JOISIE (Journal Of Information Systems And Informatics Engineering)
Vol. 10, No.1, Juni 2026, Hlm 13-21
Received: 5 Desember 2025 Revised: 8 Mei 2026, Accepted: 8 Juni 2026

p- ISSN: 2503-5304
e- ISSN: 2527-3116

DEVELOPMENT OF AN ARDUINO UNO-BASED MOBILE SYSTEM FOR TODDLER STUNTING DETECTION

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Abstract

The high prevalence of stunting in West Sumatra Province, especially in Padang City, is currently a serious problem. According to the Padang City Health Office, there were 1,569 children detected with stunting in 2024. The current problem is that stunting examinations are still carried out manually at health centers, and there is no system that can detect stunting quickly and accurately. This problem became the focus of researchers in innovating the design of a stunting detection application for toddlers. The purpose of this study is to design and build a stunting detection application for toddlers based on Arduino Uno using a mobile application. The novelty of this system is that this tool can automatically detect stunting in toddlers using Arduino Uno, so that stunting in toddlers can be detected quickly, accurately, and validly.The system development method used is the Research and Development (R&D) method with a 4-D model approach (Define, Design, Development, and Disseminate), which is a research and development method used to produce a product in the form of a model that requires various tests for product effectiveness. The result of this study is a technological innovation in the form of a stunting detection tool and system that can automatically detect stunting in toddlers validly and accurately using a mobile application. The final validation accuracy shows that the BB/U model = 0.966, TB/U = 0.979, BB/TB = 0.964. These results prove that the XGBoost algorithm is very suitable for detecting stunting in toddlers.

Keywords: Stunting; Toddler; Arduino Uno; Mobile Application

1. INTRODUCTION

Rapid technological developments have impacted various sectors, including the health sector. Stunting is a serious problem facing Indonesia. Malnutrition is a leading cause of maternal and child mortality (Ningsih et al., 2022). The WHO states that stunting is a growth disorder in children caused by repeated/chronic nutritional deficiencies that occur during the first 1,000 days of life (HPK). Basic Health Research (Riskesdas) data shows that the prevalence of stunting in toddlers in 2018 reached 30.8%, meaning that 1 in 3 toddlers in Indonesia is stunted (Sasmoko, D., 2021). Indonesia has the second-highest stunting rate in Southeast Asia and the fifth-highest in the world.

The Padang City Health Office has implemented the Simultaneous Stunting Reduction Intervention (ISPS). This movement, a joint effort to address stunting, which can affect toddler growth, has been ongoing since June 2024. According to the Head of the Padang City Health Office, Dr. Srikurnia Yati, 58,515 toddlers were monitored during this simultaneous intervention. Based on data from the Community-Based Electronic Nutrition Recording and Reporting System, as of July 5, 2024, there were 1,569 children in Padang City experiencing stunting.

The government has been monitoring child growth and development and providing complementary feeding (PMT) for stunted children. To date, 73 children have been referred to Dr. Rasidin Padang Regional Hospital, and 193 have received assistance from Baznas in the form of milk recommended by pediatricians. The interventions will be evaluated. It is hoped that stunting cases will decrease, and the Health Office can continue monitoring pregnant women. As of June

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2024, there were approximately 8,700 pregnant women, 900 of whom were anemic. The Health Office will continue to provide support with cadres to ensure that mothers with anemia and Chronic Energy Deficiency (CED) do not give birth to stunted children.

The aim of this research is to develop an automated application based on Arduino Uno to detect stunting in toddlers using a mobile app. Based on the above issues, the following problem can be formulated: How can this Arduino Uno-based application address the problem of stunting in toddlers in 11 sub-districts in Padang City, leading to a stunting-free Padang City? The proposal team focused on creating an innovative application that could address the persistent stunting problem that persists annually. In the past three years, stunting rates have continued to rise in Padang City, necessitating an immediate technological solution to this serious problem.

To address this problem-solving approach, an innovative stunting detection application for toddlers was developed, utilizing automated measurement technology with the Arduino Uno (Meisak et al., 2022). The advantage of this system is that it is an Arduino Uno-based system and tool for detecting stunting in toddlers, which can automatically detect stunting in toddlers accurately and validly. This mobile-based and integrated application addresses the limitations of manual stunting detection methods and increases the efficiency, accuracy, and reach of early detection of stunting in toddlers in Padang City.

