

Position Coordination Aid for Blind Persons Based on LoRa Point to Point

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ABSTRACT

Conventional or electronic sticks are one of the tools that are often used by people with blind persons for independent activities. Both tools have limitations that cannot provide a sense of comfort in the form of information on the distance position between blind persons. In this research, electronic hardware is designed and built, which is integrated with conventional sticks. Designs and aids are made to exchange positional information on the distance between blind persons for normal and emergency conditions. The two electronic hardware consists of a global position system (GPS) modules, LoRa radio, DF mini-player, liquid crystal display (LCD), button, and a microcontroller. Communication between electronic hardware uses a point to point topology with half-duplex communication. Each hardware device is planted with source ID and destination ID, so that as soon as the push-button is pressed, the microcontroller reads the coordinate point data from the GPS module. The combined coordinate data and source ID are transmitted to the destination ID via LoRa radio and will exchange coordinate data instead. Furthermore, the two coordinate data in each microcontroller hardware is converted into distance information (meters) using the Haversine algorithm. Distance information is displayed on the LCD and converted into sound output through the DF mini-player speaker. The result of system functionality testing, the average percentage error is 1.21%, and the reading of all the resulting distance data can sound. Testing the GPS module obtained the percentage of conformity of the coordinates with an accuracy of 99%. Testing the data communication system obtained the maximum distance on the LoRa module as far as 500 meters. The received signal strength value (RSSI) parameter has no effect on the distance tested, and the receiver's packet loss parameter will be very influential if it is blocked by an object (obstacle).

Keywords: *Haversine, Range Conversion, LoRa, Blind Persons, Point to Point.*

1. INTRODUCTION

Referring to data released by the Central Statistics Agency for Bekasi City in 2018, The number of blind persons (permanent disability) for the West Java region is 0.0092% of the total estimated 48,683,861 inhabitants of West Java or around 4,480 people. This percentage is the highest in Indonesia with almost doubling each year [1].

Referring to previous research, every blind person is required to have mobility orientation ability (OM). Commonly used OM techniques are the senses of touch, the help of a dog animal, or a stick (white cane). One of the commonly mastered OM techniques is the use of sticks. The use of the stick is relatively safe for the safety of the limbs, inexpensive, and can foster independence in

daily activities. The walking stick functions as a conventional navigation tool so that mobility activities are not limited. In addition, the sticks is used as an identity for the blind persons. However, the stick that is carried is only to know what is in front and must be touched by objects around it and cannot communicate [2]. The use of electronic sticks can provide navigation without being touched by objects and can guide the way home in conditions inside and outside the building. However, this electronic stick cannot provide information about the distance position of blind friends in the surrounding environment [3].

In this research, an electronic stick tool is designed and made that can communicate with each other between two devices. Blind persons can communicate with each other the distance position information (meters) in

normal or emergency conditions by pressing a button. Each hardware device is embedded with source ID and destination ID, so that at any time after pressing the button the microcontroller reads the latitude and longitude coordinate data from the GPS module. The combined coordinate data and source ID are transmitted to the destination ID and vice versa will exchange coordinate data. The distance information process is obtained from the data processing of the comparison of the latitude and longitude coordinates of the GPS module of the stick itself with the opponent's stick (sender). Using the Haversine algorithm, the two coordinate data are processed to produce distances. Meanwhile, communication between electronic sticks uses a point to point half duplex topology. The protocol built on the topology uses a LoRa radio module with a working frequency of 915 MHz. The distance information is translated in audio form so that it is easily understood by electronic stick users.

2. BACKGROUND

Many solutions were created to make mobility and navigational aids for blind persons. The first solution is to use a GPS module that is integrated with a microcontroller to process location data which is then sent to a web server with the help of a GSM modem for further plotting on Google Maps [2]. The second system, uses the accelerometer module to count steps and the compass module to determine the direction of the step position. Then it is processed in the microcontroller using the swarm intelligence algorithm to produce information on the number of steps and the position of the home navigation step [3]. The third system, uses the LoRa Shield module to send ship coordinates, date and time to the closest coordinates according to the coverage area of the coordinator [4]. Then, the next work designed a smart stick that can be used by blind persons so that they can detect obstacles, bumps, holes, stones and obstacles. Using speakers as a marker of sound in the form of sound when detecting an object [5].

