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Baby Weight and Length Measurement System with Data Storage Using MySQL Database

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ABSTRACT

Baby weight and length measurement system has been designed based on ultrasonic and load cell sensors with data storage using MySQL database and website interface. This research aims to produce a baby weight and length measurement system with microcontroller NodeMCU ESP32. The system is designed with an ultrasonic sensor HC-SR04 and four half-bridge load cells of 50 kg. The ultrasonic sensor works on the piezoelectric and inverse piezoelectric principles, while load cell sensors work on strain gauge principles. An ultrasonic sensor measures body length, while a load cell sensor measures body weight. According to the Ministry of Health of the Republic of Indonesia's regulations, this system also has an LCD 20×4 to display measurement and nutritional status assessment results. The experiment used four doll objects with different lengths and weights. This research shows that the ultrasonic sensor HC-SR04 used in this research has an average error of 0.494% in length measurement. The load cell sensor and HX711 ADC used in this research has an average error of 0.949% in weight measurement. The designed system automatically assesses the nutritional status and stores the measurement result and nutritional status in the database to be displayed on the website.

Keywords: Anthropometric, HC-SR04 sensor, load cell, NodeMCU ESP32, website

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INTRODUCTION

Having a healthy child is every parent's dream. Parents can maintain the child's growth from birth until the age of five years old in an optimal range. Children who experience growth and development not in

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line with their age may face various consequences, such as hindering brain development, increased susceptibility to illnesses and weakened immune systems, excessive anxiety or fear, inability to control emotions, and cognitive disorders (Merita, 2019). Their weight and length must be maintained within their anthropometric standard range to determine if a child is growing optimally. Generally, anthropometry assesses the human body's size, proportion, and composition (Sari et al., 2017). Child anthropometrics is a collection of data on body size, proportion, and composition to assess infants' nutritional status and growth trends (Kementrian Kesehatan Republik Indonesia, 2020). The baby's growth is usually observed as a body length and weight change.

Body length measurement can be done by measuring from the feet to the baby's head using a ruler, while body weight can be measured using a weight scale. The result of this measurement is then compared with the values in the child anthropometric standard table to see if the child is overweight or underweight (Wahyudi et al., 2021). This process is carried out manually by health workers in public health centres. This process is considered less effective because the result must be compared with table data and graphs from standard anthropometrics, which takes up much time and is prone to mistakes when comparing or human error while conducting the measurement.

Several studies have built measurements of body weight and length systems. Fajri and Wildian (2014) have made a height and weight measurement instrument based on microcontroller ATmega 8535 and used a phototransistor to measure the weight and body length. The built system is only for measurement without storing the measurement result. Akbar and Rachmat (2018) also built a measurement system using an ultrasonic transducer for body length measurement and a strain gauge for body weight measurement, and they displayed the result in LCD. The system sends and stores the result to a personal computer using PLX-DAQ software with a USB cable. The nutritional status assessment system based on Arduino Nano was built by Ardianto et al. (2022). This system measures body weight with a load cell sensor and body length with an ultrasonic sensor. Arduino processes the measurement result and sends it to a smartphone wirelessly using Bluetooth.

Based on the above problem, the body weight and length measurement system was developed using microcontroller NodeMCU ESP32. An ultrasonic HC-SR04 sensor was selected to measure the body length, and a load cell sensor was chosen to measure the body weight. The developed system can store measurement results in the MySQL database and display the data on the website. The website is intended to see changes in body weight and length between the measurements. The data stored in MySQL is transferred using a WiFi connection without any additional device. The system can also display the measured height, weight, and nutritional status on an LCD.

METHODS

Tools and Materials

A sensor is a device that converts a physical quantity into a signal that an electronic device can read. Sensors are used in various applications, such as industrial automation, medical diagnostics, and home automation (Wilson, 2005).

