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Travel Mapping Aid for Blind Persons Using Swarm Intelligence

Budi Setiadi*[1], Endang Darwati[2], Adnan Rafi Al Tahtawi[3], Tata Supriyadi[4], Ridwan Solihin[5], Fryma Zhafran Raihan[6], Varian Andika Wijayakusuma[7] and Muhammad Hafiz Aziz[8]

[1,2,3,4,5,6,7,8] *Department of Electrical Engineering, Politeknik Negeri Bandung, Indonesia*
[*] *Corresponding author. Email: budi.setidi@polban.ac.id*

ABSTRACT

The basic problems of blind persons in doing independent activities from one place to another are the mapping of trips to go and home navigation. The use of the conventional, electronic stick or previous research is still lacking. The results of research on localization of positions and mapping for inside and outside the room are still inaccurate. GPS (Global Position System)/GSM (Global System for Mobile)-based electronic aids are constrained by their use in building spaces, weather, accuracy, and limited areas. Information on the latitude-longitude position of at least 3 points of the satellite signal is not perfectly captured indoors due to the faraday cage factor. The signal capture of the device is affected by electromagnetic waves due to bad weather and the accuracy of the device is ± 15 m. And deliberate randomization of signals in a limited area for secret purposes (security, government). Zigbee-based electronic tools, wireless, visible LED Light, and limited fingerprint with localization results that are too large, so that the points from one another are too far. The focus of this research is developing a stick assist (whit ecan) feature that can provide route information directions independently. Data of points traveling away generated from a combination of IMU (inertial-measurement-unit) sensors and a compass. The movement of each step on-demand based on changes in speed from the IMU sensor, while the direction is in units of 0 to 360º values based on the compass sensor. Using the concept of sequential, accelerometer data, and compass are a tabulation of data points to depart is used for mapping of trips to leave. The recorded data were compared directly with the two sensors on the microcontroller using a swarm intelligent algorithm for home navigation. The algorithm processing results are informed in the form of voice instructions and the number of steps, the accuracy is 84% with a shift error of ± 1 m.

Keywords: *mapping-navigation, inertial-measurement-unit, compass, swarm intelligent*

1. INTRODUCTION

Generally, blind persons carry out independent activities from one place to another using stick aid [8]. Problems often arise when going home or returning to their original place. Previous studies have discussed a lot about localization of positions and mapping for indoors [2-7], [11], and outdoors [1,8,10]. Position localization and indoor mapping using ZigBee, WSN (Wireless Sensor Network), visible LED Light, and fingerprint sensors. The use of ZigBee and WSN functions to detect position based on the signal strength captured. Meanwhile, visible LED Light and fingerprint sensors function to detect position based on spot detection of light signals and fingerprints. When the signal, light spot, and fingerprint disappear indicates the last position and vice versa when caught strongly indicates a new position. Conditions like this indicate the direction of travel. The drawback that arises from using these three sensors is that the localization zone is too wide, so the results are inaccurate. Position localization and outdoor mapping using a GPS/GSM sensor. The use of these sensors serves to capture a minimum of 3 satellite signals. Satellite signal conditions in certain areas can be lost due to the influence of positions in buildings, faraday cages or obstruction of tall buildings, weather, and inaccurate results. Our research proposes the use of the swarm intelligence algorithm for the mapping of trips to go and home navigation for blind persons to do activities indoors. The sensor base is used two accelerometers and one compass as data tabulation of the trips and home navigation matching. The manual data matching process (based on a stick aid) serves to direct blind persons to the right position and move in steps. Command information so that it can be understood is translated in the form of voice instruction information (slide left, right, and step).

2. RESEARCH METHOD

Figure 1 shows the electronic hardware system design for travel mapping. The system consists of input, process, and output devices. The input device consists of two accelerometer sensors, one compass sensor functions to detect the movement and position of the stick aid. The microcontroller functions as a home navigation data processor based on an intelligent swarm algorithm and an SD-Card module to store the mapping of trips to go. The DF-mini player as an output device functions to issue voice instruction information based on the previously saved mp3 file.

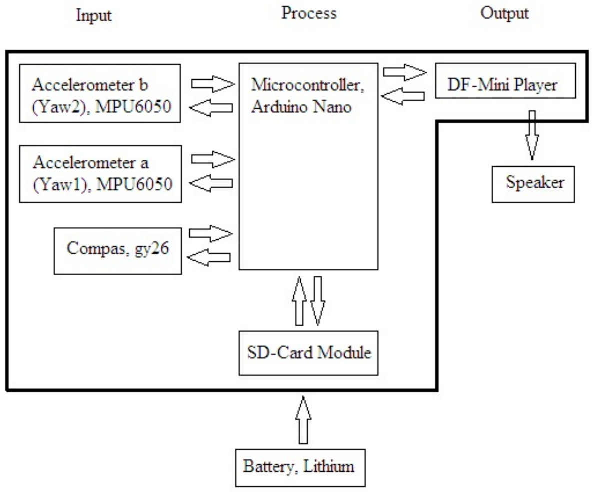

Figure 1 Design of System Hardware

The realization of the stick aid is as shown in Figure 2. The assistive device is built by integrating the WHO standard (whitecan stick) with the electronic module design.

