Design, Prototype of Arduino and Android-Based Anthropometry System for Toddler’s Head and Upper Arm Circumference Measurement

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Abstract. Nutritional status monitoring is a very important in toddler, because in this period children are vulnerable to trauma, infection, or developmental disorders. Nutritional status is one of the health indicators in the successful achievement of MDGs No. 4 related to the reduction of child mortality, which is 45% caused by malnutrition. Head and upper arm circumference are an important anthropometry parameter on toddler growth. The monitoring process for toddler in Posyandu usually by writing and plotting the data in KMS (Kartu Menuju Sehat) manually. Therefore, efforts to modernize Posyandu to facilitate Posyandu officers in taking measurements, as well as become one of the database systems of nutritional status of Indonesian toddler. The purpose of this study was to develop prototype of anthropometry using ultrasonic sensor HC-SR04 and Hall sensor UGN3503 based Arduino. The system will be integrated with the database through Android applications. The results of this study had an accuracy value of 97.72% for the testing of head circumference measuring instruments and 95.35% of the testing of upper arm circumference measuring instruments. Android applications created to serve to store and provide information about the growth and development and nutritional status of a toddler.

1. Introduction

Growth and development of children take place regularly and are interrelated from conception to adulthood. Even though there are variations, each child will pass a certain pattern and experience a very rapid increase, namely the age of 0-5 years, which is commonly referred to as the golden age [1]. The golden age is a very important period to pay attention to the nutritional status of children carefully so that it can be detected in the event of a developmental disorder [2]. Nutritional status is one of the health indicators in the successful achievement of MDGs No. 4 related to reducing child mortality, which 45% is caused by malnutrition [3].

Posyandu is an Indonesian government program to check the nutritional status of toddler using anthropometric measurements. Anthropometry is one of the assessments of nutritional status that measures human individuals to determine human physical variations [4]. The advantages of anthropometry are that the procedure is simple, safe, and can be performed in a large number of samples [5]. Compared to other methods, anthropometric are more practical to assess nutritional status in the public. In collecting data on the growth and development of toddlers, Posyandu provides a data collection book (Kartu Menuju Sehat / KMS) [6]. KMS is used to monitor children's growth, record children's health services and educational tools for parents [7].
Head circumference and upper arm circumference are important parameters in examining the nutritional status of children under five at posyandu. Head circumference describes brain growth from the estimated volume in the head, head circumference is influenced by the nutritional status of children up to 36 months of age [8]. The circumference of the upper arm describes the growth and development of fat tissue under the skin and muscles which is not much affected by the state of body fluids compared to body weight, measuring the circumference of the upper arm aims to determine energy and protein reserves. Measurement of head circumference and upper arm circumference at posyandu still uses an elastic measuring tape and the data is plotted manually in a data collection book (Kartu Menuju Sehat / KMS) [2].

In this study, the development of a toddler growth monitoring system was carried out, namely the Arduino-based and integrated head circumference measurement system for the Android application. This system uses Arduino as a data processor, ultrasonic sensor and Hall effect sensors to detect head circumference and upper arm circumference of a toddler. The Android application plays a role in accessing information on the development of children under five, storing data on the identification of toddler growth and development, and assisting in auditing measurements to monitor the nutritional status of children.

This research was conducted referring to previous research by Kinanthi, et al. Made measurement of weight, body length and head circumference in infants with graphical display using ATMEGA 32 [9]. Further research by Nurfiansyah, et al. Who made an Android-based mobile application to store and provide data about toddler growth, such as body weight, height, and head circumference every month [10]. Recent research by emotion, et al. Who developed a weight and height measurement system for toddler using Arduino with an accuracy of above 98% [11].

2. Method
This system is designed using the Arduino Mega 2560, the HC-SR04 ultrasonic sensor, the UGN3503 Hall sensor and an Android smartphone. In this study, the HC-SR04 ultrasonic sensor and the UGN3503 Hall sensor were characterized as detectors of the head circumference and upper arm circumference of toddler to determine the range and identify the sensitivity of the sensors used.

Arduino Mega 2560 as the main control of this system, Arduino is also a data processor for the head and upper arm circumference data sent by the network, then the data is stored and displayed on the android application.

![Figure 1. Block diagram of anthropometry prototype](image)

3. Results And Discussion
In this study, 4 HC-SR04 ultrasonic sensors were used to measure the diameter of the head and upper arm circumference of a toddler. Ultrasonic sensor characterization is done by comparing the sensor output value (digital value) with the measurement results of the distance measuring instrument.
Measurement limit starts from 3 cm to 20 cm. The output of the sensor is in centimeters (cm). The results of this characterization can be seen in the graph below.

