THE DEVELOPMENT OF THE NAVIGATION SYSTEM FOR VISUALLY IMPAIRED PERSONS

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Abstract The objective of this study is the development of auto-navigation system which supports activities of the visually impaired without help of others. This system navigates the subject by using information about three sensors(acceleration sensor, terestrial magnetism sensor and gyro sensor), DGPS(Differential Global Positioning System), maps and a traffic data base. In our navigation system, after inputting the destination, position of the suer is estimated, the most suitable route to the destination is calculated, and the user is guided along this route. In this report, we assess the developed method which estimates the movement of the subject.
Keywords- visually impaierd, navigation, DGPS

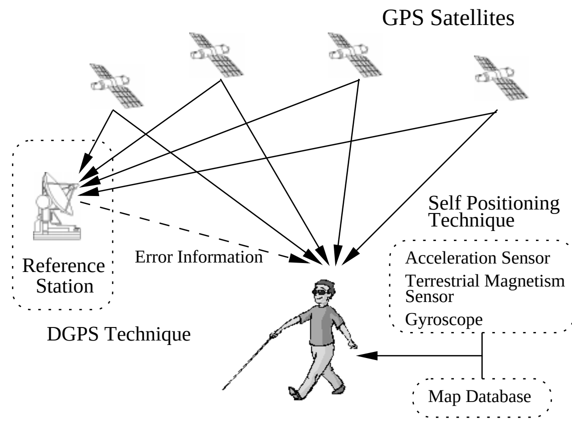

Fig. 1: The conception of the navigation system fot the visually impaired

I. INTRODUCTION

It is possible for the visually impaired to be engaged in daily activities by using a white cane. However, they are not independent enough to travel or engage in a full range of activities without assistance. Our objective is the development of a navigation system which support the independent activities of the visually impaired. In our navigation system, after inputting the destination, position of the user is estimated, the most suitable route to the destination is calculated, and the user is guided along this route.[1][2] Therefore, estimation of the position of a user and calculation of the suitable route are very important in our system. Fig.1 shows the conception of our navigation system. In our system, to obtain the position of the user, DGPS technique is used usually. However, sometimes DGPS doesn't work because of miss receiving of the signal from GPS satellites. In such cases, other positioning method (called self positioning method) is used in our system. In this papaer, we refer to the developed methods which are the positioning method without DGPS and the method of the calculating suitable route, and assess these methods.

II. METHOD

Fig.2 shows the block diagram of the developed navigation system. All the system are controlled by a handy personal computer. A visually impaired user inputs the destination using key board or voice recognition system. As mentioned earlier, usually the position of the user is measured by DGPS. The error range of ordinary GPS is about 10 to 30m. This error is too large fot the human navigation system. DGPS is the good positioning system. By useing this technique, the error range is reduced to about 2 to 3m. In our system, the reference information for DGPS is received by FM receiver, and we can obtain user's position every 5 seconds. Fig.3 shows the DGPS unit which is used in our system.

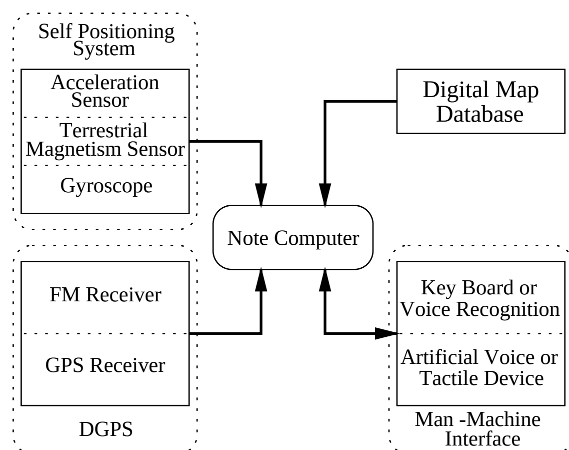

Fig. 2: Simplified block diagram of the navigation system

For example, in a street of office buildings, the signal from GPS satellites sometimes cannot be received, and the DGPS is not available. In such place, we have to estimate the position of a user using other method. In our system, the number of steps is measured by an acceleration sensor, and the moving distance is calculated by using the number of steps and user's pace. Fig.4 shows an example of output data of acceleration sensor. In this figure, each sharp peak means user's step. The direction of a user is estimated by a gyroscope and a terrestrial

