Journal of Engineering Science and Technology
Vol. 20, No. 2 (2025) 510 - 519

INTERNET OF THINGS-BASED CHILD STUNTING DETECTION SYSTEM FOR SUPPORTING SUSTAINABLE DEVELOPMENT GOALS

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Abstract

This research focused on the real-time detection of child stunting using measurement tools powered by Internet of Things (IoT) technology. Child stunting refers to a condition characterized by impaired height growth that does not align with a child's age. One of the government's primary strategies to combat stunting is through Posyandu (Indonesian community-level health service centers) that play a vital role in public health initiatives. Currently, most Posyandu in Indonesia rely on manual methods for monitoring child nutrition, with limited adoption of IoT technology for this purpose. This research introduced a system comprising both hardware and software components to address this gap. The hardware includes a load cell sensor for measuring weight and an ultrasonic sensor for measuring height. These sensors are integrated with an ESP32 microcontroller for data processing. The software component is a web-based application that receives data transmitted from the hardware via IoT technology. During testing, the hardware demonstrated accurate measurements of children's weight and height, with an average error of only 0.14 kg for weight and 0 mm for height. Furthermore, the web application performed reliably, providing stunting detection information with a 100% success rate. This study supports Sustainable Development Goals (SDGs).

Keywords: Internet of things, Microcontroller ESP32, Sensor electronics, Sensor load cell, Stunting.

1. Introduction

Child stunting is a condition characterized by delayed growth in height that is not appropriate for a child's age. It is a significant indicator of chronic malnutrition, often resulting from prolonged inadequate nutrition [1, 2]. To address this issue, the Indonesian government has implemented various programs, including those conducted through Posyandu [3]. However, most Posyandu in Indonesia still rely on manual methods to monitor child nutrition, limiting their ability to effectively track growth and detect stunting. Regular and accurate monitoring of child growth is critical to ensuring that children receive the necessary attention and interventions for healthy development.

Previous research has explored methods for measuring weight and height to support child growth monitoring. One such study utilized a load cell sensor to measure weight and an ultrasonic sensor to measure height [4]. The study reported an average measurement error of 0.66% for the load cell sensor and 0.99% for the ultrasonic sensor. However, the system's information was accessible only to Posyandu officers. Another study allowed only authorized personnel to access the application, and it lacked functionality for stunting detection [5]. A separate study focused on creating a standalone product to measure weight and height but did not include an application to provide actionable insights or information [6].

This research aimed to develop a real-time stunting detection system leveraging IoT technology. Many reports regarding IoT have been conducted (see Table 1). The proposed system combines hardware components, including a load cell sensor for weight, an ultrasonic sensor for height, and an ESP32 microcontroller for data processing. The measurements are displayed on an LCD and sent to a web application for stunting detection based on the collected data. By automating data transmission and enabling continuous monitoring through IoT technology, the system enhances the ability of Posyandu officers to document and analyse child growth data. Additionally, parents can easily track their children's development, reducing the risk of undetected stunting. The primary contribution of this research is the facilitation of more efficient and accurate documentation of children's weight and height measurements, providing both officers and parents with accessible, actionable information to support child health and prevent stunting. Stunting is a form of malnutrition that is addressed by the Sustainable Development Goals (SDGs).

Table 1. Research on IoT.

No.	Title	Ref.
1	A systematic review of the IoT in smart university: model and contribution	[7]
2	Mesh network based on MQTT broker for smart home and IoT factory	[8]
3	Easy-mushroom mobile application using the Internet of Things (IoT)	[9]
4	Greening the internet of things: A comprehensive review of sustainable IOT solutions from an educational perspective	[10]
5	Water quality monitoring in Citarum river (Indonesia) using IoT (Internet of Thing)	[11]
6	A systematic literature review of internet of things for higher education: architecture and implementation	[12]

Table 1 (continue). Research on IoT.

No.	Title	Ref.
7	Enhanced wearable strap for feminine using IoT	[13]
8	Utilization of internet of things on food supply chains in food industry	[14]
9	Computational thinking: the essential skill for being successful in knowledge science research	[15]
10	Aquarium monitoring and automatic feeding system based on internet of things	[16]
11	Examining the impact of the internet of things tourism industry in Vietnam	[17]
12	Edge computing for Internet of Things (IoT) system on Battery Monitoring System (BMS) to determine State of Charge (SoC) and State of Health (SoH)	[18]

2.Method

The research process is shown in Fig. 1, which begins with the collection of data on children's weight and height standards, categorized by gender and age. Additionally, data related to hardware specifications and software functionalities are gathered during this stage. The subsequent stage involves system design, which encompasses both hardware and software components. The system design framework is shown in Fig. 2.

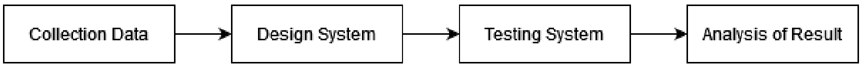

Fig. 1. The research stages.