![Graph of the ultrasonic sensor's measured distance to the reference distance](image1)

**Figure 2.** Graph of the ultrasonic sensor's measured distance to the reference distance

Based on these results can also be known relative error values on the sensor by using the following equation:

$$Error(\%) = \left| \frac{PS-PL}{PL} \right| \times 100\%$$  \hspace{1cm} (1)

PS is the value reading of the sensor used, and PL is the actual value reading or that has been tested using a laboratory measuring instrument. The average relative error value is 1.99%. Thus, with such a small deviation value, it can be interpreted that the ultrasonic sensor can be used as a distance measurement tool to calculate the diameter of the head circumference and the circumference of the toddler's upper arm. The development of the Hall UGN3503 sensor as a proximity sensor is based on its ability to detect changes in the magnetic field. Changes in the magnetic field occur due to the change in distance between the sensor and the object measured in distance. In this case, the output voltage of the sensor is proportional to the change in the magnetic field. The characterization of the UGN3503 sensor is done by measuring the sensor output voltage against the distance from the permanent magnetic source, so that the furthest distance is known from the sensor's increasingly small and stable output voltage value.

![Hall sensor voltage graph versus reference distance](image2)

**Figure 3.** Hall sensor voltage graph versus reference distance
The graph explains that the output voltage of the sensor is inversely proportional to the sensor’s reference distance, the farther the magnetic field source distance to the sensor, the smaller the sensor output voltage in the range of 3 mm - 15 mm and the farthest detection distance range of 30 mm, this will be used as a reference in the manufacture of prototypes. Testing of prototypes monitoring the circumference of the head and upper arm circumference of toddler in this study was conducted to determine whether or not this circuit system could run properly. Prototype testing was conducted with HC-SR04 ultrasonic sensor readings and Hall UGN3503 sensors simultaneously, as the HC-SR04 ultrasonic sensor has a working range from 3 cm to 400 cm with a sensor resolution of 1 cm, while the Hall UGN3503 sensor has a working range ranging from 0.1 cm to 3 cm with a sensor resolution of 0.1 cm. Therefore the simultaneous use of the HC-SR04 ultrasonic sensor and Hall UGN3503 sensor adds a level of sensory reading accuracy to measure the diameter of the toddler’s head circumference and upper arm circumference. Head circumference testing using a combination of 3 ultrasonic sensors and 12 Hall effect sensors, the sensor detection result is the result value of the elliptical circumference equation.

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\text{Elliptical Circumference} = \frac{1}{2} \pi (R_1 + R_2)
\]

D is the diameter of the circumference of the upper arm. The results of the prototype can be seen in the following image.

![Figure 4](image-url)

**Figure 4.** Prototype head circumference and upper arm circumference of a toddler (a) Front view, (b) Side view

The measurement data of head circumference and upper arm circumference that have been tested are as follows:
Based on the test results, the prototype can read the sensor output and read the predetermined algorithm properly. In this prototype, test, the result of head circumference measurement has an average error value of 2.28% and upper arm circumference measurement has an average error value of 4.65%. This average error value is smaller than the error value in previous studies, as in previous studies only used ultrasonic sensors as a gauge, whereas in this prototype it used ultrasonic sensors and hall effects simultaneously. Thus the prototype measurement results become more accurate if the ultrasonic sensor is used simultaneously with the Hall effect sensor because the Hall effect sensor has a very high precision as a distance meter compared to the ultrasonic sensor (can be seen from the resolution of the sensor).

The application of the monitoring system of toddler growth is accompanied by the creation of an account and nutritional status of the toddler. This app called "E-BALITA", this wave-based android app is made to make it easier for parents to monitor the growth of toddler in real-time, fast and efficiently. In this application there is a menu of toddler profiles, parent profiles, data on toddler growth, immunizations, healthy info for toddler and settings.
4. Conclusion
The design and prototype of an anthropometry system with the head circumference and upper arm circumference of a toddler using the HC-SR04 ultrasonic sensor and Hall sensor UGN3503 have been created. The test result of the prototype head circumference has an accuracy value of 97.72% and the test result of the upper arm circumference prototype has an accuracy value of 95.35%. The prototype integrates with an Android-based toddler growth monitoring app called "E-BALITA". The app features measurements of the toddler's head circumference and upper arm circumference as well as the nutritional status of the toddler in real time, quickly and efficiently.
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