Design of Arduino Uno-Based Height and Weight Measuring Instrument for Initial Screening of Stunting Cases

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Abstract: Monitoring nutritional status in toddlers is very important because it can be an early indicator of possible health problems in children. Currently, the process of monitoring children's nutrition is generally still carried out manually, which not only takes longer but is also less efficient in practice. To overcome the limitations of conventional measuring devices, a digital measuring device for height and weight was designed. This tool displays the results of height and weight measurements simultaneously on an LCD (liquid crystal display) screen. This tool works with uses an Arduino microcontroller as a control center and uses electronic sensors, namely the HC-SR07 ultrasonic sensor to measure height and the HX711 loadcell sensor to measure weight. From the data obtained, the error value and accuracy of the loadcell sensor after calibration produced an error value of 6.24% and an accuracy of 93.76%. Meanwhile, the ultrasonic sensor test results after the calibration process produced an error value of 0.052% and an accuracy of 99.94%.

Keywords: Stunting; HX711 load cell; HC-SR04 ultrasonic; microcontroller

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I. INTRODUCTION

The stunting is a health condition in children under five which is caused by a lack or adequacy of nutrition needed for the growth process [1]. Toddlers who experience stunting can affect their intelligence level and are at risk of becoming less than optimal and therefore more susceptible to disease. In 2022 in the Klaten Regency area there will be an increase in stunting cases by 2.4% from 15.8% to 18.2% [2]. The Ministry of Health of the Republic of Indonesia stated that based on 2018 Riskesdas data, around 30.8% of toddlers in Indonesia experienced stunting [3]. One of the obstacles in handling stunting is health workers. According to data from the Central Statistics Agency (BPS) in 2021, the number of midwives in Indonesia is around 339 thousand people, while the number of toddlers who need to be handled is 30.8 million people [4]. This causes the workload of midwives and related health workers to become very heavy. This is made worse by measuring height and weight to monitor children's growth and development or children's nutritional conditions which are still manual.

Monitoring the nutritional condition of toddlers is a very crucial action. This is because it can be an early warning of potential health problems in children. Currently, the process of measuring height and weight is still carried out using meters and spring needle scales and then the results are recorded manually on different sheets of paper so it takes quite a long time. Apart from that, help from other people is needed to ensure whether the height measurement is correct or not. Automated integration of these measurements can increase efficiency and accuracy, reduce manual involvement, and speed up the data collection process [5].

To overcome the limitations of conventional measuring devices, a digital measuring device for height and weight was designed. This tool displays the results of height and weight measurements that appear simultaneously on the LCD (liquid crystal display) screen. The making of this tool aims to help facilitate midwives or village cadres in measuring height and weight in children. This tool works with an Arduino microcontroller as the control center and several electronic sensors, such as the HC-SR07 ultrasonic sensor to measure height and the HX711 loadcell sensor to measure weight. After that, the measurement results are then displayed on the LCD screen. This measuring device provides many conveniences, including easy readability, as well as a faster process. A toddler or child can measure their height by standing upright on the scale board, with the back of the body touching the scale board then the device will immediately start the measurement process. After that, the height and weight will be displayed directly on the LCD screen display.

II. METHODOLOGY

Initial data was collected from height and weight measurements which were then compared using digital scales which are generally available on the market such as the Omron brand, Speeds and others as well as height measuring devices