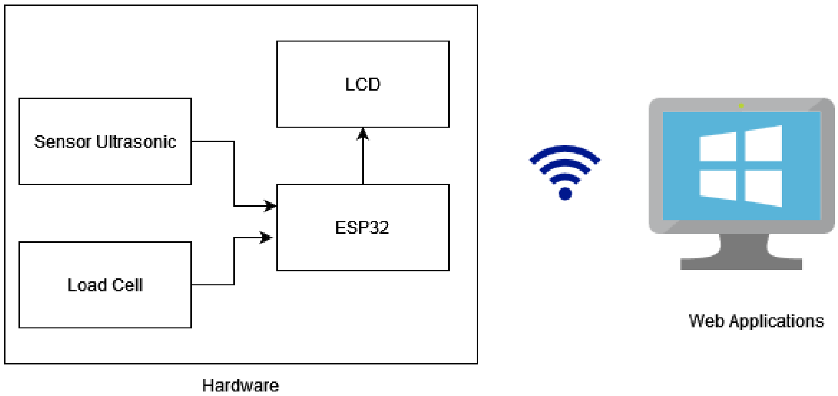

Fig. 2. Design system.

From Fig. 2, the function of each block in the hardware can be explained as follows:

(i) The load cell is a testing device used to measure electrical signals generated by converting mechanical force into electrical energy [19]. In this study, the load cell functions as a sensor to measure the child's weight.

(ii) The HC-SR04 ultrasonic sensor is a device capable of measuring the distance to an object [20]. In this research, the HC-SR04 sensor is employed to measure the child's length.

(iii) ESP32 is a microcontroller developed by Espressif Systems. It manages and processes all connected ports and Integrated Circuits (ICs) and controls drivers, enabling connected devices to function properly [21, 22]. In this study, the ESP32 microcontroller processes data from the ultrasonic sensor and load cell, which is then transmitted to a web application.

(iv) A Liquid Crystal Display (LCD) consists of a transparent electrode made of indium oxide, often configured as a seven-segment display, with an additional layer of electrodes on the rear glass [23]. In this study, the LCD is used to display the child's weight and length.

The web application design follows an object-oriented approach, utilizing Unified Modeling Language (UML) to analyse functional requirements. UML, a standard language for modeling software systems, is used to specify, visualize, and document software system artifacts [24, 25]. Among the various UML diagrams, the use case diagram is employed to depict the activities performed by users interacting with the system [26, 27]. Figure 3 shows the use case diagram for the proposed system.

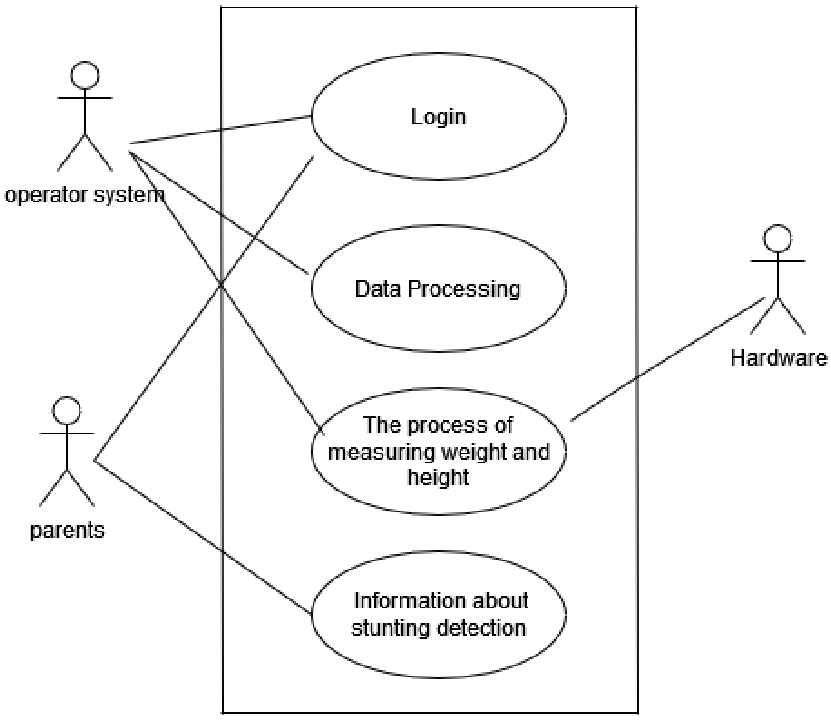

Fig. 3. Use case diagram.

As shown in Fig. 3, the system involves three primary actors: system operators, parents of children, and the hardware, which consists of tools for measuring children’s weight and height. A detailed functional description of the use case diagram shown in Fig. 3 is shown in Table 2.

The system testing process includes both hardware and web application evaluations. Hardware testing involves verifying the device's ability to accurately measure children's weight and height. The measurement results are compared against those obtained from standard measurement tools to determine the device's error rate. Web application testing focuses on assessing application functionality using black box testing methods [28, 29]. The final stage of the research involves analysing the test results to ensure the system aligns with the research objectives.

Table 2. Functional system description.

Functional	Description
Login	Functions used to enter the system
Data processing	The function is used to process child data. This function adds the identity of each child.
The process of measuring weight and height	This function is used to measure the weight and height of children. In this function, the system operator prepares the children data to be measured (data taken from those already added to the system) then the children are measured using the hardware that has been made, and the weight and height data are sent using IoT technology to the system.
Information about stunting detection	This function informs stunting detection in the form of weight, height, age, gender, and stunting detection. Functions used to enter the system.