2. RESEARCH METHODS

This study uses a quantitative approach with a comprehensive system development method, focusing on hardware and software integration. This method is designed to create an automatic and accurate stunting detection system in toddlers (Lubis, Z et al., 2019). The research flowchart illustrates what will be done during the study.

The research implementation is illustrated in a research flowchart, using a 4-D model as the method. The advantage and uniqueness (value proposition) of the proposed innovation lies in the Arduino Uno-based application technology, which can automatically measure the weight and height of toddlers and integrate this data into the application, thereby detecting whether the toddler is stunted or not (Kamarudin et al., 2018).In general, the research method is divided into four main stages: system design, hardware implementation, mobile application and backend development, and testing and evaluation.

2.1 System Design Stage

The Research and Development (R&D) method using the 4-D model approach (Define, Design, Development, and Disseminate) is a research and development method used to produce a product in the form of a model that requires various tests to determine its effectiveness (Rizkiniawan et al., 2019).

In this system design stage, a comprehensive system architecture design is carried out, which includes needs identification, namely analyzing the functional and non-functional needs of users (health workers, parents) and the system. Architectural design is also necessary to determine how each component (sensor, Arduino, Bluetooth module, and mobile application) will connect and communicate with each other (Hidayat,T, et al., 2021)(Saramudin et al., 2018). For further details, see Figure 1 below.

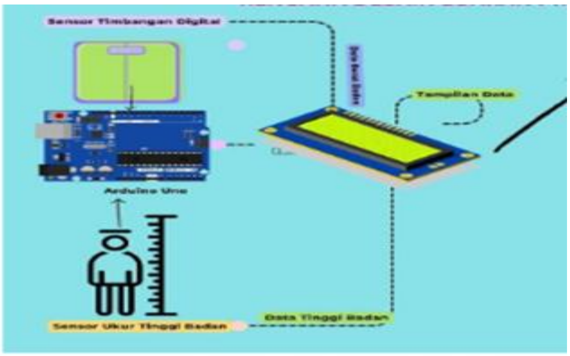

Figure 1. Stunting Detection Tool Architectural Design

The choice of technology in this case determines the technology to be used, such as the Arduino

Uno for the microcontroller and the mobile application as the user interface. The digital height and weight measurement system using the Arduino Uno works by integrating several main components that interact with each other. The process can be likened to a small team working together to produce accurate data (Agustanti et al., 2022).

2.2 Hardware Implementation Stage

This stage focuses on building a stunting detection hardware prototype. The main component implemented is a microcontroller with an Arduino Uno as the data processing center. Figure 3. Digital scale and height sensor

The Anthropometry sensor uses a weight sensor to integrate a load cell with the HX711 module to digitally measure toddler weight. Additionally, the height sensor is used in conjunction with the HC-SR04 ultrasonic sensor to measure height/length without contact.

Microcontroller is a communication module that connects the hardware to the mobile application using the HC-05 Bluetooth module for wireless data transmission. In this case, sensor calibration is used to calibrate each sensor to ensure accurate and reliable data.

2.3 Mobile Application Development and Backend Stage.

This stage involves software development, which is divided into two parts. The first part is the mobile application (Frontend).

Mobile application's display features are processed from the Bluetooth connection connecting the application to the Arduino device. The data acquisition process involves receiving weight and height data from the hardware in real time. After that, there is additional data input that allows the user to enter the toddler's age data. The result is a visual interface that displays the measurement results and predicts stunting in toddlers.

The backend includes data collection using verified historical toddler anthropometry datasets (weight, height, age). This data is processed and prepared for model training. Model implementation is necessary to train the application using the prepared data. This model will predict the risk of stunting based on WHO indicators (weight/age, height/age, and weight/height). The trained model is integrated into a mobile application or through a backend server. Data input from the hardware will be processed by the model to generate predicted stunting status results.

2.4 Testing and Evaluation Phase

This final phase aims to validate the overall system's functionality and performance. Unit testing is required, which involves testing each hardware and software component separately. In this case, integration testing is necessary to ensure smooth communication between the hardware and the mobile application.