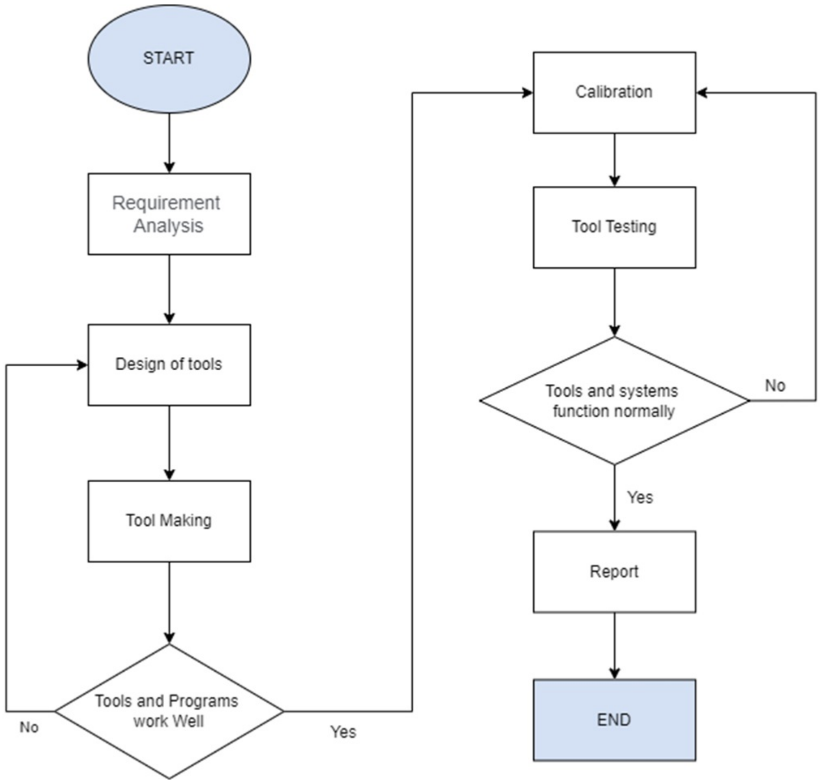

FIG. 1: Project flow diagram.

which still use meters. Making tool prototypes is done by arranging or assembling the components and collecting the required modules. Next, the tool is checked to ensure that it can function according to the desired target. The next stage involves checking the program so that it can detect and review it immediately if errors or errors occur.

The calibration process for the HX711 load cell sensor is carried out by placing a weight with a known actual mass at the center of the load cell. To obtain the calibration value for the load cell sensor, the calibration factor in the set scale section of the Arduino IDE program is adjusted by increasing or decreasing it until the weight reading from the load cell sensor matches the known weight. The result of this calibration factor is obtained from the average calculation of the calibration factor, where the weight measured by the load cell before calibration at the set scale value of 1 is divided by the actual weight (true weight).

The aspects that need to be analyzed in the system performance evaluation involve assessing the delay time to make it more efficient with the output of height and weight whether it is appropriate or not. Furthermore, a calibration process is carried out to ensure that the measurement data obtained from this tool has a high level of accuracy and is appropriate. Calibration is the process of finding the difference between the measurement results from the tool and the actual value or the estimated standard[6], [7]. The data calibration includes height and weight measurement results with the following formula:

$$\text{Error} = \left|\frac{\text{Measurement data - Actual data}}{\text{(Actual data)}} \times 100\%\right| \quad (1)$$

$$\text{Accuracy} = 100\% - \text{Error} \quad (2)$$

Each step is described in more detail according to the needs and complexity of the project concerned as follows. Fig. 1 shows the stages of the research methodology used in creating the project. The implementation of research stages consists of eight stages, namely needs analysis, prototype design, tool creation, tool and program testing, overall system design, overall testing, system calibration and testing and report creation. This flowchart provides a visual overview of the process and steps that must be taken in carrying out a project.

Based on literature studies, a weighing system was designed as shown in the block diagram in Fig. 2. From the block diagram there are 4 main components, namely the HX711 loadcell sensor, HC SR04 ultrasonic, Arduino Uno microcontroller and LCD. The following is the function of each component of the block diagram above:

1. HX711 Loadcell Sensor
   This sensor is designed to detect pressure coming from a load placed on it. This loadcell has an HX711 module as a signal amplifier to strengthen the output, which is then transmitted to the Arduino microcontroller. The HX711 module functions as a converter that can convert the voltage produced by the loadcell into a force or weight value [8, 9]. The working principle of a load

