A Study On Path Guidance System Of Guide Robot For Visually Impaired

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Abstract : In this paper, earth coordinate of the guidance robot for the visually impaired is detected by using GPS (Global Position System), and the system which leads the visually impaired to position information (TM coordinate) in Korea is achieved through map-matching with electronic map. The visually impaired need more information about the walking path than ordinary people when walking outdoor. Therefore, we studied implementation which can guide the visually impaired more safely through map-matching with GPS signal by making electronic map for the visually impaired.

Keywords: Guide Robot, GPS, Map-matching, GIS,

1. INTRODUCTION

According to the research on the handicapped person in 2000, the number of the visually impaired in Korea is assumed by 180,000 persons where is more than double in number than 70,000 persons of 1995. While, welfare facilities for the visually impaired are still in a primitive level as at most Braille type block on side-walk or signal lamp's walk guide by sound.

The outside activities of the visually impaired are heavily depending upon the use of white canes or guide dogs. However white cane is not an ensuring mean of safety and guide dog is not cost effective, not in wide use. Assistant equipment for the visually impaired has been on demand to address the problems and guides them safety.

Recently, RTA(Robotic Travel Aids) system using mobile robot is widely studied as a guide system for the visually impaired. HARUNOBU of the Yamanashi University in Japan is the representative example.

In this paper, the implementation that the guidance robot for the visually impaired guides the visually impaired in safety is studied in this paper.

Because the guidance robot for the visually impaired should guide to the destination in safety, the path of the guidance robot could be different from that of the ordinary people. Therefore, the electronic maps concerned about the characteristic of the visually impaired are necessary.

In this paper, the walking path and destination are determined by making the electronic map for the visually impaired including directions, distance, and types of the walking path which are necessary when the visually impaired are walking outdoor. Also, the system that the location of the guidance robot is presumed by using GPS signal and then the guidance robot guides the visually impaired in safety through map-matching between the electronic map and GPS signals is implemented.

The system based on the PDA especially enabled the visually impaired to walk alone carrying with the PDA and the GPS receiver without the guidance robot.

2. SYSTEM IMPLEMENTATION

Figure 1 shows the system conception of the visually impaired walk with the guidance robot wearing bone-conduction headphone and carrying with PDA. The bone-conduction headphone is the thing that provides necessary information to the visually impaired as sound, and PDA matches GPS signal from the robot by radio communication to the map. In order to input the destination where the visually impaired want to go, the braille keypad is attached on the screen of PDA.

Figure 2 shows the block diagram of the guidance system. In generally, the digital map is focus to car navigation system and difficult to apply to blind man guidance. Therefor, we composed the guidance system with two part, guardian system and user system. First system is made a new map layer for blind man, next is guidance system using the map layer.

