Walk Navigation System Using Photographs for People with Dementia

Hiroki Kaminoyama[1,2], Takashi Matsuo[2,3], Fumio Hattori[1,2], Kenji Susami[2], Noriaki Kuwahara[2], and Shinji Abe[2]

[1] Ritsumeikan University, College of Information and Science and Engineering, Hattori lab
1-1-1 Nojiurahigashi Kusatsu, Shiga, Japan
{rs012029@se, fhattori@is}.ritsumei.ac.jp

[2] Advanced Telecommunications Reaserch Institute International Intelligence Robotics lab
2-2-2 Hikaridai Keihanna Science City Kyoto 619-0288 Japan
{susami,kuwahara,sabe}@atr.jp

[3] Kinki University, College of Literature Nakatani lab
3-4-1 Kowakae, Higashi-Osaka City, Japan 577-8502

Abstract. Dementia occurs in every country of the world, especially in developed nations. Since such spatially and cognitive impaired people lack the ability to grasp positional relationship between landmarks, we have developed a walk navigation system using photographs of landmarks to benefit them and their families. Our system provides a photograph of the next target landmark to the mobile devices of cognitive impaired people. It can also identify points where cognitive impaired are likely to get lost. Our system can also support such tasks as taking tickets by photographs and animations.

Keywords: photograph, spatial cognitive ability, landmark, mobile device.

1 Introduction

In developed countries, the number of people with dementia (PWD) has been increasing year by year. This social problem occurs in developed nations where people desire to contribute to society and improve the quality of their lives. Such afflicted individuals often cause their families trouble. IT technology that supports their lives is becoming more important.

These people need support based on the particular details and circumstances of their lives. In particular we focus on the problem of going out and leaving the house. They often go to hospitals or nursing facilities with caretakers. But such excursions are burdensome and time-consuming, so navigation support is in great demand. Going out alone using a navigation system would ease the care burden on families.

Such navigation systems as satellite navigation (Global Positioning System), 3D maps, and electronic maps provide effective support. A human navigation system for PWD, whose short-term memory, judgment, and spatial cognitive ability are declining, has not been developed yet in Japan.

M.J. Smith, G. Salvendy (Eds.): Human Interface, Part II, HCII 2007, LNCS 4558, pp. 1039–1049, 2007.

Therefore, we suggest a human navigation system that uses photographs for early-stage dementia sufferers. In our system, users do not need to recognize their position and direction because they follow scenes displayed by a photograph. In addition, users do not have to memorize the course before leaving the house, and they can use this system in a mobile field environment. Furthermore, we believe that using arrows and effects can increase smooth navigation. In the case of task support, using animation helps them take a train or bus.

2 Design of Walk Navigation System

2.1 Requirements of Navigation System

Many problems exist when navigating cognitive impaired people. The following navigation requirements must be satisfied:

1) System doesn't require good spatial skills
   Based on recent studies, cognitive impaired people do not high spatial skills. In this paper, spatial skill denotes such cognitive ability as a sense of place, a grasp of approximate position, and recognizing a landmark during movement. The system should not expect users to organize space perception from maps or text instructions.
2) System doesn't rely on user memory
   Since cognitive impaired people have difficulty relying on their memory, they are prone to get lost even in familiar territory. Reading maps and looking at photographs before leaving the home is meaningless. The system must be used outdoors.
3) System does not depend on sentence direction
   PWD cannot understand text instructions. The system should direct them by a method that easily images a route.

2.2 System Overview

The Walk Navigation System shows photographs on a course at proper intervals with a mobile device. Users follow displayed scenes and reach a particular position, and then they press a button to advance to the next instruction and receive a photograph of a new landmark or a location to head toward. The system shows arrows at corners and effectively uses photographs to inform users of the course. The system also uses photographs in the task navigation scheme and exploits animation and texts to naturally advance to tasks. It avoids positioning technology due to unreliability in built-up environments and to maintain simple applications.

2.3 Walk Navigation System

Since users follow scenes displayed by photos, the system requires pictures taken at specific places to convey the course. We considered that users would understand the course by following photographed positions.