2.5 XGBoost

XGBoost (Extreme Gradient Boosting) is a machine learning algorithm that is an implementation of Gradient Boosting [17], [18]. Although the algorithm is complex and involves many equations, it is essentially based on optimisation and gradient descent. XGBoost aims to minimise the Loss Function (L) by sequentially adding decision trees. The loss function measures how well the model predicts the data [19], [20].

$$L(\phi) = \sum_i l(yi, yi) + \sum_k \Omega(fk) \quad (1)$$

Where:

- l(yi,yi) is a differentiable loss function (e.g., log loss for classification), which compares the prediction yi with the actual value yi.
- $\sum_k \Omega(fk)$ is a regularisation term to control model complexity and prevent overfitting.

The boosting process is essentially finding an additional model (ft) at each step (t) that minimises the error of the previous model (y(t-1)). This discovery is based on the first derivative (gradient) and second derivative (Hessian) of the loss function. [21]. At iteration t, XGBoost uses a second-order Taylor approximation of the loss function to accelerate the optimisation process:

$$L(t) \approx \sum_{i=1}^{n} [l(yi, yi(t-1) + gift(xi) + \frac{1}{2} hift^2(Xi)] + \Omega(ft) \quad (2)$$

Where :

- gi is the gradient (first derivative) of the loss function on the previous prediction.
- hi is the Hessian (second derivative) of the loss function on the previous prediction.

The task is multi-class classification. XGBoost is configured with objective = “multi:softprob”, which produces probabilities for each class. The main evaluation metric during training is multi-class log-loss (mlogloss):

$$\text{mlogloss} = -\frac{1}{N}\sum_{i=1}^{N}\sum_{k=1}^{K} y_{i,k}\,\log p_{i,k} \qquad (3)$$

Where, y(i,k) is the true class indicator for sample i and class k, and p(i,k) is the predicted probability for class k. In addition, merror (multi-class error rate) is also recorded in several sections as a supplement.

3. RESULTS AND DISCUSSION

This research combines Arduino Uno-based hardware (for automated measurements) (Ahmed T, et al., 2023) and a mobile-based application as a user interface and data collection platform into a single, integrated and relatively affordable system.

The technology used in this application is the Arduino Uno, an ATmega328-based microcontroller board (datasheet). This board has 14 digital input/output pins.To support the use of the microcontroller, simply connect the Arduino Uno board to a computer using a USB cable or power it with an AC-DC adapter or battery (Ullah, S, et al., 2025).

3.1 Implemetation

The results of the integration between the Arduino Uno device application will be displayed in the mobile application, as shown in Figure 2 below. After the toddler data collection process is complete, the data will be processed to detect whether the toddler is stunted or normal. All of this will be displayed in the form of information displayed in the mobile application.