Figure 2 Realization of the Stick Aid

The data processing stages that we propose consist of three, namely detection of steps and positions, mapping of trips to leave, and home navigation.

The steps and position detection stages come from two accelerometer sensors and one compass sensor. Accelerometer sensor data provides 3-DOF (3-degree of freedom) information in the form of yaw, pitch, roll. In this research, the data used were yaw. Meanwhile, the compass angle value for each stick aid motion refers to the OM (mobility orientation) technique with an angle of 22.5^0, the maximum standard of shoulder movement. The proposed design calculates steps and positions based on the movement of the stick tool as shown in Figure 3,4,5,6. Figure 3 shows the position of blind persons are still positioned. The movement of the stick tool from left to right or vice versa. The data changes yaw1 (a) and compass (ϴ).

$$\text{Yaw1} = |a1 - a2| \tag{1}$$

$$\text{Yaw2} = |b1| \tag{2}$$

$$0^0 < \Theta < 22.5^0 \tag{3}$$

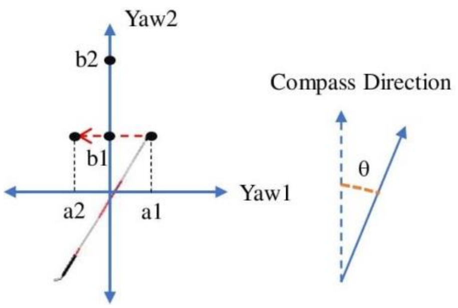

Figure 3 Still Position

Figure 4 shows the position of the blind person moving around once. The movement of the stick aid from left to right or vice versa exceeds the maximum displacement angle of the shoulders. Data that changes yaw1 (a) and compass (ϴ).

$$\text{Yaw1} = |a1 - a2| \tag{4}$$

$$\text{Yaw2} = |b1| \tag{5}$$

$$\Theta > 22.5^0 \tag{6}$$

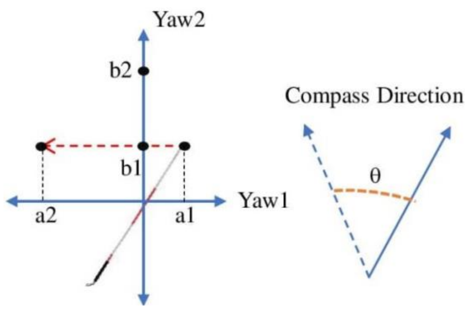

Figure 4 Rotating Position at Once

Figure 5 shows the position of blind persons moving in a circle per step. The movement of the stick aid from left to right or vice versa exceeds the maximum displacement angle of the shoulders and is performed repeatedly. Data that changes yaw1 (a) and compass (Ө).

$$\mathrm{Yaw1} = |a1 - a2| \text{ and } \mathrm{Yaw1} = |a2 - an| \quad (7)$$

$$\mathrm{Yaw2} = |b1| \quad (8)$$

$$0^0 < Ө1 < 22.5^0 \text{ and } 22.5^0 < Өn < 45^0 \quad (9)$$

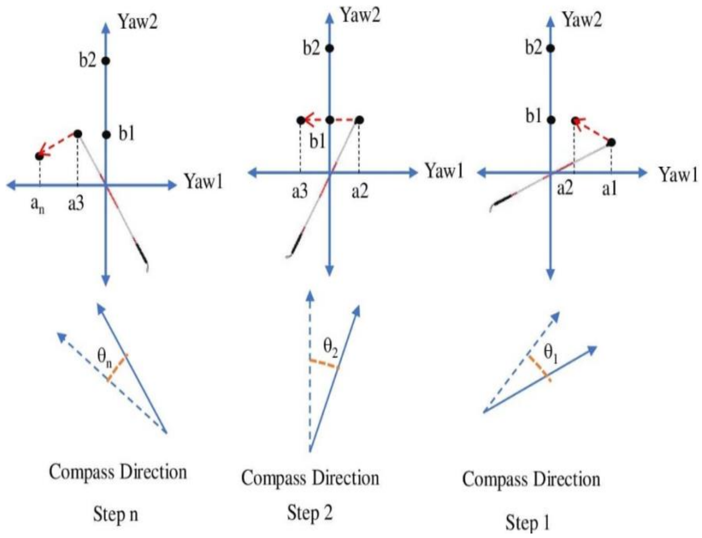

Figure 5 Rotating Position per Step

Figure 6 shows the position of blind persons stepping. The movement of the stick aid from left to right or vice versa and sideways. Data that changes yaw1 (a), yaw2 (b), and compass (Ө).