There is a study that discusses the calculation of the distance between two coordinate points using the Euclidean Distance and Haversine algorithm which is packaged in the form of an application on an Android smartphone [6]. Finally, the system designed implements point-to-point communication that functions to monitor the level of fuel reserves in an intelligent fuel distribution system using the LoRa Dragino device [7].

Research testing was carried out covering two different conditions, namely at night and during the day. The test locations were carried out in four different places, namely in the Buciper Complex, Bandung State Polytechnic, Cimahi Shooting Range and Ciwaruga.

3. RESEARCH METHODS

The stages of this research consist of three stages. The hardware, software, system realization design stages and testing.

3.1. Hardware Design

Figure 1 shows the overall hardware block diagram design. The hardware block is divided into two parts, namely, block ID 1 (stick 1) and ID2 (stick 2). The two hardware blocks are interconnected with a point to point half duplex topology radio via the cloud.

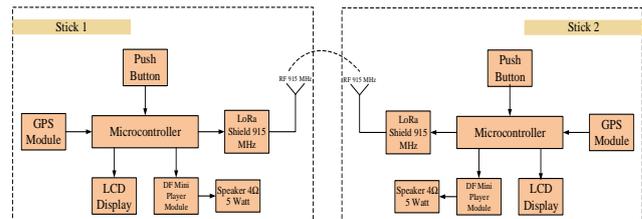


Figure 1 Hardware Block Diagram

The push button functions to request data in the form of distance between blind stick users which are packaged in audio form and also displayed on the LCD Display for testing functions. Communication is carried out for data transmission in the form of two-way or half duplex communication so that the system used can only communicate alternately and cannot be done at the same time. The IDs used on each system in the blind handicaps need to be addressed first to ID1 and ID2. When the push button on ID1 is pressed for the first time, the system will respond to the command by retrieving data from the GPS module which is taken directly from the satellite in the form of latitude and longitude coordinates to be further processed by Arduino Uno and will be sent using the LoRa Shield 915 Mhz transmitter module to the LoRa receiver. Likewise on ID2, it will process the same data as ID1. The results of the data that have been processed are converted into the form of distances that are packaged in meters using the Haversine algorithm. The distance data is converted into sound by using the DF mini-player module which is inserted a 2 GB MicroSD Card containing the recorded numbers 0 to 999 to be heard by blind people with disabilities through 4/5Watt speakers.

3.2. Software Design

Figure 2 shows a software flow diagram of the entire designed system, containing the names of functions that are interconnected in a coherent way from top to bottom.

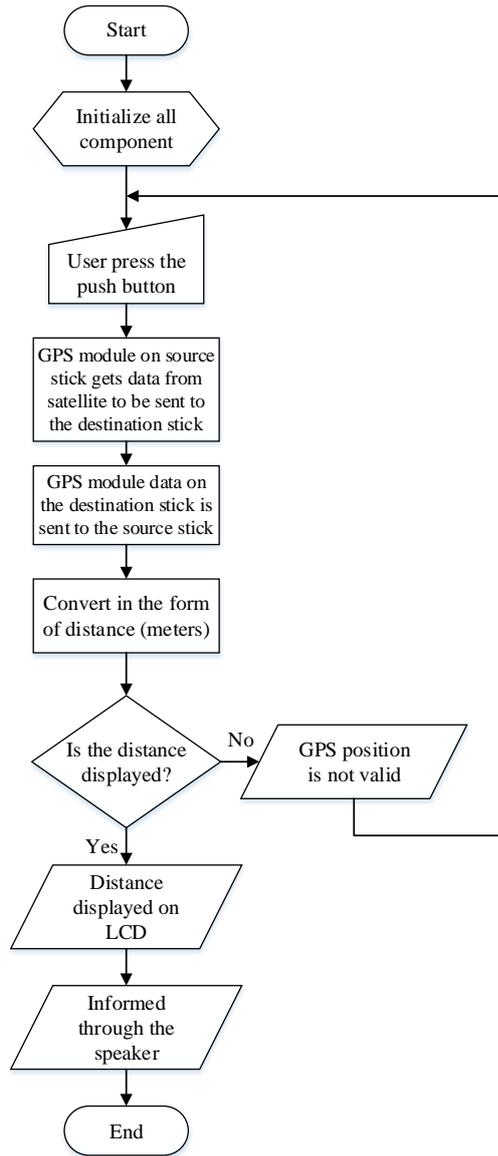


Figure 2 Overall Flowchart

The explanation of the flow chart algorithm in Figure 2 is as follows:

