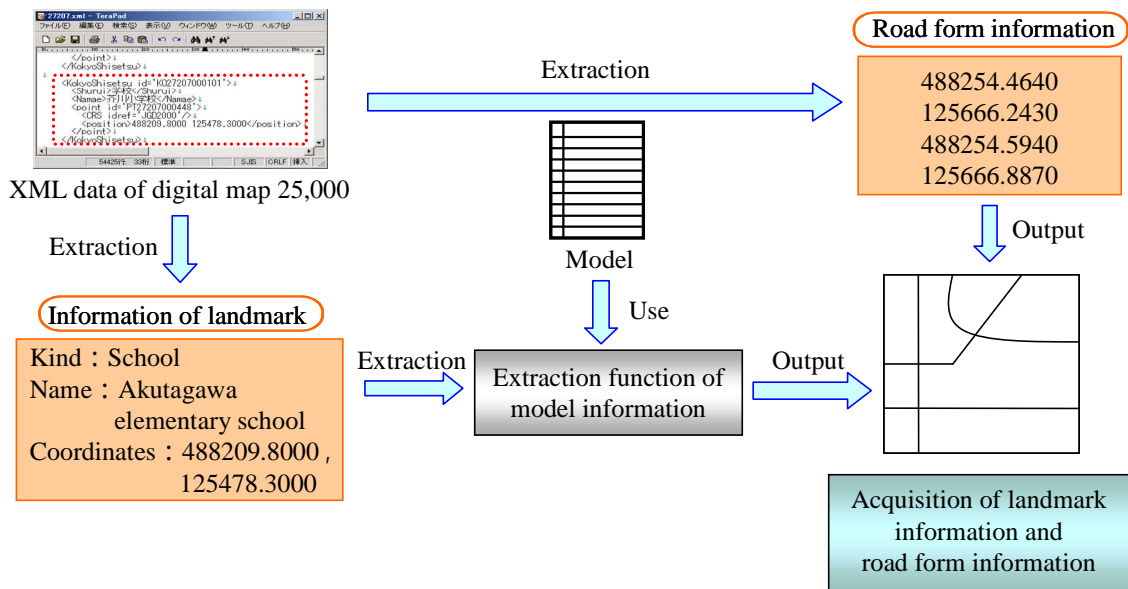


Fig.5 Processing of XML data

( 1 ) Map Information Extraction Function

In this system, digital map 25,000 is used for the base data of a route guide map. The fact that data is nationally fixed and that the credibility of data is high is a reason for using the digital map 25,000. Furthermore, digital map 25,000 can download for free from the homepage of the Geographical Survey Institute, and has the feature that anyone can easily use. The data of the digital map 25,000 is changed into XML form using the defrosting software of digital map 25,000 that the Geographical Survey Institute offers. Since structure is hierarchical, XML is very easy to treat. Moreover, since XML has been independent of a system, it can respond to upgrade of map data immediately.

( 2 ) Landmark Arrangement Function

In this function, landmarks are arranged on a map based on the model shown in Table.1. When arranging landmarks, the data of XML (Fig.5) acquired by the map information extraction function is used. Building information is acquired from the kind code of the landmark defined by XML data. The size, and color, etc. are changed when arranging the icon and label of acquired building information.

a) Kind of Icon

The icon arranged on a route guide map is changed based on the model for every kind of building. With the conventional map, the map symbol is prepared for every kinds of building, and there is an advantage that details are intelligible. However, since there are too many kinds of map symbol, the map user may hesitate to select. In order to decrease the type of landmark, it is classified

into six kinds in this system.

b) Size of Icon

In the existing research<sup>8)9)</sup> on arrangement of landmarks, they were only arranged at the corner of a street. However, the investigation into making the hand-written map has clarified that the landmark on a long straight-line road was used. And, in this system, it classified with both the corner of a street and the straight line road as the result of investigation.