The measurement system uses an HC-SR04 ultrasonic sensor for length measurement sensor and a load cell sensor as a weight measurement sensor. The HC-SR04 sensor consists of two ultrasonic transducers, a transmitter, and a receiver. The transmitter side works with inverse piezoelectric effect to create and transmit an ultrasonic sound, while the receiver side works with direct piezoelectric effect to perceive the echo. The immediate piezoelectric effect is when mechanical stress is applied to a piezoelectric material, causing it to generate an electric charge. The inverse piezoelectric effect is when an electric current is applied to a piezoelectric material, causing it to deform (Casini, 2016).

The transmitter creates and emits ultrasonic sound at 40 kHz to the object. These waves travel to the object and are reflected to the receiver. The time it takes for the ultrasonic waves to travel to the objects and back is measured by the sensor and sent to a microcontroller to calculate the distance (Zhmud et al., 2018). Ultrasonic sensors are chosen due to their high object detection capability for the wood material used for the system (Adarsh et al., 2016).

A load cell sensor is a device that measures force and converts it into an electrical signal. It uses strain gauges, small devices that change their resistance when deformed. The strain gauges are arranged in a Wheatstone bridge configuration, a type of electrical circuit that is very sensitive to changes in resistance. When a force is applied to the load cell, it causes the strain gauges to deform, which changes their resistance. This change in resistance is changing the voltage difference in the Wheatstone bridge to be measured (Ajibola et al., 2018).

The voltage difference in the Wheatstone bridge usually has a very small value (in μV). An analog-digital converter (ADC) with a high resolution is required to measure the tiny voltage difference (Marcelino et al., 2018). ADC is an electronic circuit used to convert analogue signals to digital signals. It converts continuous voltage signals into discrete signal form, allowing them to be processed by a microcontroller (Fraden, 2016).

LCD or Liquid Crystal Display is a type of display media that utilizes liquid crystals to generate the desired output (Kho, 2018). LCDs do not produce light on their own. Instead, they use a backlight or reflector to provide light. The light is then passed through the liquid crystals, which control how much light can pass through. It allows the LCD to create images by controlling the light that is allowed to pass through the crystals (Gabriel, 2020). The system used LCD to display measurement results and nutritional status results. A personal computer (PC) stores the data in the MySQL database and displays the data on the website. The weight scale is used to compare the load cell reading, and the ruler is used to compare the ultrasonic reading.

Hardware Design

The system block diagram can be seen in Figure 1. The body weight was measured with a load cell sensor, and the body length was measured with an ultrasonic sensor HC-SR04. The output from the load cell sensor is then sent to the HX711 ADC to be changed from an analogue signal to a digital signal before being sent to NodeMCU ESP32. The ultrasonic HC-SR04 output is sent directly to NodeMCU ESP32 to be processed. The system's electronic circuit can be seen in Figure 2, and the system's overall design can be seen in Figure 3.

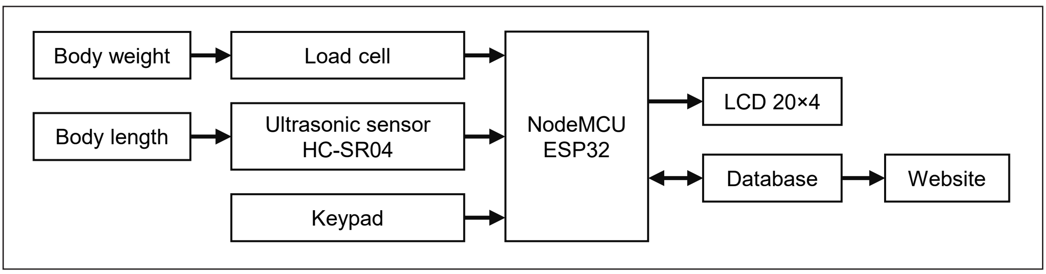


Figure 1. Block diagram of baby weight and length measurement system with data storage using MySQL database

