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Smart Health Tracker: Arduino-Powered Automatic Height and Weight Measurement with Web Integration

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A B S T R A C T

The golden age in toddlers significantly influenced their growth, so it was essential to know the adequacy of nutritional needs in children. One way to assess the adequacy of nutrition in children was by measuring height and weight. However, height and weight variables in toddlers were highly representative. Until now, both measurement processes have been done manually, and the results have been recorded in a logbook. Thus increasing the risk of errors due to human involvement in data recording. This research aimed to design a prototype of an automatic device capable of measuring height and weight automatically. This prototype was based on Arduino Uno technology using ultrasonic sensors along with weight sensors, such as load cells and HX711. Furthermore, the data generated were integrated with the web for more effective storage. From the designed device, a pretty good level of measurement accuracy was obtained. The test results showed that the height-measuring device using ultrasonic sensors demonstrated an accuracy level of 97.99%. Meanwhile, the weight-measuring device using a load cell sensor showed an accuracy level of 82.53%. After testing together with the Melati Putih Posyandu Cadres, a good response was obtained. The satisfaction level measurement using the System Usability Scale method yielded a score of 80.75 points. It can be concluded that the built system was in the acceptable category.

Keywords: ***Measuring Instruments, Height, Weight, Arduino Uno***.

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1. Introduction

Nutritional intake in toddlers affects their physical development in ways such as disorders, health effects, and prematurity [1]. Health checks on toddlers are a key factor in ensuring their optimal development. Using anthropometric indices to consider the nutritional status of children is recommended by the WHO. Calculations using these indices include weight for age (W/A), height for age (H/A), and height for weight (H/W). Tools that can be used to measure these include stadiometers and weighing scales. These tools play an important role in measuring a child's development, whether they are growing optimally or not.

The use of conventional measurement tools like the ones mentioned above carries significant risks. This is due to the possibility of errors during measurements due to the need for manual interpretation by the measurer. This was also found by researchers during observations at the White Jasmine Integrated Health Post located in Rejasari Purwokerto Barat Village. It was found that manual measuring tools are still being used at the health post. The use of manual measuring tools requires a considerable amount of storage space.

At the health post, it was found that measurements are taken twice when measuring a child's weight. The first process involves measuring the weight of the toddler's parents, then measuring again while carrying the toddler, and then the difference between the two measurements is taken to determine the child's weight. This process requires a lot of energy and time to obtain measurement results. Therefore, modernization is needed to develop automatic height and weight measuring devices that are expected to improve accuracy in measurements.

After measuring height and weight, the measurement results are generally manually recorded in a book called KIA (Mother and Child Health). However, this poses challenges due to the reliance on paper storage, making it vulnerable to damage due to age or suboptimal storage conditions. These factors, such as inadequate storage time and space, can result in data loss or document damage. The lack of backup copies can also hinder the smoothness of the service process, as access to required information becomes limited. Therefore, digital storage is expected to address the issue of physical data damage.

Interview results from the community, especially with the managers of the White Jasmine Integrated Health Post, indicate their desire to improve immunization efforts. Hence, there is a need for appropriate technological development, such as devices capable of assisting in automatic measurement and data recording processes.

When building a device for measuring height and weight, microcontroller technology will be used as the device's controller. Several sensors are required for height and weight measurement. Ultrasonic sensors are used for height measurement. These sensors have a wave base and measure distance. The distance from the item is indicated by the time interval between ultrasonic waves transmitted and then received by the ultrasonic receiver. Load cell sensors are used to measure weight. These sensors are testing tools for electrical equipment capable of converting one type of energy into another. Typically, force is converted into electrical

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signals using these sensors [2]. Measurement data will be stored on an online web server.

Based on the prototype, this automatic height and weight measuring device will be developed. Prototyping itself is a technique for forming programs rapidly and incrementally. Because the device is explicitly developed for prototyping before being produced on a real scale, prototype evaluation can begin as soon as possible. Incremental evaluation allows developers to modify the system more easily. By identifying problems periodically, quick and efficient fixes can be made, improving the overall system quality [3].

Based on the constraints arising from the height and weight measurement process mentioned above, the development of a device that can overcome these problems is needed. This research offers a solution in the form of building a device that integrates various functions and tools that were previously separated into a more efficient unit. For example, an automatic height and weight measuring device using Arduino Uno as its basis was developed and connected to a web server. With this integration, the device not only performs measurements automatically but also stores data online, facilitating access and information management. In this case, the device will measure both variables simultaneously and more accurately because the measurement occurs automatically, thus eliminating human errors.

It is hoped that this device can contribute to improving the service standards in the health sector, especially at the White Jasmine Integrated Health Post located in Rejasari Purwokerto Barat Village. It can also serve as a source for further studies to refine the established system.