3. Results and Discussion

The stages of using the system made to process data on the weight and height of children are as follows:

(i) The user or officer accesses the system via the web application to either register a child (if the child's data is not already in the system) or retrieve the data of a child scheduled for measurement.
(ii) The child is measured using the hardware, with the results displayed on an LCD screen and transmitted to the web application.
(iii) The transmitted measurement data is processed to determine the child's stunting status and then stored in the database.
(iv) The stunting detection results are displayed within the web application for easy access.

Figure 4 shows the physical design of the hardware developed to measure children's weight and height. An ultrasonic sensor is integrated into the device to measure height, while a load cell is used to determine the child's weight.

Figure 5 shows the LCD component, which displays the processed measurement data from the ESP32 microcontroller. The microcontroller is directly connected to the device. The system also features two buttons: a data check button for reviewing measurements and a send button for transmitting data to the web application. Table 3 shows the results of hardware testing for height measurement, comparing the device's performance with standard measuring tools. The comparison reveals an average measurement error of 0 cm. Similarly, Table 4 shows the testing results for weight measurement, showing an average error of 0.14 kg, with a maximum error of 0.25 kg. These findings indicate that the device provides highly accurate measurements, with minimal discrepancies compared to standard instruments, making it reliable for assessing children's height and weight.

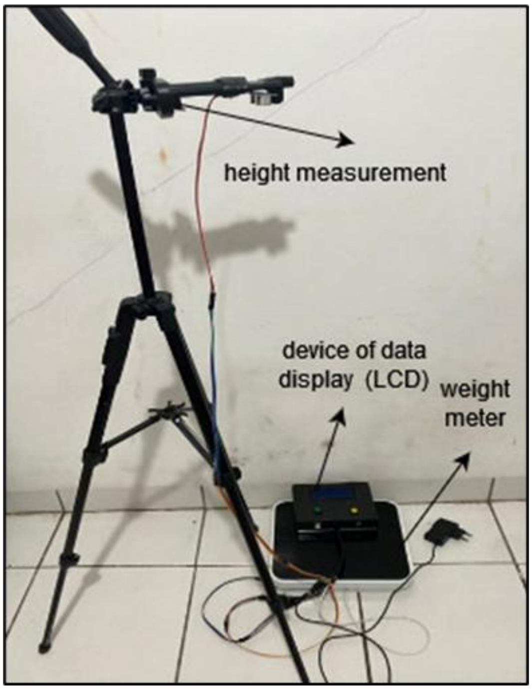

Fig. 4. Child weight and height measurement device.

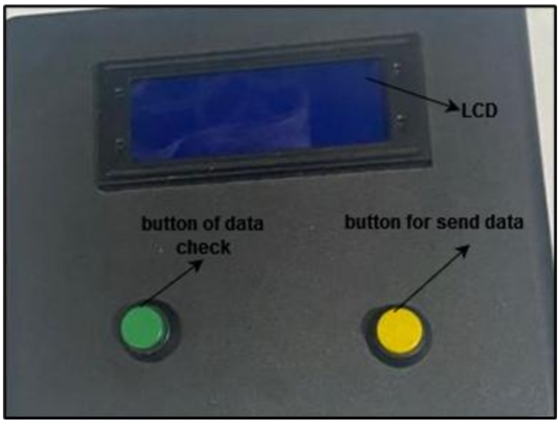

Fig. 5. LCD device for displaying measurement data.

Table 5 shows the results of functional testing for the web application, conducted using black box testing. The results confirm that the application meets 100% of the functional requirements as per the initial design specifications. The interface also provides information on the child’s stunting status, categorized as normal or below normal. In addition, this study supports Sustainable Development Goals (SDGs), as researched previously [30-34].

Table 3. Height measurement results.

Test	Measurement on Sensor (cm)	Measurement on a standard device (cm)	Difference
1	12	12	0
2	15	15	0
3	18	18	0
4	21	21	0
5	24	24	0
6	27	27	0
7	30	30	0

Table 4. Height measurement results.

Test	Load Cell (Kg)	Measurements on Digital Scales (Kg)	Difference
1	2.50	2.55	0.05
2	5.1	5	0.1
3	7.7	7.8	0.1
4	10.2	10.35	0.15
5	12.7	12.95	0.25
6	28.50	28.65	0.15
7	32.4	32.6	0.2

Table 5. Functional testing results of the web application.

Item test	Results
Login	Succeed
Data processing	Succeed
The process of measuring weight and height	Succeed
Information about stunting detection	Succeed

4. Conclusion

The test results demonstrated that the hardware is capable of accurately measuring children’s weight and height, with an average weight measurement error of 0.14 kg and no error in length measurement. Furthermore, the web application functions flawlessly, achieving 100% functionality in providing stunting detection information. This ensures parents can monitor their child’s growth effectively every month. Stunting is related to the SDGs because it's a form of malnutrition that the SDGs aim to eliminate.

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