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Calibration of Geomagnetic and Soil Temperatur Sensor for Earthquake Early Warning System

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Abstract

The study of Design of Earthquake Early Warning System for Real Time Using Geomagnetism and Total Electron Content with Fuzzy Logic through competitive grants scheme has obtained the prototype of the earthquake early warning system. However, it still needs improvements on in the calibration of thesensor system especially for MAG3110 sensor and DHT11 sensor. This calibration was done by adjusting the sensor system to the existing measuring devices standards in the Physics Department laboratory of the Sains Faculty Lampung University, to obtain measurement accuracyand to get a good result about where and when the earthquake would occurand how strong the earthquake would be. The calibration of MAG3110 sensor and DHT11 sensor obtained the standard correction results, the standard deviation of MAG3110 from 3 axes, namely x axis was 8.5, y axis was 2.66, and z axis was 1.9, whereas the standard deviation for DH11 sensor was 0.1161.

Keywords: *calibration, earthquake, geomagnetism, total electron content, fuzzy logic*

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1. Introduction

Earthquakes are a natural phenomenon of the earth that potentialy destroys tall buildings [1-4]. The study of Design of Earthquake Early Warning System for Real Time Using Geomagnetism and Total Electron Content with Fuzzy Logic through competitive grants scheme has obtained the prototypeof the earthquake early warning system [5] andit still needs calibration for geomagneticuse of MAG3110 sensor and for soil temperature use of DHT11 sensor. The study of soil temperature sensor can use LM35 sensor and SHT11 sensor to measure the temperature and the Relative Humidity (RH) [6-7]. Calibrating is checking and adjusting the accuracy of the output of the measuring instrument or sensor by comparing it with the standard/benchmark [8].

After the calibration it will obtain the characterization of the sensor. Another study of calibration on sensor obtained the characterization of the sensor to know the characteristics of carbon-polymer composite sensors tested with 9 types of gases, ie; Acetone, Nitrile Acetone, Benzene, Ethanol, Methanol, Ethyl Acetone, Chloroform, n-Hexan and Toluene. The testing is grouped into 4 clusters; selectivity, sensitivity, influence of temperature and humidity [9]. There are several methods that can be used to perform the calibration, as an example is camera calibration using orthogonal lines [10] and when it is difficult to make clock of the simulator synchronized in the real time calibration wideband simulator, it can use deviation value on the calibration as the sampling deviation [11]. In another study, to get the data from Very Low Frequency (VLF) receiver is a high sensitivity receiver that is builtbased on AD744 Op-Amp [12]. In parameter calibration can provide references for flexible straw modeling and parameters calibration of other crops, for terms of those three calibrated parameters exhibited 4.20% difference with the measured one [13].

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2. Research Method

The steps taken in this study are as follows:

a. Designing and constructing calibration models on magnetic fluxgate sensors, ground temperature sensors with Secondary Reference Standard method.
b. Implementing the mathematical form for calibration process.

Working procedures in this research are as follows:

a. Preparing the Sheet of Calibration Result Report (CRL)
b. Recording number of calibration orders, equipment specifications, environmental temperature conditions and information specified on the worksheet
c. Conducting initial check of sensor connection and sensor position.
d. Turning on standard indicators and sensor indicators to be calibrated.
e. Collecting data is then recorded in CRL as many as ten cycles with inteval ten minutes
f. Repeating steps for five different points until all the data is complete.
g. Turning off all equipment when it's done

3. Results and Analysis

3.1 Magnet Sensor MAG3110 Calibration Data (3 dimensions x, y, z)

The calibration data were conducted using MAG3110 in 5 cm depth. Tables 1-5 shows the result of the calibration process.