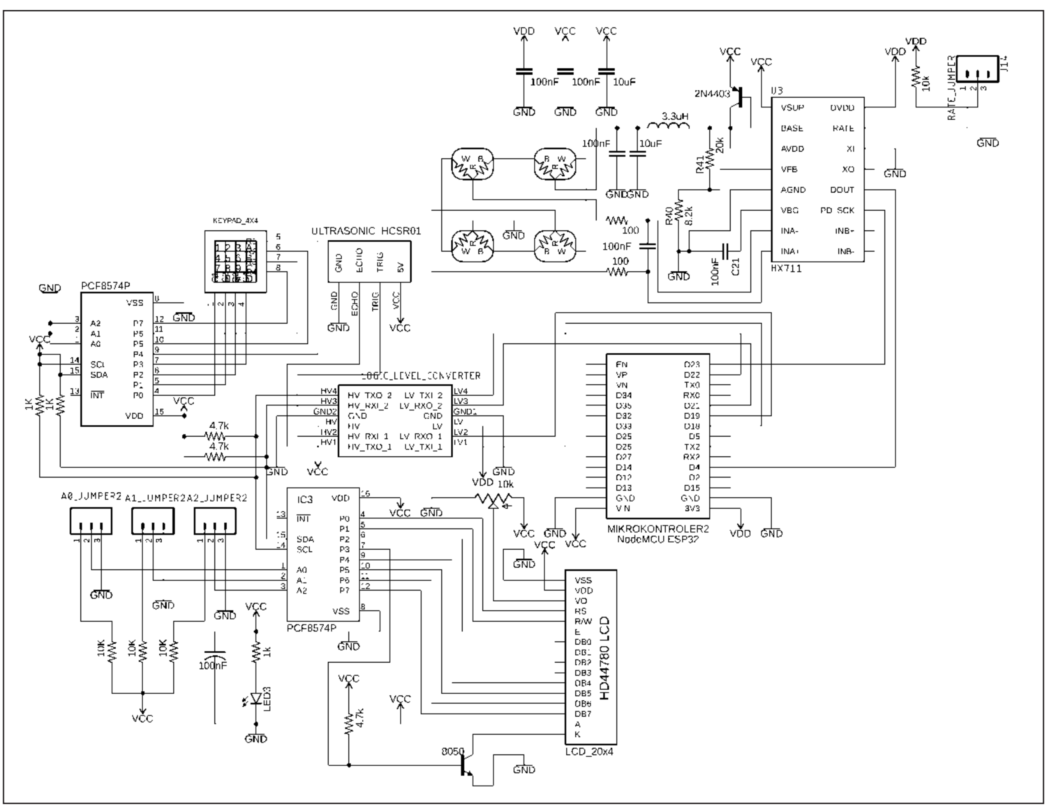


Figure 2. The circuit schematic of baby weight and length measurement system

All data that NodeMCU ESP32 has processed is sent to the database server using a WiFi connection to be displayed on the website and to assess nutritional status. Weight measurement, length measurement, and nutritional status assessment results are also displayed on a 20×4 LCD. The website also shows the measurement record based on ID to track the body weight and length changes in graphs and tables.

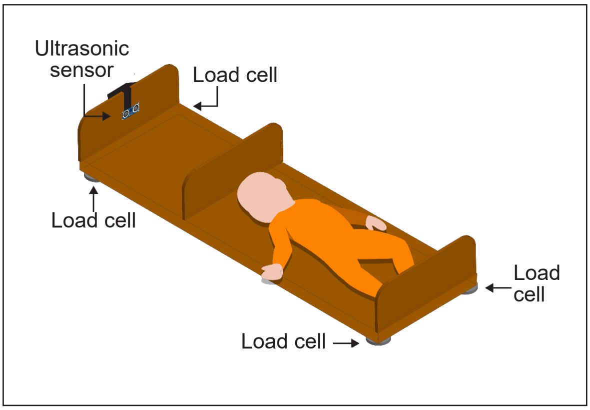


Figure 3. The hardware design of the baby weight and length measurement system

Characterization of HC-SR04 and Load Cell Sensor

Sensor characterization is used to determine the sensitivity of a sensor by subjecting it to a series of tests. A ruler is used to characterize the HC-SR04 sensor, and the weight scale is used to characterize the load cell sensor. The characterization of the HC-SR04 sensor is done by giving the sensor several distances and recording the time for the ultrasonic wave to propagate from the transmitter and back to the receiver. The recorded time is then used to find the transfer function to calculate the distance.