System shows a photograph at:

1) starting and end points;
2) corners to convey orientation;
3) such places as intersections to avoid confusion even if the user goes straight.

However only showing photos to create user recognition of a course is hard. We decided the following rules to convey a course by photographs:

1) When showing a photograph, the system tempts a user to slowly go forward by visual effect
2) Arrows clearly indicate course
3) Frames enclose landmarks

Fig. 1. Examples of Walk Navigation

2.4 Task Navigation System

In many cases, users have to walk and take public transportation. But since PWD have difficulty taking buses, trains, and other vehicles alone, we propose a task support system that uses animation, text, and photographs.

1) The system clearly displays a photograph of task objects. A photograph of an operational object helps users understand, for example, ticket machines and buttons on buses.
2) The system explains tasks. Photographs, animation, and text instruction allow users to visually imagine tasks.

3 Evaluation of Effects of Spatial Cognitive Ability

We experimented using the walk navigation system to check the correlation of spatial cognitive ability. We measured movement times and the number of times the device was referred to. Then we examined the relation between spatial skill and movement time.

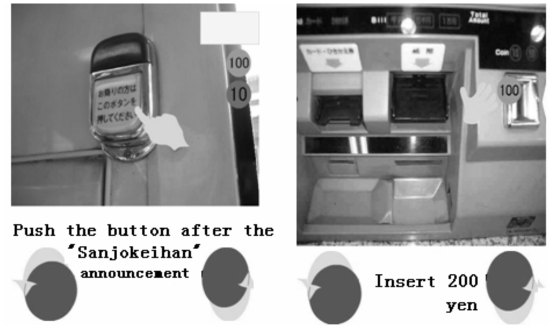

Fig. 2. Photograph on left shows example of getting off a bus by pressing a button and right shows ticket machine

Our system was implemented in Flash and ran under a Windows Pocket PC on a HP iPAQ. This version does not use text instructions and has a forward/backward button at the display's bottom.

Fig. 3. Walk navigation system displayed on a mobile phone (left) and PDA (right)

3.1 Method

Observation

We compared the following three methods:

1) Our system
2) System without arrows and effects
3) Paper map (A4)

We measured the following by analyzing participant behavior:

1) Time
2) Number of times they referred to PDA/maps
3) Times referred they referred to PDA/maps
4) Number of times participants got lost

Participants

We recruited 30 healthy adult women/men aged 20 to 49 as participants who took a spatial skills test before the experiment. We grouped them into three navigation sets (our system, our system without arrows, and maps) and each group's score was equal. No participant knew about the PDA device and or our navigation system.

Course

Supposing a typical trip, we experimented in two areas. One is from station to bus stop, and the other is from bus stop to another bus stop. Each course was approximately a simple distance of 200 meters.

Procedure

We briefly explained PDA usage to those using it and then summarized the experiment for all participants. We did not show maps to participants until the experiment started. After receiving a map, participants were given starting points and destinations.

An observer accompanied participants during the experiment to record their behavior by digital video camera, walking behind them to avoid giving hints about the course. When a participant asked about the course, the observer answered, and observer counted it as a mistake. If participants got lost, observers hailed them and returned to a suitable position.

3.2 Results

Table 1 shows the observation results.

Table 1. Observation results: lost times means total number of errors; others are averaged

	Our system	System without arrows	Maps
Time (sec)	567.1	679.7	654.1
Reference number	66.5	75.6	35.1
Total reference time (sec)	233	237.2	173.9
Lost times	3	6	6

Effect of photographs

From the map results in which a correlation coefficient between movement time and spatial skill score is 0.6, a highly spatially skilled person can move faster than a lowly spatially skilled person. There is no correlation in walk navigation system (correlation coefficient is nearly 0) against a map. Using arrows and visual effects reduces the variance for movement time. By the above, the walk navigation system is effective for spatially impaired people.

