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Design Baby Mass and Height Monitoring System Based on Arduino and Android Application

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Abstract. Baby mass and height are important parameters of their growth and development. Monitoring of these parameters still use the conventional method by writing the results of the measurement into the baby growth chartbook. In this work, we designed and develop the mass and height monitoring system using load cell sensor, ultrasonic sensor HC-SR04, Hall sensor UGN3503 and microcontroller Arduino UNO R3. The monitoring system involves two main parts including hardware of mass and height measurement tool and Android application system for displaying baby growth chart. The operation of the sensor was investigated by utilizing the various mass and length. Experimental results showed the load cell sensor possesses high accuracy of 98% and the ultrasonic sensor has accuracy of 99.32%. The Android application was developed to save the data and to provide the growth and development chart.

INTRODUCTION

Monitoring of baby mass and height are known as an important component of primary health maintenance such as the prevalence of stunting. Growth and development of baby are very crucial in the human life so it need more attention on physical parameters as well as nutritional status. The baby mass and height measurements must be carried out periodically to obtain the information of their growth and development. Linear growth is the best overall indicator of children's well-being and provides an accurate marker of inequalities in human development. This is tragically reflected in the millions of children worldwide who fail to achieve their linear growth because of suboptimal health conditions, inadequate nutrition, and care. They also suffer the severe irreversible physical and cognitive damage that accompanies stunted growth [1].

To overcome these issues, Indonesian government has a Posyandu program in society every month to monitor children's growth and development. The routine assessment for children was done by evaluating the changes of mass, height and head circumference every month. All these assessment still using a Dacin (hanging) scales and a manual height measurement instrument, then the results will be written on a baby growth chart-book (Kartu Menuju Sehat /KMS) [2]. This work was to developed high accuracy baby mass and height measurement, continued by integrating into Android application and web databases. Sensors used in this study are ultrasonic sensors and Hall effects sensors as a distance measurement, and load cells sensor for mass measurement [3]. The Android application and web databases were developing to display the health status of children, including mass, height, and health status. The other functions of this Apps are giving the information about development milestone, vaccine schedule, foods, and health info.

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METHODS

The developed system composes of an HC-SR04 ultrasonic sensor, sixteen units of UGN3503 Hall-effect sensor, load cell sensor, Arduino-UNO R3, and android smartphone. The ultrasonic sensor integrated with Hall-effect sensor was used in measurement of baby height/length. Meanwhile, the load cell sensor functions as a mass measurement. Every used sensor was characterized to determine the range of the sensors, and to identify its resolution [4]. The control system of this device uses an Arduino-UNO microcontroller. The Arduino UNO microcontroller I / O pin has the ability to read mass and high values sent by the network; then the results will be recorded and displayed on the Android smartphone screen. The block diagram of this system was depicted in the Fig. 1.

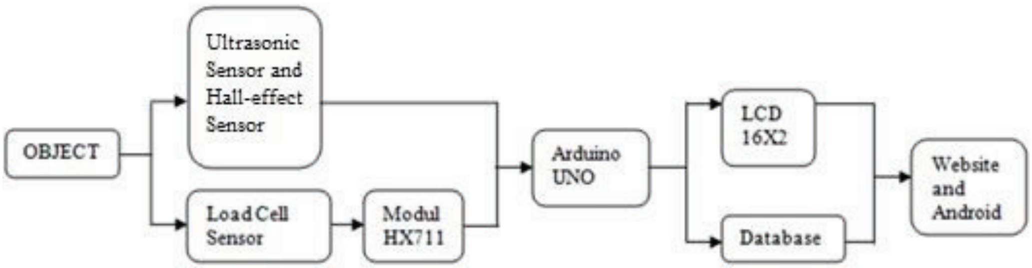


FIGURE 1. Block Diagram of the mass and height monitoring system

RESULTS AND DISCUSSION

HC-SR04 Ultrasonic Sensor Characterization

The ultrasonic HC-SR04 sensor was used for evaluation of baby height. The sensor was calibrated to obtain the minimum and maximum distance that can be detected by the sensor. The data of minimum distance measurement and maximum distance are shown in fig 2a and fig 2b, respectively. Figure 2a appears that the ultrasonic sensor capable to detect the closest distance of 3 cm, and works effectively measuring smallest change in distance of 1 cm. Whereas in Figure 2b, the farthest distance detected by the ultrasonic sensor is 100 cm.