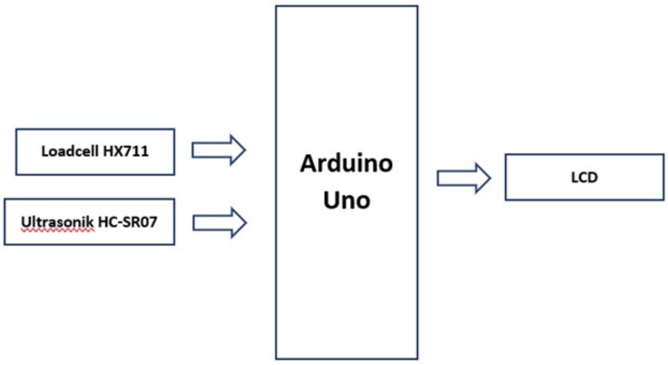

FIG. 2: Block diagram of digital weighing system design.

cell sensor is similar to a digital scale, where this sensor produces a voltage output in response to changes in resistance that arise due to changes in the position of the load support. This change then produces an output on the amplifier.

2. Ultrasonic HC - SR04 Sensor
   This tool uses an ultrasonic sensor to measure body height. The ultrasonic sensor consists of a 40kHz signal generator circuit, an ultrasonic transducer (speaker), and an ultrasonic microphone. The transducer converts the 40 kHz signal into sound waves, and the microphone detects the reflection of the waves [10]. The HC SR04 ultrasonic sensor has a maximum range of 400 - 500 cm from the center point [9].

   In testing the HC-SR04 ultrasonic sensor, it was carried out by placing an object in front of the ultrasonic sensor as an obstacle. After that, measurements are carried out using this object, and the output results will be displayed on the display screen. This sensor detects the distance between the ultrasonic sensor and the head or object being measured.

3. LCD (liquid crystal display)
   LCD (liquid crystal display) in this research is used to display the output produced from height and weight measuring instruments. In this research, the LCD used is a dot matrix LCD with a screen size of 16 $\times$ 4 [11].

4. Arduino Uno Microcontroller
   Arduino Uno is an arduino board that uses the ATmega328 microcontroller as the core of its function. The Arduino Uno is equipped with 14 digital pins (with 6 pins usable as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a voltage source connector, an ICSP header, and a reset button [12]. The Arduino microcontroller is a device that can be programmed and functions to send and receive data from various sensors, including the HC-SR04 ultrasonic sensor and the HX711 load cell. Arduino is a hardware device that uses an Integrated Circuit (IC) Microcontroller as the main controller in a circuit [13].

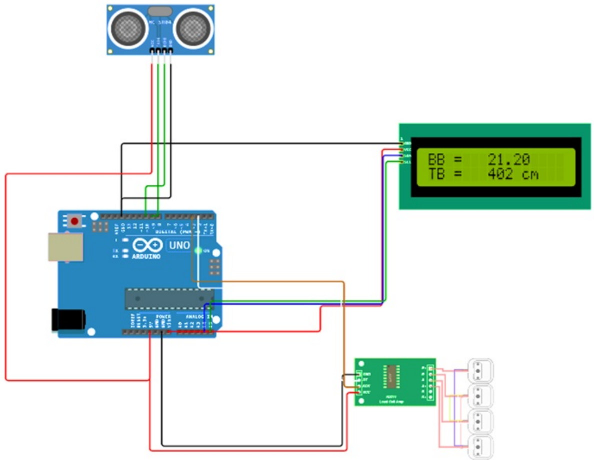

FIG. 3: Electronic circuit tools.

III. RESULTS AND DISCUSSIONS

A. Circuit Simulation

Because the voltage produced by the loadcell sensor is only millivolts and is analog, in this research it is necessary to add an amplifier circuit and analog-digital converter to the loadcell, namely the HX711 module. The HX711 module series aims to amplify and convert analog signals into digital signals so that they can be processed by a microcontroller as seen in Fig. 3.