The numbers of types of landmarks and their arrangement and position as shown in Table.1 were computed as the result of this investigation. The appearance ratio about a type is set to  $p_m$ , and the appearance ratio about an arrangement place is set to  $q_n$ . The product of  $p_m$  and  $q_n$  is set to  $c(m,n)$ .  $c(m,n)$  is an appearance ratio about the kind and arrangement position of a landmark. From this appearance ratio, the icon size of the landmark arranged on a map is computed. The maximum of  $c(m,n)$  is set to  $max(c(m,n))$ . The icon size  $As(m,n)$  is determined from comparing  $(c(m,n))$  with  $max(c(m,n))$ . The method of computing icon size is shown in a Formula (1).

$$As(m,n) = \frac{c(m,n)}{max(c(m,n))} \quad ( 1 )$$

Based on the appearance ratio shown by the model, the icon of a landmark with a high appearance ratio is emphasized and output. For example, as shown in Fig.6, “the famous building arranged at the corner of a street” which is the highest appearance ratio defines as size 1. Size 1 that is the maximum size of the icon to arrange

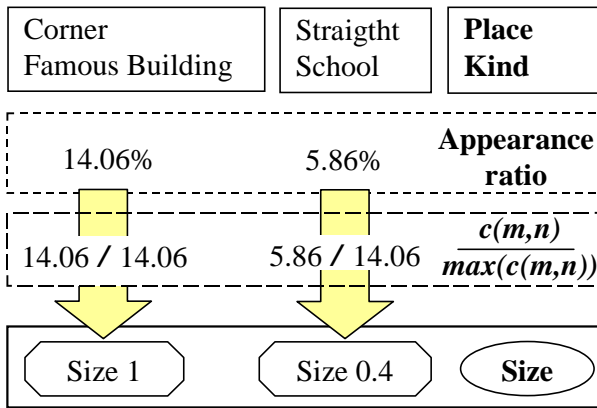


Fig.6 Determination of icon size

and is made into the standard for the icon size. “The school stationed on the straight line road” which an appearance ratio is low becomes size 0.4.

### c) Color of Icon

The consciousness color<sup>14)</sup> that will hold the attention for a short time is used to arrange the icon color. The list of consciousness colors is shown in Table.2. This system arranges the blue that a user can recognize out of a consciousness color in a short time<sup>15)</sup> only to the most important landmark of an appearance ratio. In a JIS (Japanese Industrial Standards), it is recommended that blue shows directions and care<sup>16)</sup> and JIS is considered to be suitable in marking a route guide map. By recognizing a landmark for a short time, use of consciousness color supports recognizing the landmark in the real world from the icon arranged at the route guide map.

### ( 3 ) Label Adjustment Function

In this function, the label size displayed on a map is adjusted. It is important to arrange a label on a map, when reading a map<sup>17)</sup>. However, when a label is expanded too much, it will be difficult to read a map. Icon size was determined by comparison with  $\max(c(m,n))$  that is the maximum of an appearance ratio. A landmark whose appearance ratio is 10% or more shown in Table.1 is made into initial size. A landmark whose appearance ratio is 5% or more of less than 10% is made into 80% of initial size, and a landmark whose appearance ratio is less than 5% is made into 60% of initial size.

Table.2 Consciousness color in short-time presentation

List of consciousness color				
Blue	Light-blue	Green	Yellowish green	Yellow
Orange	Red	Purple	Pink	White

## 5 . Actual Proof Experiment

In order to check the validity of the route guide map created by this research, the actual proof experiment was conducted. 40 university students were made into the subject in the actual proof experiment. The subject was divided into the group using the route guide map created by this system, and the group using a commercial map. Subjects moved to the Akutagawa elementary school from the north entrance of on foot. In addition, people who are not familiar with the geography around the Akutagawa elementary school were chosen as the subject.

### ( 1 ) Experiment Method

In this actual proof experiment, the route guide map for the Akutagawa elementary school from the north entrance of Takatsuki station of Japan Railway was created using the digital map of Takatsuki-shi, Osaka as base data. The created map is shown in Fig.7. The subject moved to the destination, looking at the map created by this system, or a commercial map<sup>18)</sup>. The commercial map has the feature which arranges more landmarks with a name than the map created by this system. The commercial map was more suitable than the map created by this system in respect of guidance by a landmark.

In this experiment, a questionnaire survey was conducted. The questionnaire asked “Was the map helpful?”, “Could the landmark be found?”, “Could it be reached easily?” and “Would you like to use a map again?”. The evaluation to each item of the questionnaire could be five steps, “5: I think that it is strong.”, “4: I



Fig.7 Execution result

think so.” , “3: It can be called neither.” , “2: I do not think so.” , “1: I do not think so at all.” . Moreover, a description form detailing why the evaluation had been carried out was prepared for each item of the questionnaire.