No. Order	:	0	Location	:	Lab. FisDas
Device	:	MAG3110	Environment condition	:	Fluxmagnet (µT)
Brand	:	Extrinsic	Depth of measurement	:	5 cm
Resolution	:	0.10 T			
Range	:	Full Scale Range 1000 T			

Table 1. Depth 5 cm Area 2

Std (µT)			MAG3110 (µT)			Correction (µT)		
X	y	z	x	y	z	x	y	z
1292	-455	365	1293	-451	362	1	1	2
1292	-454	365	1283	-456	365	10	2	0
1293	-454	365	1273	-457	365	20	3	0
1293	-454	365	1284	-456	367	9	2	-2
1293	-454	365	1291	-457	367	2	3	-2
1293	-454	365	1290	-457	368	3	3	-3
1293	-452	365	1290	-457	362	3	3	3
1293	-454	365	1290	-457	364	5	3	1
1293	-454	365	1287	-457	364	6	3	3
1293	-454	365	1286	-457	364	7	3	2

Table 2. Depth 5 cm Area 2

Std (µT)			MAG3110 (µT)			Correction (µT)		
x	y	z	x	y	z	x	y	z
1292	-455	365	1293	-451	362	1	1	2
1293	-454	365	1283	-456	365	10	2	0
1293	-454	365	1273	-457	365	20	3	0
1293	-454	365	1284	-456	367	9	2	-2
1293	-454	365	1291	-457	367	2	3	-2
1293	-454	365	1290	-457	368	3	3	-3
1293	-452	365	1290	-457	362	3	3	3
1293	-454	365	1290	-457	364	5	3	1
1293	-454	365	1287	-457	364	6	3	1
1293	-454	365	1286	-457	364	7	3	1

Table 3. Depth 5 cm Area 3

Std (µT)			MAG3110 (µT)			Correction (µT)		
x	y	z	x	y	z	x	y	z
1292	-455	365	1293	-455	362	1	0	2
1293	-454	365	1283	-456	365	10	2	0
1293	-454	365	1273	-457	365	20	3	0
1293	-454	365	1284	-456	367	9	2	-2
1293	-454	365	1291	-457	367	2	3	-2
1293	-454	365	1290	-457	368	3	3	-3
1293	-452	365	1290	-457	362	3	3	3
1293	-454	365	1290	-457	364	5	3	1
1293	-454	365	1287	-457	364	6	3	1
1293	-454	365	1286	-457	364	7	3	1

Table 4. Depth 5 cm Area 4

Std (µT)			MAG3110 (µT)			Correction (µT)		
x	y	z	x	y	z	x	y	z
1292	-454	365	1293	-454	362	0	0	3
1293	-454	365	1283	-456	365	10	2	0
1293	-454	365	1273	-457	365	20	3	0
1293	-454	365	1284	-456	367	9	2	-2
1293	-454	365	1291	-457	367	2	3	-2
1293	-454	365	1290	-457	368	3	3	-3
1293	-452	365	1290	-457	362	3	3	3
1293	-454	365	1290	-457	364	5	3	1
1293	-454	365	1287	-457	364	6	3	1
1293	-454	365	1286	-457	364	7	3	1

Table 5. Depth 5 cm Area 5

Std (µT)			MAG3110 (µT)			Correction (µT)		
x	y	z	x	y	z	x	y	z
1293	-454	365	1293	-454	362	0	0	3
1293	-454	365	1283	-456	365	10	2	0
1293	-454	365	1273	-457	365	20	3	0
1293	-454	365	1284	-456	367	9	2	-2
1293	-454	365	1291	-457	367	2	3	-2
1293	-454	365	1290	-457	368	3	3	-3
1293	-454	365	1290	-457	362	3	3	3
1293	-454	365	1290	-457	364	3	3	1
1293	-454	365	1287	-457	364	6	3	1
1293	-454	365	1286	-457	364	7	3	1

From the Tables 1-5 data, the average correction of the x coordinates of the reading of the device taken from the sensor is:

$$\overline{D}x = \frac{0+10+20+9+2+3+3+3+6+7}{10}$$
$$\overline{Dx} = 6{,}3$$

The standard deviation for the x coordinate of the device can be calculated in the following way

$$\sigma = \sqrt{\frac{\sum(\overline{Dx}1 - \overline{Dx})^2}{n}}$$
$$\sigma = \sqrt{\frac{(0-6{,}3)^2 + (10-6{,}3)^2 + \cdots}{10}}$$
$$\sigma = 8{,}5$$