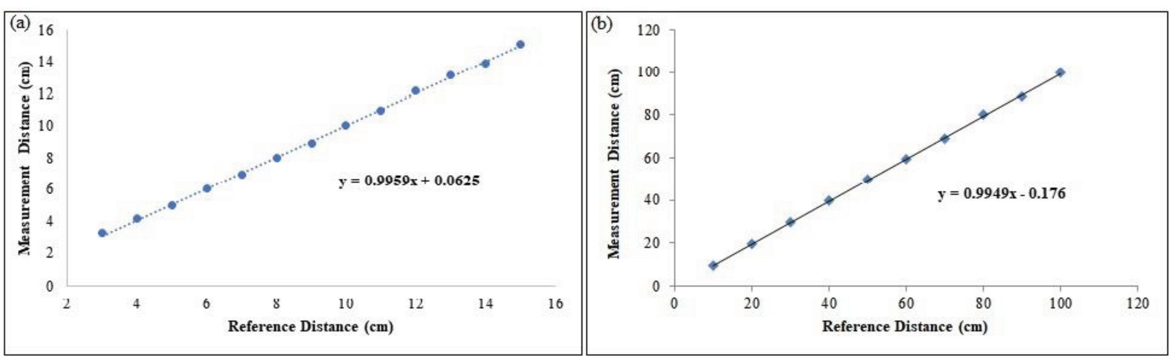


FIGURE 2. Ultrasonic sensor characterization (a) Minimum distances measurement (b) Maximum distances measurement

The relative error of the sensor is a comparison between the measurement distance (Md) and reference distance that can be calculated using equation 1 :

$$Error\ (\%) = \frac{|Md-Rd|}{Rd} x\ 100\% \quad (1)$$

According to the equation. 1, the maximum relative error of measuring the minimum distance is 6.67% occurs at a reference distance of 3 cm, and the maximum relative error of measuring the maximum distance is 2.75% occurring at a reference distance of 20 cm.

UGN3503 Hall Sensor

The usage of Hall effect sensors to detect small-order distances aims to complement the measurement limitations of ultrasonic sensors. Hall effect sensor is a magnetic sensor; thus it needs magnetic material to produce magnetic fields. By measuring the sensor output voltage to the distance of permanent magnetic source, the optimal working range of the sensor could be obtained. Figure 3 shows the characterization measurement of Hall effect sensor. It appears that the sensor's output voltage is inversely proportional to the sensor's detection distance. The sensor has a sensitivity of 0.069 Volt/mm; it has an optimal working range of 3 - 30 mm with the closest detected of distance difference is 1 mm

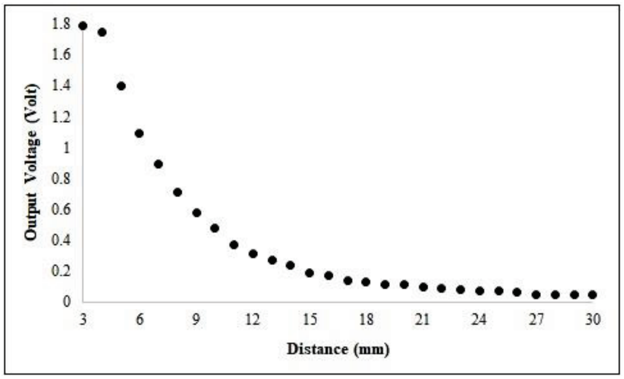


FIGURE 3. Characterization Hall effects sensor UGN3503 by comparing the reference distance and sensor output voltage

Load Cell Sensor

The load cell sensor calibration is carried out using non zero calibration, which the sensor output voltage does not show zero when it has not been given a load [5]. The mass of 1 kg is placed on the sensor and the output of the sensor voltage is recorded. During the weighing process, the load may result in reaction to the metallic elements of the load cell resulting in elastic shape changes. The style posed by this strain (positive and negative) is converted into an electrical signal by the strain gauge that is attached to the spring element. Figure 4 shows the characterization measurement of load cell sensor.

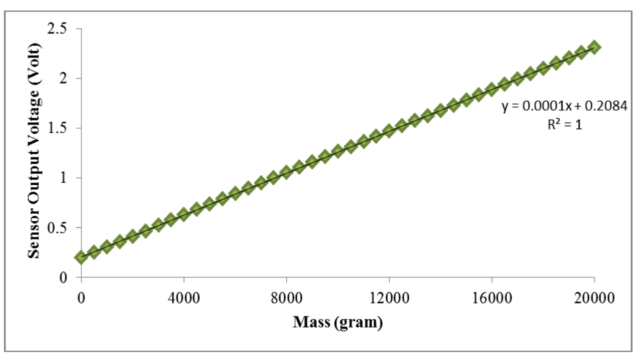


FIGURE 4. Load cell sensor characterization graph

Based on the fig 4, the sensitivity value of sensor obtained 0.0001 V/gram in which every 1 gr mass will produce output of 0.0001 V. The output voltage was proportional to the changes of mass. The location of load was arranged in order to get uniform mass distribution. The load sensor can work well in a mass range of 100-19.999.98 grams

Prototype Validation

The device was developed using one ultrasonic sensor and 16 Hall effects sensors. The Hall effect sensor installation was performed at every multiples distance of 3 cm according to the maximum distance characterization. The first Hall effect sensor is placed at a distance of 33 cm to the reference point. Then there is an indicator to determine the equation to be used in the repetition of microcontroller algorithms. The indicator installation is at a distance of 3 cm increments from the initial position to reach the last Hall effects sensor. Whereas the ultrasonic sensor, placed at a distance of 90 cm. The measurements were detected using a buffer board whose positions in front of the baby's feet. The sensor detection result shown in the LCD is a fixed value of 90 cm minus the detecting distance of the sensor against the buffer board. For the body mass evaluation, 20 kg load cell sensor was placed beneath baby's bedside board. The developed prototype can be seen in fig 5.The results of mass and height measurement using the developed prototype presented in table 1.