The load cell sensor characterization is done by connecting the load cell sensor to HX711 ADC and then to the microcontroller. The characterization is done by giving the sensor various masses and recording each ADC decimal output from HX711. This value is then used to find the calibration factor to determine the measured mass.

Software Design

The software is used to control how the hardware works. Figure 4 shows the flowchart of how the software works. NodeMCU ESP32 will try to connect to the WiFi network. If NodeMCU ESP32 cannot connect to the WiFi network, the NodeMCU will open the WiFi setting page, and if the NodeMCU ESP32 connects to the WiFi network, the system will wait for ID input from the keypad. The system will read the name, gender, and age in the database based on the input ID. The system will measure the weight from the load cell sensor and length from the ultrasonic sensor until the save button is pressed. After pressing the save button, the NodeMCU ESP32 will send the measured height and weight to the database. The database will send back the nutritional assessment result, and the LCD will display the length measurement result, weight measurement result, and nutritional assessment status.

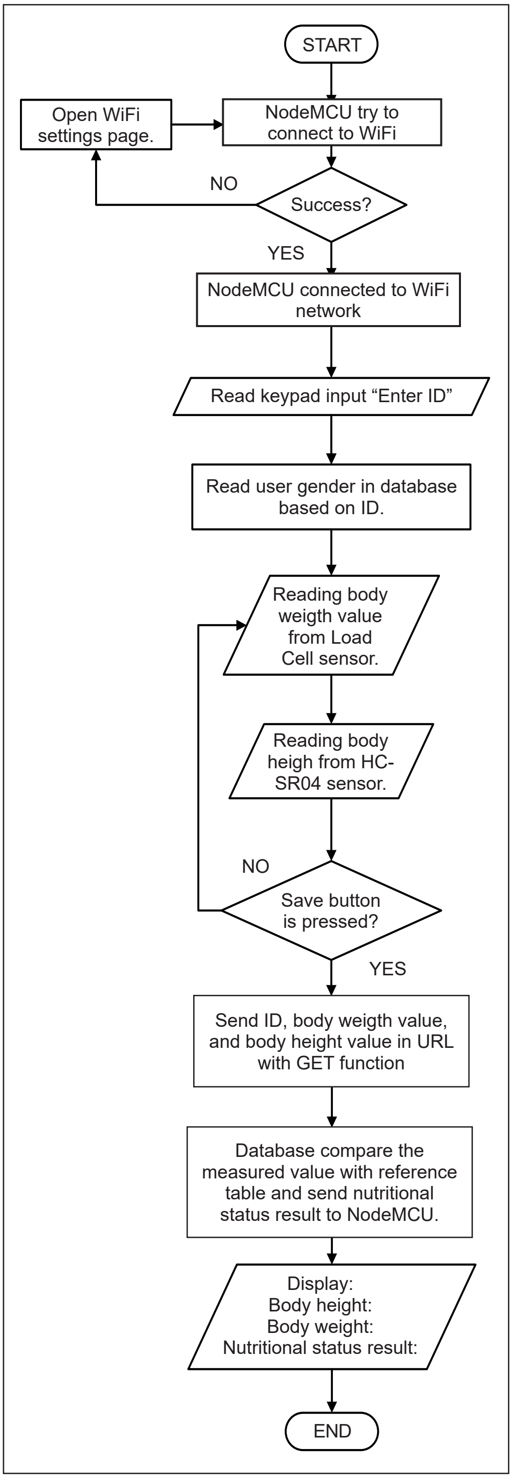


Figure 4. The software flowchart of baby weight and length measurement system

Database Design

The database in this system is built with MySQL and uses XAMPP software. The database is used to store the required data for the system. The database consists of several tables that have their own function.

Website Design

The website is used as an interface system for the user. The website displayed the data from the database to be easy to understand. The website can also change user data such as name, date of birth, and gender. The website consists of several pages that have their function. The pages are index, view, edit, and add users.