Based on the background of the issues, the objectives of this research are as follows:

1. To determine the accuracy percentage of height and weight measurement results automatically using Arduino Uno compared to manual measurement tools.
2. To digitize the storage of measurement data that has been conducted.
3. To determine the level of user satisfaction with the system used. The limitations of this research are as follows:
4. This device's design is tailored to health post staff's capabilities to ensure ease of use.
5. The measurement object is toddlers (infants under three years old).
6. The maximum height that can be measured is <110 cm.
7. The maximum weight that can be read by the load cell sensor is <200 Kg.
8. The research output is a prototype.

The sensors used are commercially available and easy to find in the market.

2. Methods

This research begins by taking steps aimed at improving and resolving related issues. The following are the sequential steps described by the author:

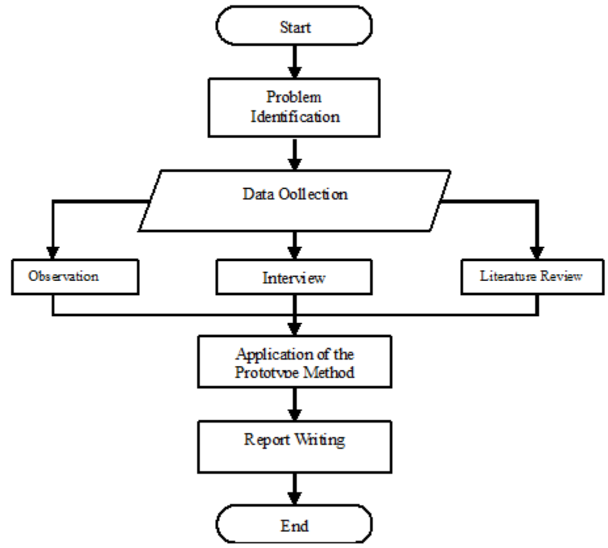

Figure 1. Research Framework

Based on Figure 1, it can be explained that the researcher starts the research by identifying problems and collecting data through observation, interviews, and literature review involving the exploration of journals, books, and final reports related to the topic under investigation.

The approach used in this research is an evolutionary prototype approach. This approach allows for overcoming the client's technical unawareness by better connecting them with the required specification requirements using prototype models that can be developed gradually. Furthermore, the researcher applies the prototype method through the design of the system, which includes processes such as creating a block diagram of the system, a schematic of the automatic height and weight measuring system, a flowchart of the system, system architecture, and Entity Relationship Diagram (ERD) tables. The final step in this method is testing the design method, namely black box testing

3. Results And Discussion

The results of observations and literature review confirm that the use of manual measuring tools often indicates suboptimal accuracy due to susceptibility to human error and storage constraints requiring significant space. The potential for human error in manual tool usage is the primary cause of measurement inaccuracy. Additionally, the storage of devices and measurement data is also a significant concern as it requires ample space, thus impacting workspace efficiency. In response to these issues, the "Design and Construction of an Automatic Height and Weight Measuring Device Based on Arduino Uno Integrated with Web" can be utilized as a tool to measure height and weight accurately and precisely automatically.

A. Functional Requirements Analysis

Functional requirements are the requirements that entail the processes performed by the system. The processes carried out in this system are:

- Input Requirements:
  - Ultrasonic Sensor HC-SR04 used for measuring height.
  - Load cell sensor used for measuring weight.
  - The adapter is used to provide power to the microcontroller system.

- Processing functions to process inputs, then execute according to the program code inputted via a computer by the programmer to generate desired outputs.

- Output Requirements:
The output section consists of supporting components of the system, used as actuators or indicators of the process generated by the microcontroller based on inputs, consisting of:
    - LCD I2C 16x2 is used to display measurement results from the microcontroller.

B. *Non-Functional Requirements*

Non-functional requirements are used to support the system's development. These requirements encompass hardware and software requirements:

- Hardware Requirements:
    - Processor: Intel Core i5 @1.60 GHz (8 CPUs), RAM 12 GB with a 500 GB Hard disk.
- Software Requirements:
    - Arduino Integrated Development Environment (IDE): This software is used to write the program code that will be uploaded into the Arduino Uno controller.
    - Fritzing: This software is used to illustrate the research design.
    - Sublime: This software is used to write the web program that will be connected to the Arduino Uno.

C. *Testing*

Load Cell Testing as Weight Measurement Device. This testing is conducted by placing a load on the constructed device to test if the load cell can function as expected. The testing is performed nine times, and from the results displayed, calculations can be made to determine the accuracy level of the device.

Table 1. Testing Results: Weight Measurement Trials

No.	Weight indicated on the manual measuring tool (kg)	Weight indicated on the automatic measuring device based on Arduino Uno (kg)	Error Percentage (%)	Accuracy Percentage (%)
1	5	4,4	13,64	86,36
2	11	9,6	14,58	85,42
3	6	5,3	13,21	86,79
4	11	9,56	15,06	84,94
5	12	11	9,09	90,91
6	11	9	22,22	77,78
7	14	12	16,67	83,33
8	13	12	8,33	91,67
9	13	9	44,44	55,56
10	11,5	10	15	85
Total			17,47	82,53

In the table, the measurement results from the automatic measuring device based on Arduino Uno are quite accurate compared to the results obtained using the manual measuring tool. The automatic measuring device based on Arduino Uno yields measurement results that are close to the values obtained from the manual measuring tool, with an average accuracy percentage of 82.53% and an average error percentage of 17.47%. The presence of an error percentage is due to limitations in the load cell sensor and the stability of power transmitted from the microcontroller to the sensor.