Then:
Average correction : 6.3
Standard Deviation of the correction : 8.5
Minimum tool correction : 0
From the Tables 1-5 data, the average correction of the y coordinates of the reading of the device taken from the sensor is

$$\overline{D}y = \frac{0+2+3+2+3+3+3+3+3+3}{10}$$
$$\overline{Dy} = 2{,}5$$

The standard deviation for the y coordinate of the device can be calculated in the following way

$$\sigma = \sqrt{\frac{\sum(\overline{Dy}1 - \overline{Dy})^2}{n}}$$
$$\sigma = \sqrt{\frac{(0-2{,}5)^2 + (2-2{,}5)^2 + \cdots}{10}}$$
$$\sigma = 2{,}66$$

Then:
Average correction : 2,5
Standard Deviation of the correction : 2,66
Minimum tool correction : 0
From the Tables 1-5 data, the average correction of the z coordinates of the reading of the device taken from the sensor is

$$\overline{D}z = \frac{3+0+0-2-2-3+3+1+1+1}{10}$$
$$\overline{Dz} = 0{,}2$$

The standard deviation for the z coordinate of the device can be calculated in the following way

$$\sigma = \sqrt{\frac{\sum(\overline{Dz}1 - \overline{Dz})^2}{n}}$$
$$\sigma = \sqrt{\frac{(3-0{,}2)^2 + (0-0{,}2)^2 + \cdots}{10}}$$
$$\sigma = 1{,}9$$

Then:
Average correction : 0,2
Standard Deviation of the correction : 1,9
Minimum tool correction : -3

3.2 Calibration Data of DHT11 Sensor

The calibration data were conducted using DHT11 in 5 cm depth. Tables 6-10 shows the result of the calibration process.

No. Order	: 1	Location	:	Lab. FisDas
Device	: DHT11	Environment condition	:	Temp (°C)
Brand	: DFRobotDHT11	Depth of measurement	:	5 cm
Resolution	: 1 °C			
Range	: 0 - 50 °C			

Table 6. Depth 5 cm Area 1

Std(°C)	DHT11(°C)	Correction(°C)
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02
24,98	25	-0,02

Table 7. Depth 5 cm Area 2

Std(°C)	DHT11(°C)	Correction(°C)
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89
25,11	26	-0,89

Table 8. Depth 5 cm Area 3

Std(°C)	DHT11(°C)	Correction(°C)
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75
25,25	26	-0,75

Table 9. Depth 5 cm Area 4

Std(°C)	DHT11(°C)	Correction(°C)
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35
25,65	27	-1,35

Table 10. Depth 5 cm Area 5

Std(ºC)	DHT11(ºC)	Correction(ºC)
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03
23,97	24	-0,03

From the Tables 6-10 data, the average correction of the instrument reading taken from the maximum temperature is:

$$\overline{D} = \frac{-1{,}35 - 1{,}35 - 1{,}35 - 1{,}35 - 1{,}35 - 1{,}35 - 1{,}35 - 1{,}35 - 1{,}35 - 1{,}35}{10}$$

$$\overline{D} = -1{,}485$$

The standard deviation of the device can be calculated in following way

$$\sigma = \sqrt{\frac{\sum(\overline{D}1 - \overline{D})^2}{n}}$$

$$\sigma = \sqrt{\frac{(-1{,}35 + 1{,}485)^2 + (-1{,}35 + 1{,}485)^2 + \cdots}{10}}$$

$$\sigma = 0{,}1161$$

Then:

Average correction	: -1,485
Standard Deviation of the correction	: 0,1161
Minimum tool correction	: -0,02

4. Conclusion

The calibration of MAG3110 sensor and DHT11 sensor obtain the standard correction results, the standard deviation of MAG3110 from 3 axes, namely x axis is 8.5 then y axis is 2.66 then z axis is 1.9, whereas the standard deviation for DH11 sensor is 0.1161. The calibration data is expected to improve the earthquake early warning system.

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