**( 2 ) Experiment Result**

The result related to the goal attained was summarized in **Table.3**. The questionnaire result was summarized in **Table.4**.

**a ) Number not to Reach to the Destination**

For the group of subject using the route guide map created by this system, 80 percent of the subjects were able to reach the destination within the set period as a result of the experiment. On the other hand, the group of subjects using a commercial map who reached the destination within time limit was only 50 percent of the subject.

**b ) Questionnaire Result**

Taking each item of the questionnaire, the significant difference was acquired from the result of official approval<sup>19)</sup>. And an evaluation of the map created by this system is higher than an evaluation of the commercial map by all the items. In particular, the difference 1.0 was acquired in the item “Whether the landmark was able to be found”. From the subjects who used the map created by this system and were able to arrive at the destination sent opinions, “The landmark's having been found easily at a turn in a road.” and “It was easy to move since the landmark of the straight line road was arranged for every point.”. On the other hand, from the subjects who were not able to arrive at the destination, “There is too few landmarks”, and the opinion “It is difficult to arrive at the destination once the way is lost” were sent.

**( 3 ) Evaluation of the Actual Proof Experiment**

A large number of subjects using the map created by

this system were able to arrive at the destination within the set period. From this experimental result, it appears that the route guide map utilizing a cognitive element was more helpful to trip movement than the conventional map. Moreover, the subjects using the map created by this system were able to find landmarks easily as evidenced by the result of the questionnaire. From the result of the experiment, the model to arrange landmarks identified by this system proved to be effective in creation of a route guide map. On the other hand, since the map was simplified, when the way was lost, it was difficult for the subjects to regain the necessary direction.

**6 . Application of this Research**

City planning to consider of the optimal installation of a sign and a guidance signboard is proposed as a practical example of the model of a landmark created by this research. In city planning, it is important to determine the plan of a future town so that it may be incorporated into the plan<sup>20)</sup> of maintenance of a city area planning, development, and preservation. The city plan which also took disaster planning into consideration would be indispensable. Guidance by sign or signboard is important and it is necessary to install preferred movement channels at the time of a disaster where they would be recognized by people using their usual routes. And, it should become possible by arranging a sign and a guidance signboard to move around effectively based on the model created by this research.

Moreover, the navigation system for the pedestrian on a mobile phone needs to have landmarks of optimum position and shape. And, highly accurate navigation can be achieved using the model.

**Table.3** Number to reach the destination

	Number to reach	Number not to reach
Map created by this system	16 people	4 people
Commercial map	10 people	10 people

**Table.4** Questionnaire result

Questionnaire item	Evaluation average at the time of using the map created by the system	Evaluation average at the time of using a commercial map	Existence of the significant difference of the system and the commercial map
Was the map helpful?	4.3	3.9	
Could the landmark be found?	4.2	3.2	
Could it reach easily?	3.8	3.3	
Would you like to use a map again?	3.9	3.7	

## 7 . Consideration

In this research, making a model of landmarks and developing a system for making route guide map achieved the following:

- Making a model to arrange landmarks at best position
- Making a route guide map based on the model

Moreover, the proof experiment clarified the following:

- The map made by developed system is effective for the pedestrian traffic
- User can adequately recognize the landmark

From the above result, it is thought that installing this system would be effective in making the route guide map from the above-mentioned result. Moreover, the model clarified the type and position of landmarks considered by spatial perception to be effective for the route guide map. In addition, it was clarified that it is useful to make cognitive map, because the user could find the landmark easily. The model made by this research can be applied to various fields such as disaster preventions and navigation systems.

## 8 . Conclusions

In this research, the type and position of the optimal landmark were modeled in pedestrian traffic, and the system that creates the route guide map for pedestrian traffic support based on the model was developed. In this system, using the digital map 25,000 published by Geographical Survey Institute publication could reduce cost.

By the experiment, it was clarified that the map created by this system was effective as a route guide map for pedestrian traffic support. Moreover, while the arrangement in consideration of a cognitive map of the landmark was effective for the route guide map, it was clear that it is helpful to individual cognitive map formation.