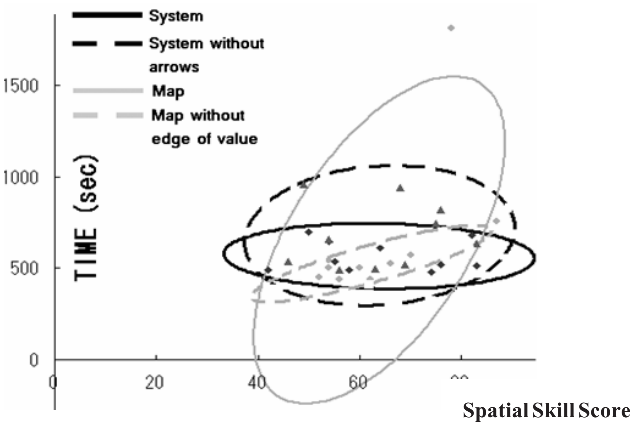

Fig. 4. Correlation between spatial skill and measured time. Graph shows 90% Probability ellipses for each method. High points of spatial skill mean low spatial cognitive ability.

Referring to device/maps

The number of times a PDA/map is referenced reflects the ease with which a course is understood. Results show map users did not read maps less than PDA users. Understanding a map is not easy due to the amount of confusing information, but if users can understand it, they do not need to refer to it often. Some participants actually only glanced at the map a few times, but a few participants repeatedly consulted the map. On the other hand, in our system, users tended to look at the device each time they turned at a corner and when operating it, and so on. This increased the number of references, but using arrows and effects can reduce a few seconds of referring.

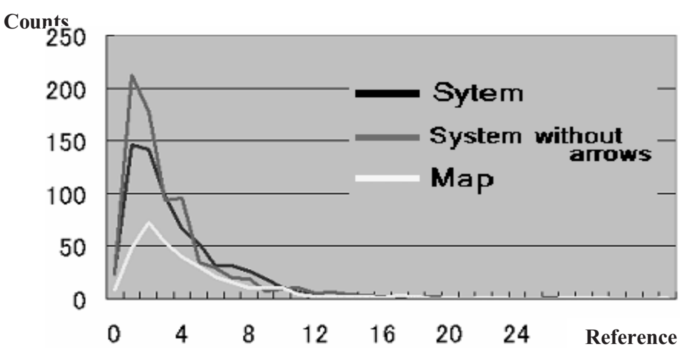

Fig. 5. Number of references participants made. Highest peaked line is system without arrows. Line in between two lines is our system. Lowest line is map.

3.3 Conclusion

We described an experiment of our walk navigation system concerning spatial cognitive ability in this section. We compared three methods that investigated a photograph's effectiveness for human navigation. The results show that the walk navigation system is effective for spatial cognitive impaired people, so PWD will also benefit. Moreover, it can teach a course using arrows and effects, but users have to constantly watch displays or scenes. Thus, users look at the device more than maps. This can be dangerous at crossroads and on stairs.

4 Evaluation of Memory and Landmarks for Navigation Aid

We suppose a situation where PWD use our Walk Navigation System in places they have visited before, not new places. In such places, landmarks become more important for remembering the course, so verifying our system as an alternative method for memorized landmarks is essential for our system. We examined the differences between movement by memory and movement by walk navigation system using difficult paths.

Specifications differences exist between the previous and current versions. First, our system was implemented in Flash and ran under a mobile phone on a W43H. Second, we explained each photo by adding such text instructions as "Go straight," or "Turn left here and go that way."

4.1 Method

Observations

We observed the following four points:

1) movement time from starting point to destination
2) mistake rate
3) landmark rate
4) our system rate

We asked participants for the decisive factor used for selecting the course at the 29 corners during the experiments. When they referred to photos and chose a course or looked at their mobile phone at the corner, we counted it as (4). When they used a building or something as a landmark, we counted it as (3).

Participants
All participants were university students who weren't very familiar with the place. We didn't tell them the experiment details not to remember the course. Ten proceeded to the destination by memory (Memory Group), and the other ten participants used our system (System Group). During the experiment, we tested participant spatial skill scores[9] by questionnaire.