During the height measurement testing, objects are placed on the constructed device to evaluate if the ultrasonic sensor operates as expected. The testing is conducted multiple times, allowing calculations to be made based on the displayed results to determine the accuracy level of the constructed device.

Table 2. Testing Results: Height Measurement Trials

No.	Height indicated on the manual measuring tool (kg)	Height indicated on the automatic measuring device based on Arduino Uno (kg)	Error Percentage (%)	Accuracy Percentage (%)
1	44	45	2,22	97,78
2	92	91	1,10	98,90
3	43	43	0,00	100,00
4	86	87	1,15	98,85
5	14	15	6,67	93,33
6	46	45	2,22	97,78
7	94	92	2,17	97,83
8	60	60	0,00	100,00
9	23	22	4,55	95,45
10	15	15	0,00	100,00
Total			2,01	97,99

In Table 2 above, it can be observed that the measurement results from the automatic measuring device based on Arduino Uno are quite accurate compared to the results obtained using the manual measuring tool. The automatic measuring device based on Arduino Uno yields measurement results that closely approximate the values obtained from the manual measuring tool, with an average accuracy percentage of 97.99% and an average error percentage of 2.01%. The presence of an error percentage is attributed to unstable footholds/boundaries.

Table 3. Black Box Testing Results

Test Class	Test Item	Achievement	
		T	F
Login Page	The login menu opens when the page is loaded	✓	
	Staff can log in by pressing the "Login" button.	✓	

Test Class	Test Item	Achievement	
		T	F
Dashboard Page	The main menu opens after the Staff logs in	✓	
	The User Page opens when the Staff press the "Pengguna" button.	✓	
	The Toddler Registration Page opens when Staff press the "Pendaftaran Balita" button.	✓	
	The measurement page opens when the Staff press the "Pengukuran" button.	✓	
Registration Page	Staff can add toddler data to the database.	✓	
	Staff can delete toddler data from the database.	✓	
	Staff modify toddler data that is already registered in the system.	✓	
	The page displays a list of toddlers already registered in the system.	✓	
Measurement Page	Staff can search for toddler data based on inputted identities.	✓	
	Measurement data automatically appears after the toddler is placed on the measuring device.	✓	
	Measurement data is stored in the database after the user presses the "Simpan" button.	✓	
User Page	Staff can add new users.	✓	
	Staff can modify registered user data.	✓	
	Staff deletes users registered in the system.	✓	

Before satisfaction level measurement is conducted, the data will first be processed using Microsoft Excel. Here are the results from the questionnaires filled out by the respondents:

Table 4. SUS Score Analysis: Unveiling User Experience Insights

No	Score										Total	Total x 2,5
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10		
1	4	3	4	1	4	3	4	3	4	1	31	77,5
2	4	3	4	1	4	3	4	3	4	1	31	77,5
3	5	4	5	1	4	3	4	3	4	1	34	85
4	4	4	4	1	4	3	4	4	4	0	32	80
5	4	3	4	1	5	3	4	3	4	1	32	80
6	4	4	4	1	4	3	4	3	4	1	32	80
7	5	3	5	2	5	3	4	3	4	1	35	87,5
8	4	4	4	1	4	3	4	3	4	1	32	80
9	4	3	4	3	4	3	5	3	4	3	36	90
10	4	2	4	1	3	2	4	3	4	1	28	70
Total											323	807,5
Average Scores												80,75

The calculation is conducted according to the necessary steps to compute the System Usability Scale (SUS) score. Conversions will be made for each question item based on the results of the questionnaire. After the conversions are completed, calculations will be carried out according to the System Usability Scale (SUS) formula. Once the results are obtained, the average of the total scores will be taken, and in this study, an average score of 80.75 points was obtained. The final score from the SUS testing in this research is 80.75 points from 10 respondents. Referring to the interpretation guidelines found in Table 3.9 regarding the meaning of scores on SUS, it can be interpreted that this system falls into the "acceptable" category.

4. Conclusions

Based on the results of the conducted research, the researcher has successfully developed a prototype automatic height and weight measuring device integrated with a web server. The constructed device exhibits a fairly good level of accuracy, with a precision of 80.99% for weight measurement and 97.94% for height measurement. The accuracy of the sensors is influenced by limitations in the specifications of the sensors used. The web system in this study has been tested with an acceptable level of satisfaction.

In creating a prototype height and weight measuring device based on Arduino Uno integrated with a web server for other researchers, it is recommended that they carefully select sensors and thoroughly check their specifications, including aspects such as sensitivity, accuracy, and measurement range, which should be considered meticulously. Understanding the sensor specifications well can ensure that the constructed device performs optimally and provides accurate results in the future.

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