1. Start by initializing all components used in the system.
2. If all components are ready, the user can press the push button to find out the data in the form of distance in meters.
3. The GPS module on stick 1 looks for coordinates in the form of latitude and longitude obtained from satellites.
4. The GPS module on stick 2 also looks for coordinates which are then sent using the LoRa module.
5. The two coordinate point data obtained are processed by the microcontroller for further conversion in the form of distance using the Haversine algorithm. The distance of the earth's surface circle based on latitude

and longitude, with the constant radius of the earth (R) is 6371.

$$X = R * \text{Cos}(\text{latitude}) * \text{Cos}(\text{longitude}) \quad (1)$$

$$Y = R * \text{Cos}(\text{latitude}) * \text{Sin}(\text{longitude}) \quad (2)$$

$$Z = R * \text{Sin}(\text{latitude}) \quad (3)$$

Because it uses two coordinate points to get the distance between the two points, the results are X_a, X_b, Y_a, Y_b, Z_a and Z_b . Furthermore, the six results are calculated using the following formula:

$$|X_a - X_b| = m \quad (4)$$

$$|Y_a - Y_b| = n \quad (5)$$

$$|Z_a - Z_b| = o \quad (6)$$

The final calculation to get the distance between the two coordinate points is:

$$\text{JARAK} = \sqrt{m^2 + n^2 + o^2} \quad (7)$$

6. The converted data is displayed on the LCD and informed in the form of sound to the speaker.
7. If the data is not displayed, then the GPS has not got the coordinates. So, the user presses the push button again to carry out the same process algorithm as points 1 to 6.

3.3. System Realization

The realization of the electronic wand assistive device is shown in Figure 3. The assistive device is built by integrating the WHO standard wand and the designed electronic hardware.

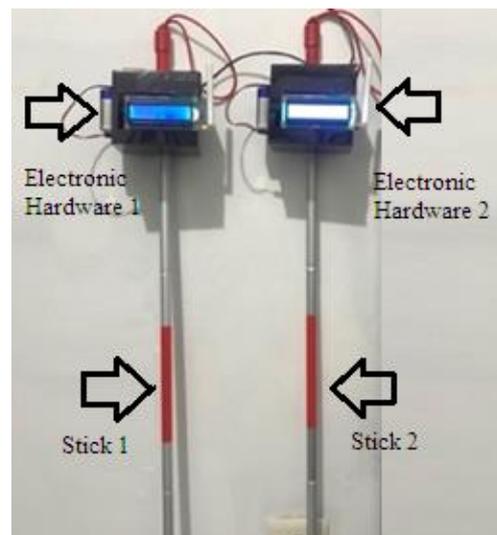


Figure 3 System Realization

Table 1 shows the specifications of the electronic hardware used.

Table 1. Electronic Hardware Specification

No.	Item	Specification/Type
1	Microcontroller	Arduino nano V.3
2	GPS	Ublock Neo-6Mv2
3	LoRa	Shield 915 MHz
4	DF mini-Player	UART
5	Speaker	4Ω/5W
6	LCD	16x2, I2C
7	Button	Normally Open
8	Batterie	9V, 300mA

3.4. Testing and Result

This tool has been tested by involving people with visual impairments at BRSPDSN Wyata Guna Bandung for testing.

Figure 4, and Figure 5 show the test results of the entire system at night and during the day.