Height measurement on this device is carried out by utilizing the function of an ultrasonic sensor. The ultrasonic sensor consists of four pins, namely the VCC, GND, trigger and echo pins. On the HX711 module, there are four pins that must be connected to the Arduino, namely the VCC, GND, DT, and SCK pins. The VCC and GND pins are connected to the 5V and GND pins on the Arduino. The DT pin is connected to pin 2, while the SCK pin is connected to pin 3 on the Arduino. The VCC pin functions as a voltage source which is connected to the VCC pin also on the Arduino, while the GND pin is used as ground which is connected to the GND pin also on the Arduino. The trigger pin functions as a signal output from the sensor connected to pin 9 on the Arduino, while the echo pin functions to capture reflected signals from objects and is connected to pin 10 on the Arduino.

Without using an I2C module, an LCD text display will require 6 pins on the Arduino (RS, E, D4, D5, D6, and D7) but on the other hand, by using an I2C connection only 2 pins are needed, namely SDA and SCL. The connection between the I2C module and Arduino is carried out via four pins, namely VCC, GND, SCL and SDA. The VCC and GND pins on the I2C module are connected to the Vin and GND pins on the Arduino. In addition, the SCL pin is connected to the analog pin A5 on the Arduino, and the SDA pin is connected to the analog pin A4 on the Arduino.

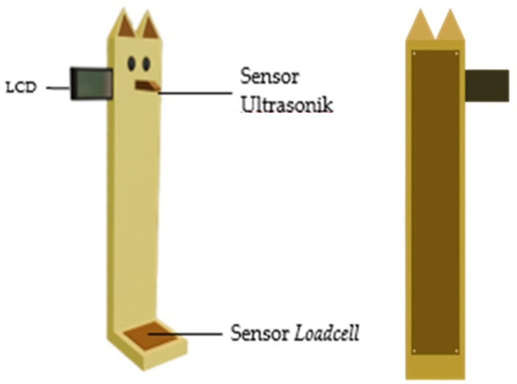

FIG. 4: Tool frame design a). front view b). back view.

B. Tool Framework Design

The design of the tool frame is a key part of ensuring optimal performance and safety of the electronics inside. The design of the frame, which combines the functions of weight measurement and height measurement, requires careful planning to ensure accuracy and comfort in use. The framework must include a proper place for the loadcell sensor (weight) which is placed below and the ulrasonic sensor (height) which is placed above, as well as supporting the LCD screen as an output display. The design of the back of the weighing frame is designed with the ability to be opened and closed. This is useful to facilitate the cabling process. The design of a child-friendly measuring instrument can bring significant innovation in children's weight and height measurement experience.

With a focus on children's safety, comfort and interest, these measurements are designed to create an environment that supports their growth and health. Colorful designs and attractive motifs can create visual appeal, making the measuring process more fun and less scary for children. Therefore, a child-friendly scale design not only provides accurate weight data, but also creates a positive relationship between children and health workers and supports the formation of healthy living habits from an early age.

C. HX711 Loadcell Sensor Test Results

In testing the loadcell sensor that is carried out is weight testing. In this study, testing of the loadcell sensor was carried out 5 times using items or objects of different weights. In this test, the loadcell sensor measurement results will be compared with the measurement results using the speeds brand digital scales to determine the error value and accuracy. The following loadcell sensor test values can be seen in Table I.

In testing using a loadcell sensor, the average error value (%) is 36.6% with an average accuracy value (%) of 63.4%. The loadcell sensor measurement results have an average difference with the original weight. This is because the initial value of the loadcell sensor before being given a load shows the number (-) minus the original weight. After performing

TABLE I: X711 Loadcell Sensor Test Results.

Original weight kg	Load cell measurement kg	Difference	Error (%)	Accuracy (%)
20	13	7	35%	65%
47	30	17	36%	64%
52.3	31.3	21	41%	59%
53.5	34.5	19	35%	65%
56.3	36.3	20	36%	64%

TABLE II: The Result of the Load Cell Sensor Calibration Process.