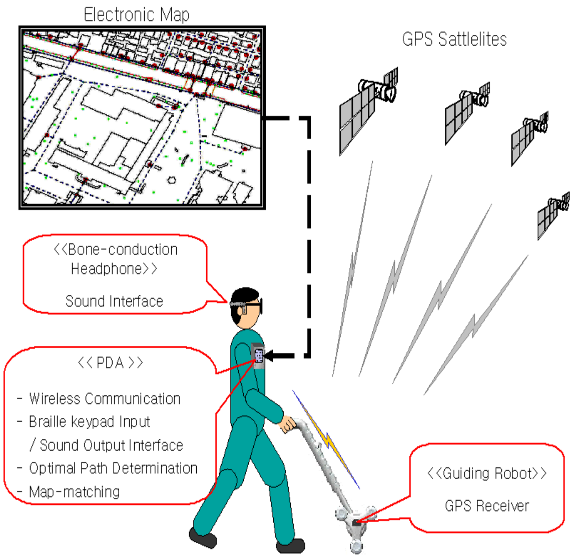


Figure 1. System Conception

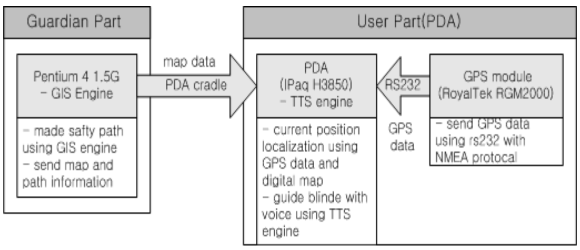


Figure 2. Syste block diagram

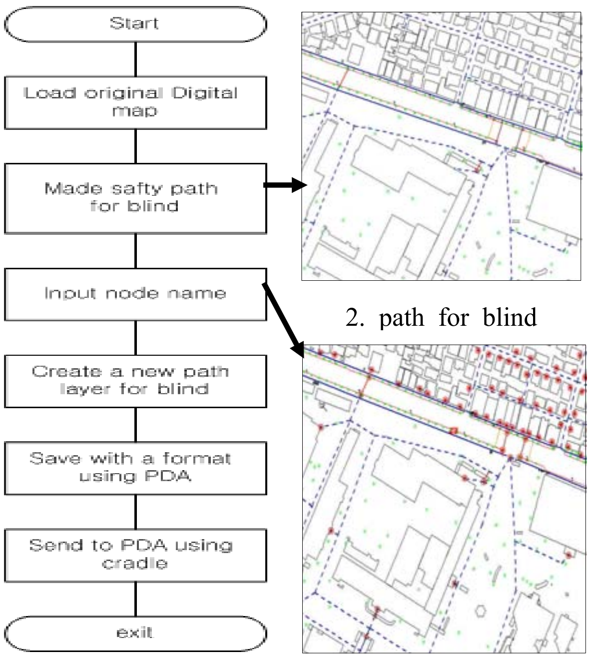
2.1 Guardian Part program base on PC

The electronic map for the visually impaired includes the information which is necessary while walking. The 1:1000 electronic map has layers which consist of information for the visually impaired. Compared to the general electronic map, the link that has the directions, distance, and types of the walking path for the visually impaired and the node that points out the destination which the visually impaired can select are added.

The visually impaired are difficult to walk in the sidewalk without the braille block, the road, the crosswalk, and the overpass etc. Therefore, the proper way to detour according to kind of path for safety must be selected in case of deciding the optimal path.

The type of path in the link are the sidewalk with the braille block and without the braille block, the road that cars and people pass together, the crosswalk, the stairs, and the overpass. The safer path is selected among each same distant paths using different weights as dangerous levels.

Figure 3 shows the electronic map for the visually impaired around Inha University. Solid lines and dotted lines that are shown in figure 2 are paths, the "link", that the visually impaired can walk, and ◎ indications are the "node" that indicates the destination that the visually impaired can select. The family of the visually impaired can update the electronic map as the visually impaired want because the links and the nodes in the electronic map could be modified in the softwares based on PC.



2. path for blind

1. Flow chart

3. the layer for blind

Figure 3. Guardian program

2.2 User Part program based on PDA

Figure 4 show the diagram of the user program in PDA.

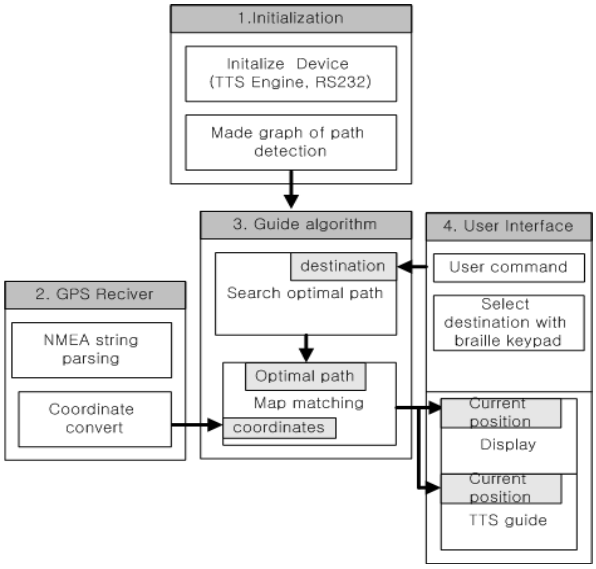


Figure 4. The diagram of PDA system

Initialization is include device initialize and create a undirected weighted graph for searching the path. we presented the graph with adjacency-list method. Each vertex in the graph have maximum four edge and define six weight values for distinct path kind.