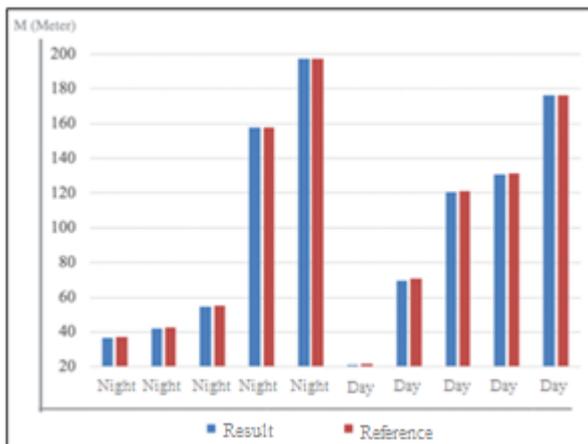


Figure 4 Graph of Distance Testing at Night and Day

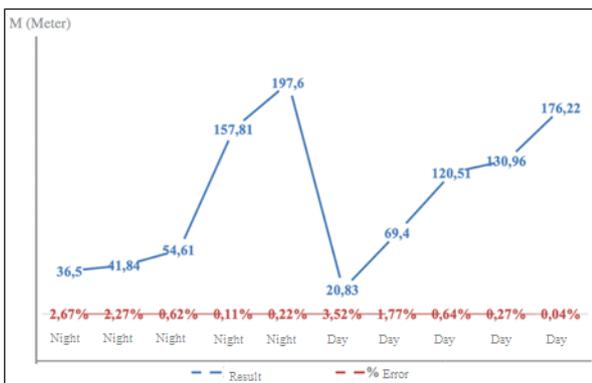


Figure 5 Graph of Distance Accuracy Calculation Testing at Night and Day

Figure 4 and figure 5 show a distance comparison using the Geocalc application.. The results of testing the entire system, the functionality of the tool from start to finish. The two coordinate point data obtained from the GPS module are processed into the form of distance on the microcontroller and compared with the distance results obtained from the Geocalc application. The resulting distance is set such that it returns only two digits after the comma. In the distance test conducted at night and during the day, the error percentage was 1.213491%. This happens because the GPS module gets coordinates in the form of latitude and longitude points that change almost every second. Thus, the calculation of the distance conversion will have an effect. The total value of the difference obtained is below the value of 2 and the percentage of errors obtained is below 3%.

Figure 6, and Figure 7 show the data from the calculation of the accuracy of the latitude point.

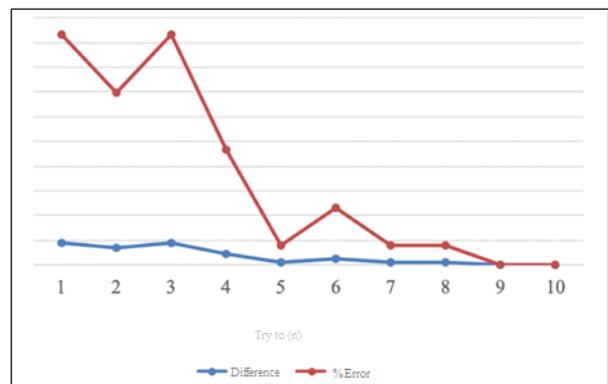


Figure 6 Latitude Point Accuracy Calculation Graph

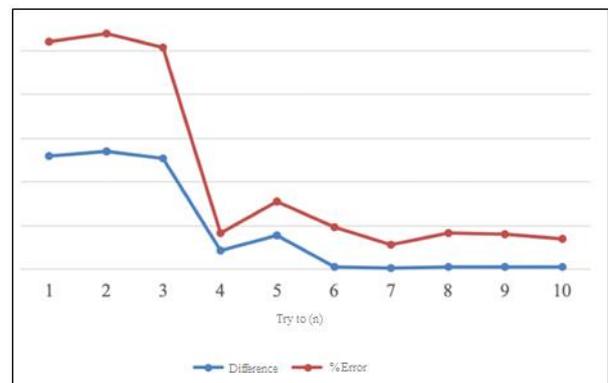


Figure 7 Longitude Point Accuracy Calculation Graph

Figure 6 show, latitude point accuracy calculation. The results of testing the coordinates using the GPS module. The test was carried out in two different conditions, namely indoors and outdoors. The test was carried out for 2 minutes by looking at the difference in the coordinates of the resulting latitude and longitude points and compared with the reference data generated by the Google Maps application. The difference in the results of the coordinates in the indoor test can be seen from the change in the last 3 digits. The longer the GPS

module testing, the closer the coordinates to the reference data. Seen in the 2nd minute, the difference in the latitude point is only the last 2 digits of the last digit and the longitude only differs by the last 1 digit of the number. This happens because the more frequent the measurements are repeated, the more accurate the positioning will be. The percentage of errors in the room is less than 0.003%. In outdoor testing, the resulting coordinates are closer to the reference data, which only differs from the last 2 digits of the number. Where at minute 2 differs only 1 digit last digit in latitude data and longitude data. With an outdoor error percentage below 0.001%. This happens because the satellite will directly send data to the GPS module if the test is carried out outdoors. It is different if the test is carried out indoors, data transmission is blocked and hampered by buildings so that the coordinates sent are further away from the reference data.