$$\mathrm{Yaw1} = |a1 - a2| \quad (10)$$

$$\mathrm{Yaw2} = |b1 - b2| \quad (11)$$

$$0^0 < Ө < 360^0 \quad (12)$$

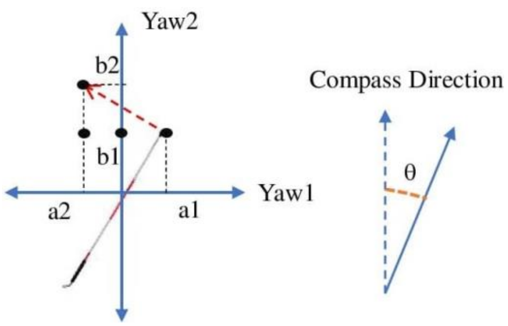

Figure 6 Stepping Position

The proposed design calculates for steps the mapping of trips to leave using a sequential concept, as shown in Figure 7. The recording results are made into two variables, step (i) and position (Ө), and stored in tabulated data.

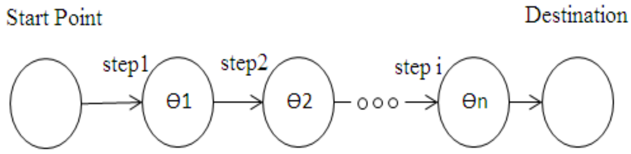

Figure 7 Nodes Network Model (Mapping of Trips to Leave)

The proposed return navigation design uses the intelligent swarm algorithm, as shown in Figure 8. The stages of the return navigation algorithm are as follows:

1. Read tabulation data of steps and positions (the mapping of trips to leave), using the FILO (first in last out) concept;
2. Perform the inverse process of position data: if Ө ≥ 180^0, then Ө - 180^0. If Ө <180^0, then Ө + 180^0;
3. Read data from accelerometer sensor reading and compass position directly;
4. Match the position data (manually with the stick aid rotated left/right) between points 2 and 3 and stop rotating until there is voice instruction information (step).

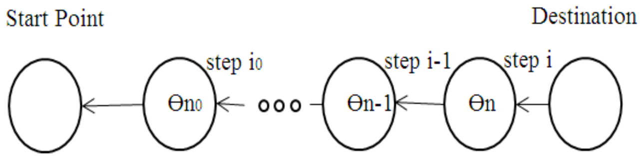

Figure 8 Nodes Network Model (Home Navigation)

3. RESULTS

The mapping of trips to leave the test and home navigation was carried out in the BRSPDSN Wyata Guna Bandung neighborhood building. The test subjects consisted of 2 people, namely blind persons with male gender, and female. Each subject was tested 5 times. Each test is carried out as many as 36 steps on the same route. The stages of the mapping of trips to go process are guided by an alert companion (researcher). And home navigation is done independently based on voice instructions from the stick aid. The test measurement results are shown in Table1 below.

Table 1 Tests Measurement Results

Testing	∑ Point ϴ	Accuracy $0^0<\Theta<10^0$	Accuracy $\Theta>10^{0}$	Shift Goal to Start Point (m)	Gender
1	36	28	8	2	Male
2	36	25	11	3.1	Male
3	36	18	18	3.6	Male
4	36	26	10	2.2	Male
5	36	22	14	3.4	Male
6	36	30	6	1.3	Female
7	36	25	11	3	Female
8	36	27	9	2.2	Female
9	36	25	11	2.3	Female
10	36	26	10	1.9	Female

Figure 9 shows the chart of the mapping of trips to leave and home navigation with the best level of accuracy and shift error (sixth test).

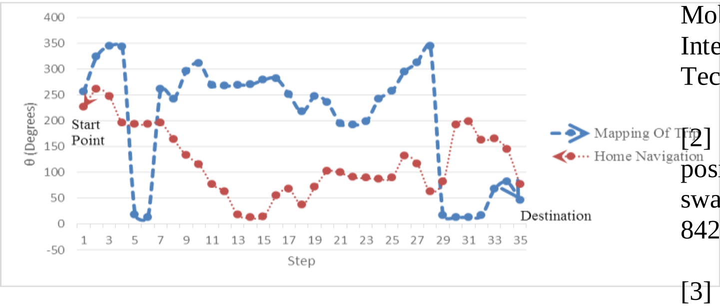

Figure 9 the Best Results (the Mapping of Trips to Leave and the Home Navigation)

4. CONCLUSION

Based on the results of testing and analysis of home navigation, the accuracy of the successful displacement of position is about 84% with a shift error back to the start point about 1m.

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