RESULT AND DISCUSSION

Characterization and Testing of the HC-SR04 Sensor as a Distance Sensor

Characterizing the HC-SR04 sensor begins with giving the sensor various distances and recording the ultrasonic sound time to propagate from transmitter to receiver. The record time is from 0 cm to 50 cm with an increase of 5 cm. The graph of change in distance with time is shown in Figure 4. According to Figure 5, the transfer function of the ultrasonic sensor is $y = -17.7x + 115.41$, and this equation is used to find the distance in the ultrasonic sensor.

Testing the HC-SR04 sensor begins by giving the sensor various distances and comparing the distance reading from the sensor with a ruler. The distance is set from 5 cm to 50 cm with an increase of 5 cm. Table 1 shows the result of the HC-SR04 sensor test with an average error of 0.494%. It indicates that the sensor used in this system can operate properly.

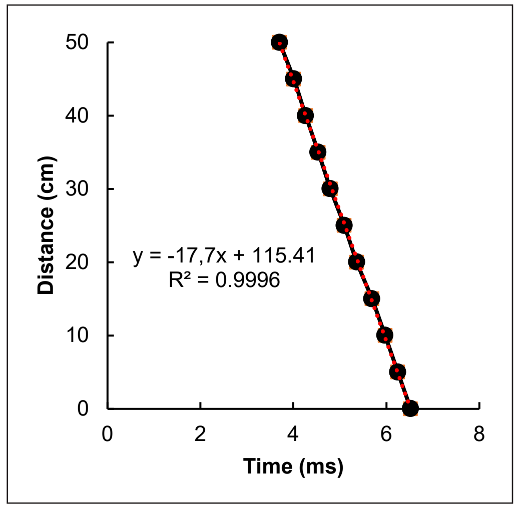


Figure 5. Graph of the distance over time

Characterization and Testing of the Load Cell Sensor with HX711 ADC as a Weight Sensor

The load cell sensor characterization begins by giving the sensor several weights and recording the decimal number from the HX711 ADC output to find the calibration factor. The calibration factor value is obtained by subtracting the decimal value when there is a mass with a decimal value when no mass is given and dividing the value by a known mass value. The characterization result of the load cell sensor with HX711 ADC is shown in Table 2. The average calibration factor is then used to calculate the body weight.

The load cell sensor testing begins by giving the sensor various weights and comparing the weight reading from the sensor with the weight scale. The weight is set from 1 kg to 20 kg with an increase of 1 kg. Table 3 shows the load cell sensor test result with an average error of 0.949%, and the sensor used in this system can operate properly.

Table 1
HC-SR04 sensor testing result

Distance (cm)							
Ruler	HC-SR04 sensor						
	Attempt No-					Average	Error (%)
	I	II	III	IV	V		
5	4.960	5.080	5.010	5.080	5.080	5.042	0.840
10	9.840	9.960	9.900	9.900	9.900	9.900	1.000
15	15.020	15.020	14.850	14.900	14.900	14.938	0.413
20	19.950	19.950	19.890	19.890	19.840	19.904	0.480
25	25.140	25.140	25.020	25.020	25.070	25.078	0.312
30	29.770	29.770	30.120	29.740	30.240	29.928	0.240
35	35.020	35.120	35.070	35.070	35.070	35.070	0.200
40	39.960	39.990	39.960	39.690	39.960	39.912	0.220
45	44.680	44.660	45.070	45.070	45.070	44.910	0.200
50	49.360	49.410	49.410	49.820	49.410	49.482	1.036
Average error (%)							0.494