Figure 7 show, longitude point accuracy calculation. The percentage of latitude data error generated is 0.01259% with a latitude point accuracy of 99.98741% smaller than the average longitude data error percentage which is 0.000315% with a longitude point accuracy of 99.999685%. This happens because during the measurement process there are several types of errors or errors during measurement, for example systematic errors originating from the tool or errors due to the number of transmitting satellites that have changed.

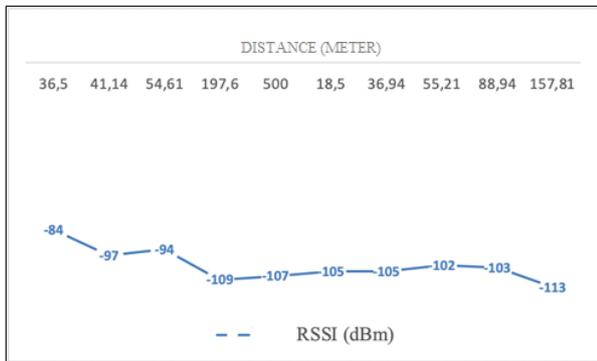


Figure 8 Graph of Data Communication Testing on RSSI . Value

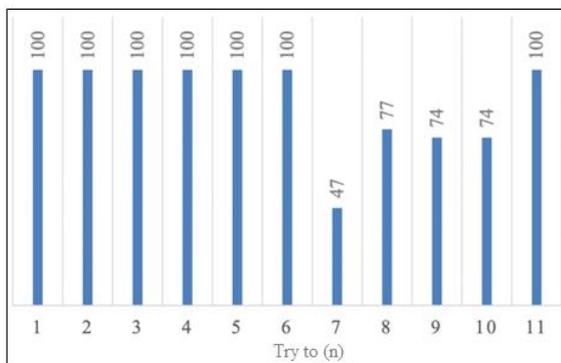


Figure 9 Graph of Data Communication Testing on Packet Loss

Figure 8, and Figure 9 show the data from the data communication test results.

The data communication system between stick 1 and stick 2 uses each 915 MHz LoRa Shield module with a 2dB omni-directional antenna. The test results are in the form of RSSI values, aiming to see the amount of data that is packet loss on the receiving system. The test was carried out as many as 10 experiments by testing on two different conditions, namely on straight and unobstructed road conditions or Line of Sight (LOS) and conditions blocked by objects (obstacles). Obstacle objects in the form of houses, cars and large trees that hinder the spread of the signal. Figure 8 show, the test results show the strongest RSSI value at a distance of 0 meters with a value of -84 dBm. Meanwhile, the weakest RSSI value is at a distance of 157.81 with an object blocked condition, which is -113 dBm. The resulting RSSI value varies, independent of the maximum and minimum distances generated by the LoRa module. However, it can be seen in the obstacle condition that the RSSI value produced is smaller than the LOS condition, the resulting value is above -100 dBm. This happens because the signal spread is blocked which causes the received signal to become weaker.

Figure 9 show, test results with packet loss parameters, is to see the number of packets that are not received at the receiving end. Testing on the LOS state, the time span used is 5 minutes. The test was carried out in an open room and no packets were lost during the test. Thus, the percentage of the amount of data received is 100%. In contrast to the LoRa module testing when an object is blocked, the test is only carried out for 3 minutes (except for test number 11 for a distance of 157.81 Meters). During the test, one LoRa module was stored in the house and the other LoRa module was stored in an open room with different distances. It can be seen that during the test there were packets that were lost for more than 1 minute, besides that there were also some missing data or damaged data. With the obtained percentage of the number of packets received by 88.36363%.

4. CONCLUSION

Based on the results of testing and analysis, the average percentage error is 1.21% and the reading of all the resulting distance data can sound. Testing the GPS module obtained the percentage of conformity of the coordinates with a accuracy of 99%. Testing the data communication system obtained the maximum distance on the LoRa module as far as 500 meters. The received signal strength value (RSSI) parameter has no effect on the distance tested and the receiver's packet loss parameter will be very influential if it is blocked by an object (obstacle). Ergonomically this device needs to be made lighter and more resistant to rain conditions.

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