GPS receiver part processing NMEA string parsing and coordinate convert from WGS84 to TM in korea using Molodensky-Badekas model. In the NMEA0813 sentences, we used GPRMC sentence for position information, use PDOP, and SNR from GPGSV sentence for estimate the error of GPS.

The user interface is composed braille keypad input system and voice output system using tts engine. hence, user can select the destination name with ARS method. In addition we made braille keypad using PDA touch screen.

The guide algorithm have path detection algorithm and map matching algorithm. While the optimal path for the ordinary people is the shortest path, that for the visually impaired should be concerned about safety first of all. In this paper, the method which decides the optimal path for safety of the visually impaired is proposed using Back Tracking algorithm. Also, the graph for the determination of path combines the necessary information for the visually impaired's walking. Back Tracking algorithm is DFS (Depth-First Search). DFS is that any search algorithm which considers outgoing edges of a vertex before any neighbors of the vertex, that is, outgoing edges of the vertex's predecessor in the search. Extremes are searched first. This is easily implemented with recursion. An algorithm which marks all vertexes in a directed graph in the order they are discovered and finished, partitioning the graph into a forest. If the value exceeds the determined limit in the Back Tracking algorithm, then it comes back to the vertex which was selected in the previous step. In the process of searching the optimal path using Back Tracking algorithm, the path detours in case of danger. Furthermore, if the visually impaired want to minimize the number of overpasses and crosswalks, not the shortest path but the optimal path could be selected through the adjustment of the number of specified type.

The modified point-to-curve matching method is used for map-matching method. The point-to-curve matching method is the method that projects to the nearest arc after measuring the distance from each received points. Because this method has the advantage of easy and fast operation due to little amount of measuring, it is more efficient than other algorithms in the map-matching method. However, this method could mismatches to the wrong road around two roads near the crosswalk due to the error of GPS. In this paper, the way of a 1st order equation that minimizes error in the data including error is used by the information of robot's moving direction. In addition, the method that the error is revised at the next received point is added to improve map-matching using error between received and matched point.

3. EXPERIMENT RESULT

For this experiment, RGM2000 GPS reception module of Royaltec company is attached on IPAQ H3850 PDA using RS232C. The produced information of electronic map is stored in PDA through PDA cradle. PDA receives GPS information by NMEA way through RS232c, and map-matches to the received map information, then composes guidance information through drawing the location in Korea, and guides as sound through TTS(Text-To-Speech) engine.

Figure 5 shows GPS receiver and PDA that composes for an experiment.

Figure 5. The experiment system
(left is input screen, right is guide screen)

In order to recognize how much GPS reception signal and actuality walk path show difference, the GPS signals were received around actual residental walking paths. GPS data that received through PDA simulated in PC.

Figure 6 indicates is targeted real path for experiment. And GPS signals that were received by actual walking around residental area in the Inha university. Figure 7 show the received GPS data. Figure 8 shows the map matching result.

The result shows that except for area A, B, C, other path's data show good results almost same as actual walking.