Procedure
Participants made a round trip of the route, which included 29 corners and a distance that normally requires about 22 minutes on foot. On the outward trip, an observer accompanied participants to the starting point. After that, the spatial skills of the participants were tested, and the observer gave detailed explanations of the experiment. System Group participants received instructions for using the mobile

phones and moved to the destination. Memory Group moved to the destination relying on memory. After the experiment, the observer sought feedback of the walk navigation system and suggestions for refinements.

4.2 Results

Table 2 shows the observation results.

A 5% level of statistically significant difference was found in the rate of mistakes. Other data did not have it. There were individual differences for each data category.

Table 2. Observation results

	Spatial skill scores	Time	Mistake rates	Landmark rates	Our system rates	Both methods
Memory	67.2	24:01	27.50%	40.40%		
System	63.2	23:31	3.60%	26.40%	44.30%	1.20%

Interviews

The participants were asked to give feedback on the experiment. 80% believed that it was useful, but the others did not. The following comments are impressions of our system.

- It was easy to use and better than maps.
- Photographs should be replaced automatically.
- Some photos were too indistinct. There were also some differences between the photos and the actual scenes.
- I wish I knew the distance between each photo.

4.3 Study and Conclusion

Comparing the Memory and System Groups, there was a big difference in the residential areas. Pedestrians often get lost easily in residential areas due to a lack of landmarks. In short, the role photographs play in navigation is equally or more important than landmarks, and they are useful in areas of similar scenery like residential areas. Forgetful people have difficulty remembering landmarks, so our system is effective for people with declining memory.

From interviews and participant remarks, when participants made a mistake, they didn't look at the mobile phone. Such mistakes reflect the overconfidence of people who have high spatial skills scores. Of course, mistakes were made even by participants who checked their mobile phones. Such errors were caused by indistinct photographs or when our system didn't show photographs at proper intervals. Even without landmarks, users recognized the course by photographs; but if a photograph didn't have any characteristics at all, it was hopeless.

5 Task Navigation System Experiment

Persons suffering from dementia must accomplish many tasks when taking public transportation. We experimented to determine if task support could support such situations. All specifications are identical to Section 3.

5.1 Method

Observations
We compared the following two methods:

(1) our system (with task support)
(2) just showing a goal (without task support)
Participants were examined following task contents based on real life.
(a) In the bus:

i) get a numbered ticket
ii) push a button (buzzer) to get off
iii) insert coins and a numbered ticket

(b) Getting a ticket from a machine:

iv) insert coins
v) push the child button
vi) push the 120-yen button
vii) take a ticket and pass through the gate

Participants
Assuming they have similar cognitive ability levels as early-stage PWD, we recruited 20 boys and girls aged 8 to 9 and randomly divided them into two groups: with and without task support. None knew about either PDA or this navigation system.

Procedure
In this experiment, the children moved toward a destination with a PDA. They walked on the course and proceeded to the task part without interruption. An observer and parents followed them for protection and to record their actions.
Before the experiment, we explained how to use the PDA. We did not explain the task support system or the destination. After beginning the experiment, their parents and observers did not explain anything. When they asked a question, the observer answered it.

5.2 Results

Figure 6 shows the number of mistakes in this experiment. The task support group made six mistakes, but the without task group made 32 mistakes. The without task support groups made mistakes by asking passersby or their parents about the task. The task support group made several mistakes including forgetting their task during waiting a bus or failing to notice the task support system, but most understood their task.

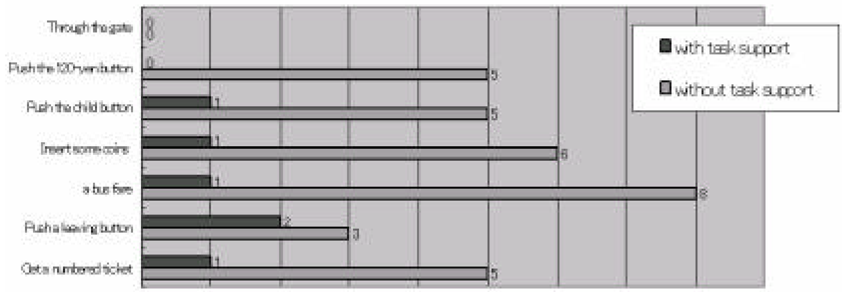

Fig. 6. Result of task support experiment; graph shows number of mistakes for each group

5.3 Summary

We described the task navigation system experiments in this section. Third grade children examined the task support navigation system. Most children with the task support system made a few mistakes in all parts, but children without task support made many mistakes. The task navigation system using animation and photographs is effective.