No	Load cell measurement Weight kg	Actual Weight (Kg)	Difference	Calibration Factor
1	135678	5	135673	27136
2	135677	5	135672	27135
3	135774	5	135769	27155
4	135782	5	135777	27156
5	135765	5	135760	27153
6	135754	5	135749	27151
7	135781	5	135776	27156
	Average		135739	27149

the calibration process on the loadcell, it is expected that the measurement results will be more accurate. In this study, the measurement results from the load cell sensor readings are presented in Table II. These results were obtained from the average calculation of the calibration factor, where the load cell measurement weight before calibration at the set scale value of 1 is divided by the actual weight (true weight) according to the formula:

$$\text{Error} = \left|\frac{\text{Measurement Weight}}{\text{(Actual Weight)}} \times 100\%\right| \tag{3}$$

The calibration factor was adjusted until the HX711 load cell sensor reading showed an average set scale value of 27149. This data adequately represents the weight measurements of a diverse group of children, ranging from lighter to heavier weights. During the calibration process, the tests were conducted using rice, as rice has a consistent weight and can be measured with high accuracy. Rice is also unaffected by environmental changes such as humidity or short-term deformation, which can impact the measurement results if using a water jug that could leak or a cardboard box that could absorb moisture and deform. The consistency and flexibility of using rice in measurements ensure accurate and reliable calibration results, making it a more suitable choice for testing weight measurement devices. The test results of the load cell sensor after calibration are shown in Table III.

Based on the results of measurement tests involving 5 children's objects to carry out weight measurements, the aim is to determine the accuracy of the tools made in this final project. From the data obtained, the error value and accuracy of the

TABLE III: Loadcell Test Results after Calibration.

Original weight kg	Load cell measurement kg	Difference	Error (%)	Accuracy (%)
53.70	50.38	3.32	6.18%	93.82%
41.25	38.48	2.77	6.71%	93.29%
47.55	44.62	2.93	6.16%	93.84%
51.95	48.76	3.19	6.14%	93.86%
54.65	51.35	3.3	6.03%	93.97%

TABLE IV: HC-SR04 Ultrasonic Sensor Test Results.

Original Height cm	Ultrasonic measurement cm	Difference	Error (%)	Accuracy (%)
120	74	46	38%	62%
109	67	42	39%	61%
116	64	52	44%	56%
112	63	49	43%	57%
118	71	47	39%	61%

loadcell sensor after calibration produced an error value of 6.24% with an accuracy value of 93.76%.

D. HC-SR04 Ultrasonic Sensor Test Results

The ultrasonic sensor testing carried out is distance testing. In testing this sensor, the results of ultrasonic sensor measurements will be compared with the results of measurements using a meter measuring instrument which is carried out manually with the aim of knowing the error value and accuracy value. The test data results are shown in Table V.

In testing using an ultrasonic sensor, the average error value (%) was 40.6% and the average accuracy value (%) was 59.4%. The ultrasonic sensor measurement results have an average difference of 47.2 with the original height. After carrying out the calibration process on the ultrasonic sensor, it is hoped that the measurement results will be more accurate. The calibration process involves comparing the output produced by the ultrasonic sensor with the actual weight value or a known standard. The test data results are shown in table 5.

TABLE V: Ultrasonic test results after calibration.

Original Height cm	Ultrasonic measurement cm	Difference	Error (%)	Accuracy (%)
115	114	1	0.08%	99.9%
111	110	1	0.09%	99.9%
100	100	0	0%	100%
105	104	1	0.09%	99.9%
120	120	0	0%	100%

Based on the results of measurements involving 5 children's objects to measure different heights, the ultrasonic sensor measurement results obtained after the calibration process produced an error value of 0.052% with an accuracy value of 99.94%.

IV. CONCLUSION

This tool is capable of displaying height and weight measurement results simultaneously on an LCD (liquid crystal display) screen. This ideal height and weight measuring tool is a combination of height and weight measuring tools. Each of these tools uses a different sensor, namely the HC-SR04 Ultrasonic Sensor and the HX711 loadcell. In designing tools for measuring height and weight, it can work well. Success is demonstrated through the response of the measurement tool which can provide an average accuracy value of 96.85% with an error value of 3.146%.

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