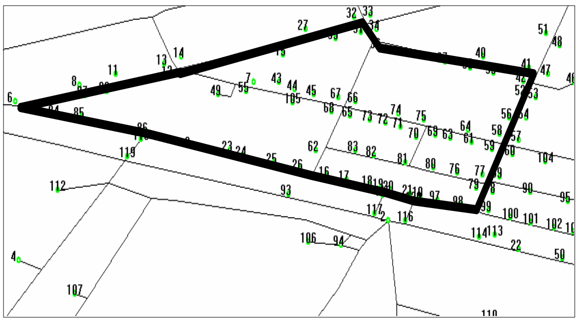


Figure 6. Real Path

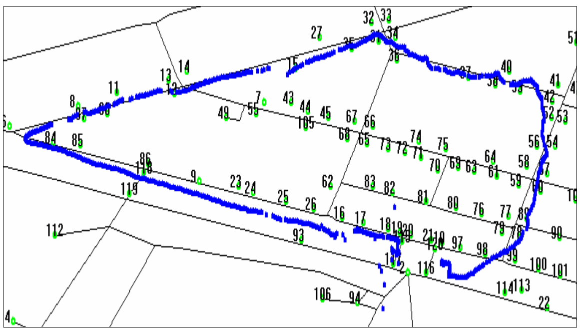


Figure 7. GPS Data

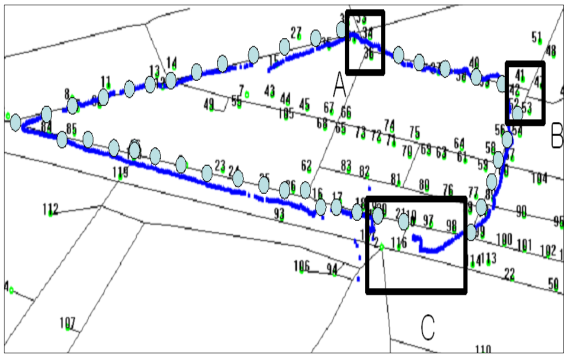


Figure 8. Map matching result

The area of A, B is a alley, and area C has a high-rise building. Therefor, there are serious multi-path error. The table 1 shows the mismatching error(Nmber of mismatching data / total Number of received data) in two different environment. The table describe the environment with PDOP value. With PDOP lower than 6, can get good matching result. In the case of cycle slip and PDOP>10, the GPS data is have too much error to use it. Therefor, the high PDOP value means the bad environment for receiving GPS signal.

Table 1. Influence of the environment

	Experiment 1	Experiment 2
Num of data	770	800
Cycle slip error	5%	20%
PDOP>10	6%	19%
10>PDOP>6	11%	25%
PDOP<6	73%	46%
Matching error	15%	35%

Even if, with lower PDOP GPS data, also have big absolute error. Figure 9 shows the error and PDOP in a rectilinear movement.

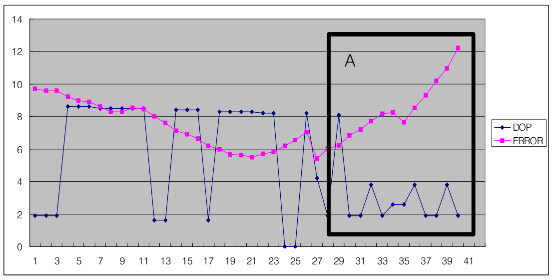


Figure 9. Error and PDOP in Rectilinear movement

In the area A GPS data have lower PDOP value, but the error is more than 10m and become higher. Therefor the rate of PDOP is also a important factor to estimate GPS error.

4. CONCLUSION

In connection with the implementation of guidance robot for the visually impaired, map-matching between GPS and electronic map which is for self localization and determination of right path of robot is studied in this paper.

map-matching received GPS signal to the optimal path in the electronic map, although it is similar with real walking path, a few miss map-matching cases occurred at the difficult points to receive.

In case of big error, that is, map-matching is failed, if map-matching is achieved not only depending on the GPS signal but also with INS of robot, the result may be more correct. Furthermore, although the starting point of the guidance robot cannot be known exactly using GPS reception signal, it is helpful to implement if the starting point is detected through the vision sensor and so on.

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