6 Conclusion

In this paper we described a human navigation system using photographs for early-stage PWD. Such individuals often go out with their caretaker to nursing facilities but they can't go alone because they have trouble understanding their location, direction, and distance from maps or memory. They need not only walk support but also task support for taking public transportation. We therefore developed Walk Navigation System, in which users do not have to be conscious of their position and direction because arrows and effects lead them to their destination. In walk navigation experiments with our system, spatially impaired people moved with large time reduction required to navigate routes as well as healthy people. Our system is effective in places without landmarks or for people with declining memories. However, uncharacteristic photos or places where scenes are similar such as intersections confuse users who easily get lost. In task support navigation, each task is carefully explained by animation, photographs, and text instruction. Our study has shown that the task support system is probably effective for children and PWD too.

7 Future Work

We have many problems based on the outcomes of experiments and interviews. In the future we will try the following:

1) system verification for people with dementia
2) improving the method of showing photos
   People with dementia get confused if they can't understand their direction when getting off a bus in complicated crossings. Text instruction is basically hopeless,

so we need more investigation of different methods for providing information from photographs.

3) improving usability
Comparing real scenes with photographs is demanding and dangerous in busy streets, on stairs, and so on. When they get lost, the system must re-orient them, but it can't do that yet.

4) develop an authoring tool
An authoring tool, which easily edits photographs taken by caretakers and volunteers to automatically create contents, must be developed.

Acknowledgements

We would like to thank all the people who participated in the experiments. Also we would like to thank the ATR Robotics and Communication Laboratories members for their detailed comments, suggestions, and constant support. This work was partially funded by The National Institute of Information and Communications Technology (NICT).

References

1. Goodman, J., Gray, P., Khammampad, K., Brewster, S.: Using Landmarks to Support Older People in Navigation. In: Mobile HCI2004 (2004)
2. Bosman, S., Groenendaal, B., Findlater, J.W., Visser, T., de Graaf, M., Markopoulos, P.: GentleGuide: An exploration of haptic output for indoors pedestrian guidance. http://www.industrialdesign.tue.nl/portfoliosAndPublications/publications/markopoulos/BossmanEtAl_GentleGuide.pdf
3. Bradley, N.A., Dunlop, M.D.: Understanding contextual interactions to design navigational context-aware applications, http://www.cis.strath.ac.uk/~mdd/research/publications/02bradleydunlopa.pdf
4. Liu, A.L., Hile, H., Kautz, H., Borriello, G., Brown, P.A., Harniss, M., Johnson, K.: Indoor Wayfinding: Developing a Functional Interface for Individual with Cognitive Impairments. In: Proceedings of Computers & Accessibility, ASSETS 2006, Portland, Oregon (October 2006)
5. Spatio-Temporal Association with Multiple Photographs (STAMP) http://home.csis.u-tokyo.ac.jp/~tanaka/stamp/stamp.html
6. Tanaka1, H., Arikawai, M., Shibasaki, R.: A Pseudo-3D Association of Photographs by using Spatial Hyperlinks, http://home.csis.u-tokyo.ac.jp/ ~tanaka/database_tod17.pdf
7. Miyake, S., Kusunoki, H., Mitani, T., Okabe, K., Torigoe, H., Yokota, K.: A tourist guidance system using the simple 3D functions, http://www.ieice.org/iss/de/DEWS/proc/2003/papers/4-P/4-P-02.pdf
8. Murakoshi, S.: Houkou onti no nazo ga wakaru hon (in Japanese) Shueis ha, p. 56 (2003)