In the future, a suitable guide map for an individual user will be developed, by considering the individual differences like sex, age and presence of a sense direction. Moreover, creation of a more general model, will be investigated to correspond to various routes, because the investigated route in this research was limited. Furthermore, a concrete application proposal to city planning or transport planning is also due to be devised.

## References

- 1) Jan Selwood, Winnie Tang : *Connecting Our World - GIS Web Services* - , Independent Pub Group, 2003.11.
- 2) Okabe, A. : *The Challenge of Space Information Science*, Iwanami Shoten, 2001.3.
- 3) Institute of Electrical Engineers of Japan : *The Foundation and Application of GIS - Integration Technology of Space Information*, Ohmsha, 2001.3.
- 4) Kadomoto, S. : *Car-Navigation System - Public Presentation Type Data Structure KIWI and its Usage*, Kyoritsu Shuppan, 2003.2.
- 5) KDDI Co. : EZ Navi Walk, <[http://www.au.kddi.com/ezweb/service/ez\\_naviwalk/](http://www.au.kddi.com/ezweb/service/ez_naviwalk/)>, ( accessed 2006.5 ) .
- 6) Google Co. : Google Map, <<http://www.google.co.jp/maps/>> , ( accessed 2006.5.5 ) .
- 7) Aragaki, N., Nojima, H. : *Science for no sense of direction*, Kodansha, 2001.8.
- 8) Kimura, N., Sawatari, T., Hosokawa, N., Takahashi, N. : Interactive Digital Mapping with a Rubber Metaphor Based on Cognitive Maps, *Information and Communication Engineers technical research report*, Institute of Electronics, Vol.103, No.39, 65-70, 2003.5.
- 9) Kajita, T., Yamamori, K., Hasegawa, J. : Development of Deformation Map Automatic Generation System, *IPSI Journal*, Information Processing Society of Japan, Vol.37, No.9, 1736-1744, 1996.9.
- 10) Geographical Survey Institute : Map, Aerial Photo, and Geography Investigation, <<http://www.gsi.go.jp/tizu-kutyu.html>> , ( accessed 2006.5.5 ) .
- 11) Yokozawa, K., Wada, E., Mitsumatsu, H. : The Coding and Transformation of Cognitive Maps in a Virtual Environment, *Information and Communication Engineers technical research report*, Institute of Electronics, Vol.87, No.1, 13-19, 2004.1.
- 12) Matsuda, M., Sugiyama, H., Doi, M. : A Personalized Route Guidance System for Pedestrians, *Information and Communication Engineers technical research report*, Institute of Electronics, Vol.87, No.1, 132-139, 2004.1.
- 13) Murakoshi, M. : *The book which a mystery having no sense of direction understands - Why do people turn a map?* , Shueisha, 2003.4.
- 14) Nakajima, S., Turi, S., Takamatsu, M., Nakajima, Y. : A categorized color perception in a Traffic Information Board, *Institute of Image Information and Television Engineers technical report*, The Institute of Image Information and Television Engineers, Vol.26, No.29, 11-14, 2002.3.
- 15) Kawakami, M., Shibayama, T. : A Relation between Visibility of Color and Working Efficiency, *Journal of the Illuminating Engineering Institute of Japan*, The Illuminating Engineering Institute of Japan, Vol.86, No.5, 313-317, 2002.5.
- 16) Japanese Standards Association : JIS Z 8721:1993, Japanese Standards Association, 2005.3.
- 17) Wagner, F., Wolff, A. : A Combinatorial Framework for Map Labeling, *Proceedings of the 6th International Symposium Graph Drawing, Lecture Notes in Computer Science*, Springer, Vol.1547 , pp.316-331, 1998.8.
- 18) Shobunsha : *City map Osaka 8 Takatsuki*, Shobunsha, 2006.1.
- 19) Nagata, K. : *Structure of the statistical method*, Union of Japanese scientists and Engineers, 1996.1.
- 20) Ministry of Land, Infrastructure and Transport Japan, "Talk of City Planning with which it goes ahead All Together", <[http://www.mlit.go.jp/crd/city/plan/03\\_mati/index.htm](http://www.mlit.go.jp/crd/city/plan/03_mati/index.htm)> , ( accessed 2006.8. ) .