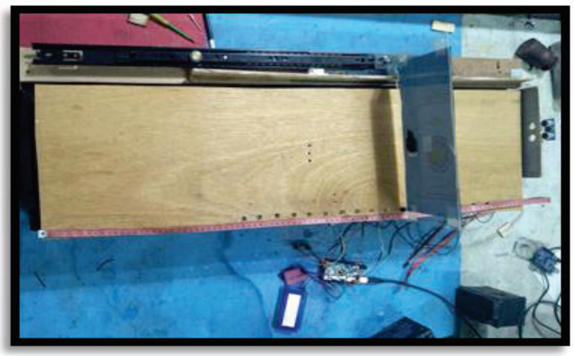


FIGURE 5. Body Mass and Height Measurement System

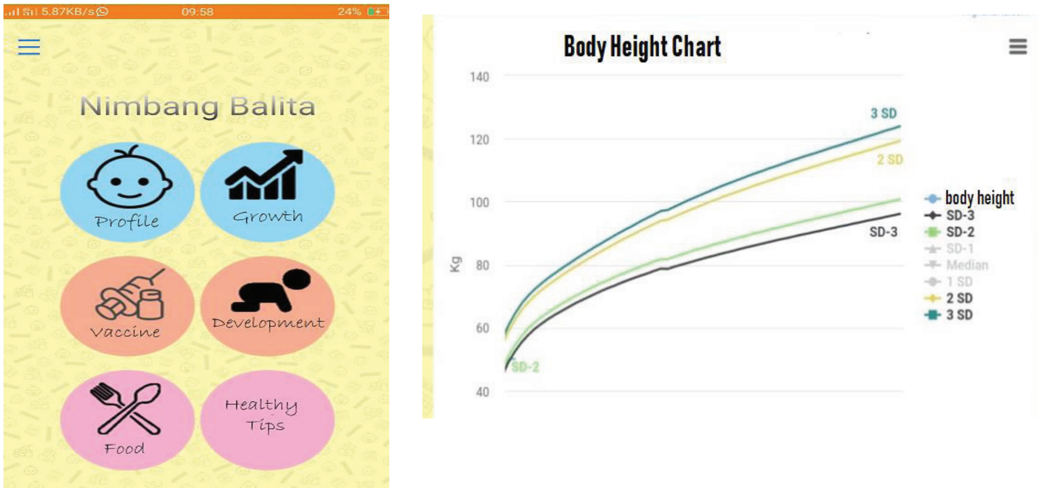
TABLE 1. Measurement result using the developed prototype

No.	Standard Measurement		Prototype Measurement		Relative Error (%)	
	Mass (kg)	Height (cm)	Mass (kg)	Height (cm)	Mass	Height
1	3,28	49,55	3,256	49,50	0,73	0,10
2	3,28	62,30	3,241	62,30	1,19	0
3	3,65	39,90	3,539	39,90	3,04	0
4	3,65	44,30	3,430	44,30	6,03	0
5	5,28	53,30	5,138	53,30	2,69	0
6	5,28	59,30	5,259	59,30	0,40	0
7	5,63	49,90	5,581	49,90	0,87	0
8	5,63	54,50	5,370	54,50	4,62	0
9	9,08	66,50	9,047	66,50	0,36	0
10	9,38	65,50	9,261	65,50	1,27	0

According to the results, the average error measurement of baby height is 0.010%. This error value is smaller than the error value in previous studies that only use the ultrasonic sensor; therefore the prototype gives more accurate results while using the ultrasonic sensor and the Hall Effect sensor. Meanwhile, for baby mass measurements using load cell sensors, the average error value is 2.12%.

Monitoring App system

The monitoring system application of baby growth accompanied by the nutritional status of the toddler was developed using Android. The application,s name is "Nimbang Balita" which means Monitoring and Growth Toddler. This application is available at https://files.appsgeyser.com/Nimbang%20Balita_9337273.apk. This application contains menus such as profiles, growth, development, immunization, healthy food, healthy info, account settings, and about the application. The application display is shown in figure 6.



(a) (b)

FIGURE 6. (a) Home menu of "Nimbang Balita" Application on Android smart-phone, (b) chart of baby height measurement

CONCLUSION

It has been designed prototype of baby mass and height monitoring system using load cell sensor, ultrasonic sensor and Hall effects UGN3503 sensor. The prototype show an accuracy 99.99% for the measurement of height and 97.88% for the mass measurement. The prototype was supported by Android application and web databases system for displaying the information of mass and height chart and also give the health status of baby.

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