Table 2
Characterization of load cell sensor

Mass (g)	Decimal output Attempt No- I	II	III	IV	V	Average	Tare value	Calibration factor
0	1122396	1112411	1112387	1112418	1112366	1114396	-	-
1000	1132303	1132354	1132477	1132502	1132542	1132436	20070	20.07
2000	1155578	1155544	1155600	1155583	1155587	1155578	43212	21.61
3000	1176700	1176719	1176714	1176711	1176718	1176712	64346	21.45
4000	1199026	1199098	1199062	1199052	1199055	1199059	86693	21.67
5000	1221840	1221748	1221693	1221660	1221695	1221727	109361	21.87
6000	1242535	1242518	1242521	1242531	1242559	1242533	130167	21.69
7000	1262268	1262239	1262199	1262204	1262225	1262227	149861	21.41
8000	1284563	1284560	1284562	1284600	1284596	1284576	172210	21.53
9000	1305386	1305505	1305604	1305700	1305747	1305588	193222	21.47
10000	1327521	1327493	1327413	1327411	1327420	1327452	215086	21.51
11000	1350261	1350293	1350238	1350256	1350219	1350253	237887	21.63
12000	1372009	1371996	1371945	1371888	1371875	1371943	259577	21.63
13000	1393600	1393604	1393515	1393458	1393447	1393525	281159	21.63
14000	1418121	1417783	1417790	1417619	1417640	1417791	305425	21.82
15000	1437050	1436997	1437027	1436984	1436968	1437005	324639	21.64
16000	1458779	1458772	1458694	1458646	1458567	1458692	346326	21.65
17000	1480731	1480753	1480707	1480671	1480609	1480694	368328	21.67
18000	1502852	1502438	1502206	1502022	1501965	1502297	389931	21.66
19000	1524726	1524718	1524614	1524466	1524386	1524582	412216	21.70
20000	1548779	1548733	1548653	1548614	1548552	1548666	436300	21.82
Average calibration factor								21.56

Table 3
Result of load cell sensor testing

Mass (kg)

Weight scale	Load cell Attempt No- I	II	III	IV	V	Average	Error (%)
1	1.02	1.02	0.98	0.95	0.92	0.98	2.200
2	2.01	2.00	2.01	2.04	2.05	2.02	1.100
3	2.97	2.97	2.97	2.98	2.99	2.98	0.800
4	3.95	4.07	4.06	4.07	4.06	4.04	1.050
5	4.86	5.11	5.11	5.12	5.13	5.07	1.320
6	6.08	6.09	6.12	6.09	6.10	6.10	1.600
7	7.09	7.11	7.12	7.14	7.13	7.12	1.686
8	8.10	8.11	8.10	8.11	8.09	8.10	1.275

Table 3 *(continue)*

Weight scale	Load cell Attempt No- I	II	III	IV	V	Average	Error (%)
9	9.16	9.18	9.15	9.14	9.13	9.15	1.689
10	10.13	10.18	10.15	10.16	9.96	10.12	1.160
11	11.14	11.14	11.14	11.15	11.14	11.14	1.291
12	12.15	11.99	12.00	12.01	12.02	12.03	0.283
13	13.03	13.05	13.06	13.05	13.10	13.06	0.446
14	14.15	14.10	14.14	14.08	14.06	14.11	0.757
15	15.13	15.11	15.11	15.11	15.09	15.11	0.733
16	15.96	15.94	15.92	15.93	15.91	15.93	0.425
17	16.96	16.97	16.96	16.95	16.94	16.96	0.259
18	17.96	17.96	17.91	17.91	17.91	17.93	0.389
19	18.94	18.93	18.94	18.91	18.91	18.93	0.389
20	20.00	20.02	20.04	20.04	20.03	20.03	0.130
Average error (%)							0.949

System Database

A database of baby weight and length measurement systems has been successfully built. This database is used to store the data for the website. The database is consisting of several table such as bb_pb_l, bb_pb_w, bb_u_l, bb_u_w, gender, length_status, pb_u_l, pb_u_w, record, user, weight_status, and weight_status_by_length.