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Fig. 3: A picture of GPS receiver

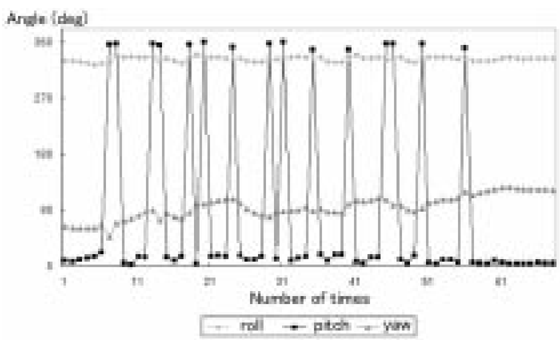

Fig. 4: Output example of acceleration sensors

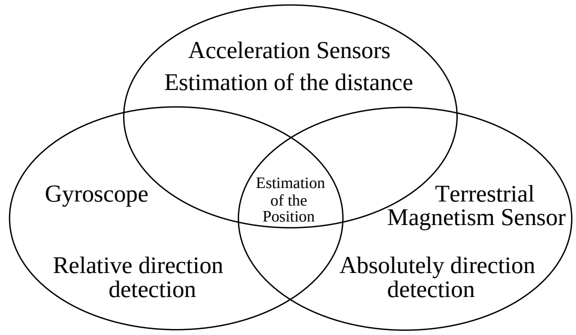

Fig. 5: The conception of the self positioning system

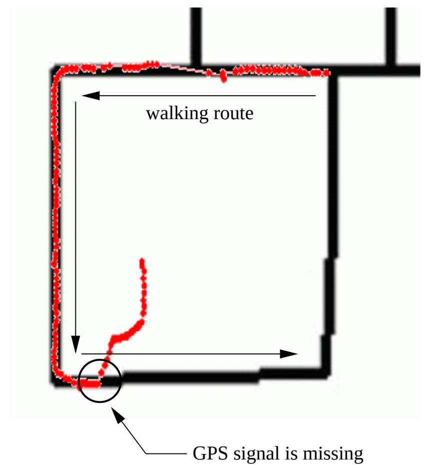

Fig. 6: Positioning result with DGPS

magnetism senor. This method is called the self positioning method. The conception of self positioning method is shown in Fig.5.

The result of self positioning system has some error. These error are mainly caused by offset of a gyroscope output. In our system, the map matching mehod is used in order to cancel these error. Our navigation system has a digital map database. In this map database system, a road is expressed as a line from one crossing to another crossing. The system also knows the latitude and the longitude of all crossings. In our map matching method, on the straight road, an output of the self positioning system is matched on the nearest point on the road. On the nera crossing area where is within 5m of crossing, if the direction of the user changes largely, this point is matched on the crossing. The outline of the map matching method of our system is shown in Fig.7.

Calculation of the suitable route for the visually impaired is one of most important things in our navigation system. For the car navigation system which is popular in Japan, the shortest route is an optimal route usually. However, the shortest route is not always a suitable route for the visually impaired. For example, a road which contains stairs, rough parts or some obstacles is not suitable. Therefore, in our system , the route is calculated using the information of the road condition and determined by using Dijkstra's algorithm. This algorithm finds the shortest route. So, in the map database of our system, the span od a road which means the span from one crossing to another crossing is set up as safety level of the road. For example, if one road is dangerous for the blind, the road's span of database is set up longer than real span.

III. EXPERIMENT

Three normal subjects were tested with our new methods. Subjects wore the navigation system, and walked following instructions.