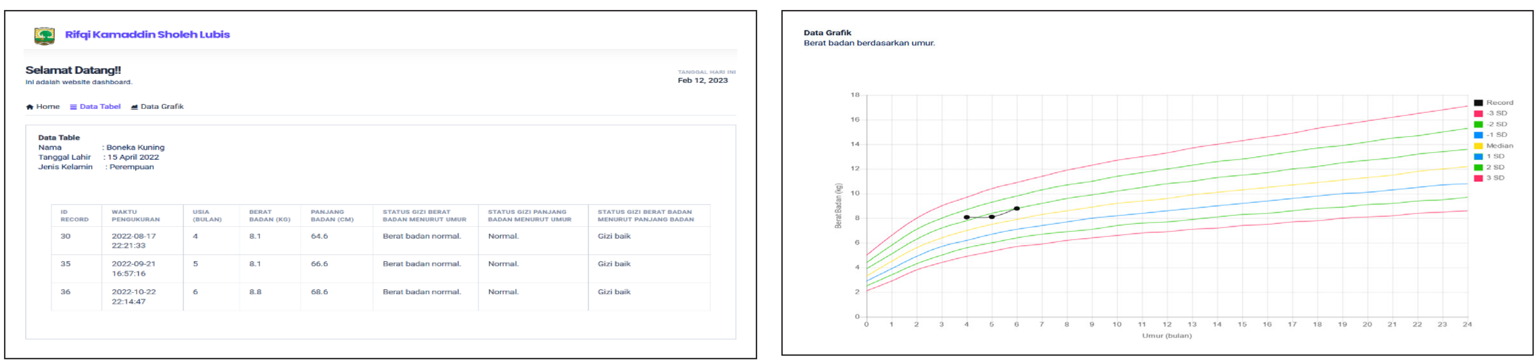
Overall Test of Baby Weight and Length Measurement System

A comprehensive test of the system is done by giving four doll subjects with different lengths and masses with their ID. The test begins with giving ID input from the keypad. The system will display the name, gender, and age in LCD based on ID. The system then measures the weight with the load cell sensor and the length with the HC-SR04 sensor. While measuring, the user can choose to save the measurement result in the database by pressing A in the keypad, do the tare on weight scales by pressing B in the keypad, or recalibrate the load cell sensor to find the new calibration factor by pressing C in the keypad. When the A button is pressed, the system will record the weight and length measurement result and send it to the database for assessment of nutritional status. The database returns the assessment result to the system, displaying the LCD's measured weight, length, and nutritional status. The overall test result of the system can be seen in Table 4.

Measurement results and nutritional status data are also successfully stored in the database and displayed on the website. The website displayed the measurement history in two forms: the table form and the graph form (Figure 6).

Table 4
Overall system test result

ID	Subject/Gender (M/F)	Age (Month)	Comparator		Designed system		Error (%)	
			Length (cm)	Weight (kg)	Length (cm)	Weight (kg)	Length (cm)	Weight (kg)
1	Yellow doll/F	4	65	8.1	64.6	8.1	0.662	0.124
		5	66	8.3	66.6	8.1	0.848	2.289
		6	68	9.0	68.6	8.8	0.897	2.333
2	Red doll/M	7	70	9.3	70.9	9.2	1.243	1.392
		8	72	9.5	72.7	9.4	1.000	1.677
		9	74	9.7	74.6	9.6	0.865	1.232
3	Blue doll/F	2	57	5.7	57.6	5.7	0.965	0.526
		3	60	7.0	60.8	6.7	1.333	3.885
		4	62	7.5	62.6	7.4	1.016	1.065
4	Rabbit doll/M	2	58	6.2	58.1	6.1	0.310	2.419
		3	62	6.5	62.6	6.4	1.016	1.538
		4	64	7.3	65.1	7.1	1.703	2.195
		Average Error					0.988	1.723



(a) (b)

Figure 6. Website view: (a) table view; and (b) graph view

CONCLUSION

This research has successfully developed a system for measuring body weight and length using MySQL database data storage. The load cell sensor can be utilized with a calibration factor value of 21.56 and has an error percentage of 0.949% in weight measurement. The HC-SR04 sensor produces an average error of 0.494% in length measurement with transfer function $y = -17.7x + 115.41$. The system also successfully sent the measurement result to the database, which can be accessed using a web browser to see measurement history and nutritional status. Thus, the system is functioning well and suitable for use.

The system can store measurement results and classify nutritional status, which is impossible with the system designed by Fajri and Wildian (2014). The system also uses a WiFi network to transfer data, which offers greater flexibility and eliminates the need for cables. In contrast, the system designed by Akbar and Rachmat (2018) still uses a cable, and the system designed by Ardianto uses Bluetooth, which can only transmit data over short distances.

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