1. Subjects walked along decided route, and the system tracked subject's route using DGPS.

2. Subjects walked along decided route, and the system tracked subject's route using self positioning method.

3. Map matching method was applied for results of the self positioning.

4. Subjects walked following a result of the suitable route calculation. And the safety of this result was evaluated.

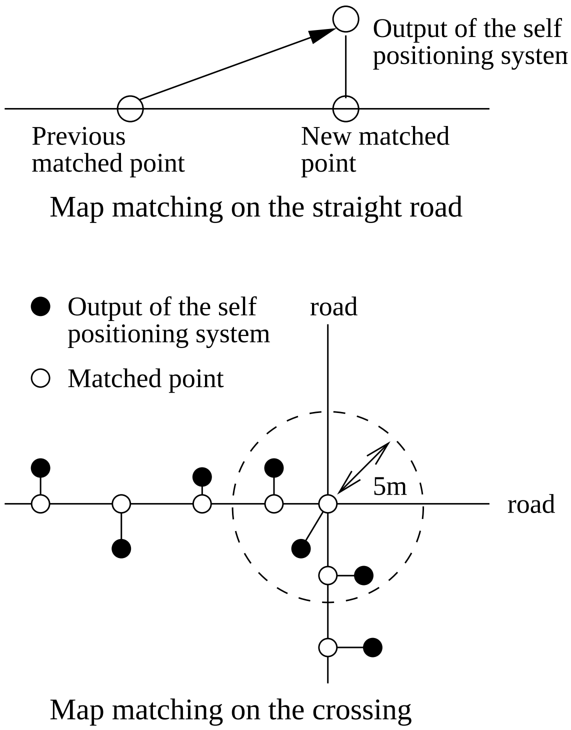

Fig. 7: The outline of the map matching method

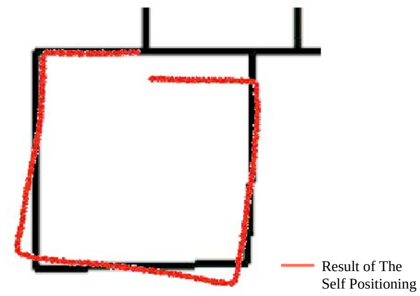

Fig. 8: Tracking result without map matching

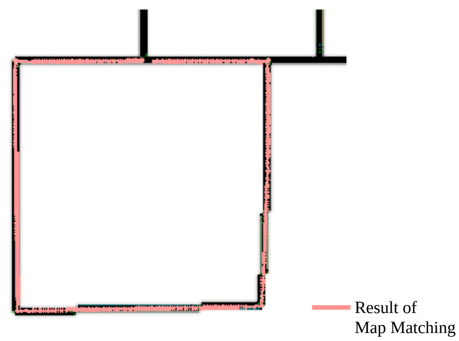

Fig. 9: Tracking result with map matching

IV. RESULTS

From these experiment, the following characteristics become clear.

1. Fig.6 shows the result of the positioning with DGPS. From this picture, we can see that error of DGPS is very small and DGPs is a good positioning technique for human navigation, while DGPS works perfect.

2. Fig.8 shows the result of the self positioning system. As time passes the error of self positioning become increase. Especially, the error of direction becomr increase. This error is due to a inteftation of the offset which is included in the output of a gyroscope. For short term using, this error is negligible. However, for long term measurement, this error cannot be bypassed.

3. In order to cancel the error of self positioning system, the map matching technique was used. A result of the map matching is shown in Fig.9. The result of the map matching has little positioning error.

4. The suitable route was calculated by using our new algorithm. The result of the calculated route did not contain unsuitable route. And subjects could walke from the start point to the destination safely.

V. CONCLUSIONS

We are developing the navigation system for the visually impaired. This system measures the position of a blind useer, using DGPS, the developed self positioning system and the map matching techniquie. And this system can calculate the suitable route for the visually impaired by using our new slgorithm.

We feel that our new positioning mehtods are powerful. And the method for calculating suitable route also works well. Therefore, we've concluded that our new methods will be useful for the navigation system for the visually impaired.

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