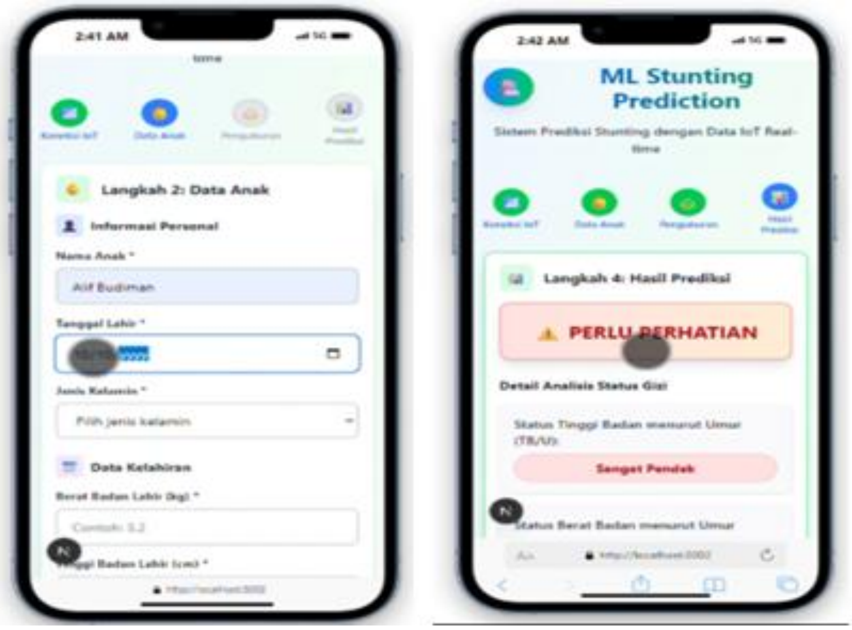

Figure 2. Mobile-based stunting detection application display

The application interface, as shown in Figure 2, includes everything needed to program the microcontroller, such as a USB cable and power supply via an adapter or battery. All of this is provided to support the use of the Arduino microcontroller, which simply needs to be connected to a computer with a USB cable or to a power source with an AC-to-DC adapter or battery to begin use. The Arduino Uno is compatible with shields designed for the Arduino Duemilanove, Decimila, and

Uno (Nugroho et al., 2024). The required raw materials or equipment include hardware such as a laptop or personal computer (PC), Arduino Uno 1.6.5, a SIM900A GSM modem, a data cable for the Arduino, a 16x2 character LCD, nuts and bolts, and a rainbow cable. The required software is Arduino IDE 1.6.5 and Proteus Version 8.1 (16). For toddlers, height and weight measurements are taken to detect stunting using the Arduino Uno, which is connected to the stunting detection application (Ghozali et al., 2024).

3.2 Discussion

This research uses Backend & Frontend development using Noe.js server and Mysql Database, Detection Algorithm development, Education and Health Content. The testing consists of Unit testing, Integration Testing, User Testing (Beta Testing), Security Testing, Performance Testing (Rizaldi et al., 2025). Finally, Launch and Maintenance is Launching Google Play Store, Apple App Store, or as a web application. With this design, the stunting detection application can be developed, tested, and implemented properly, ensuring maximum benefits for its users. The results of this technological innovation can be seen in Figure 3 below:

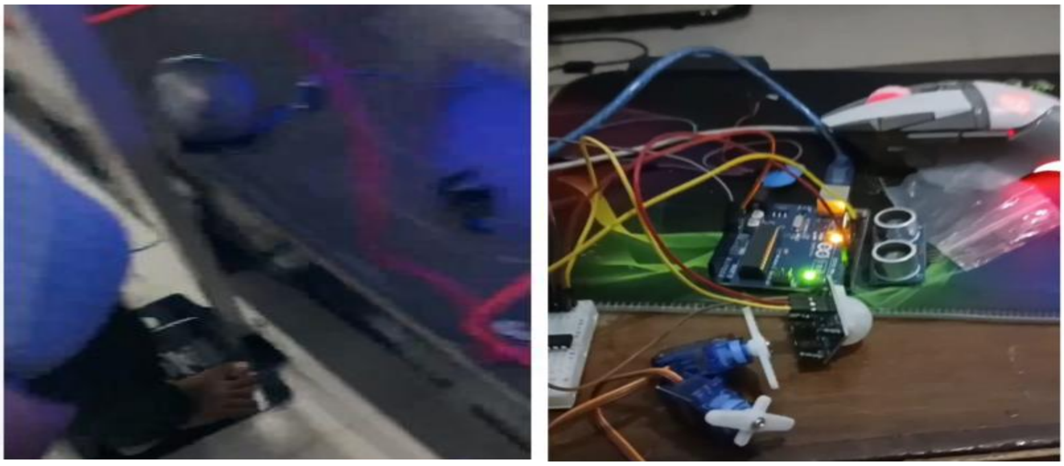

Figure 3. Arduino Uno Design in Height and Weight Measurement

Figure 3 show the design of the Arduino Uno device that is connected to the height and weight measuring device. Arduino Uno has communication facilities with computers, other Arduino, or other microcontrollers. ATmega328 provides UART TTL (5 Volt) serial communication available on digital pin 0 (RX) and pin 1 (TX). Serial communication media via USB uses an ATmega16U2 chip located on the board and appears as a Virtual COM Port (on a computer Device) to communicate with software on a computer (Muliyah et al., 2020).

This study successfully developed three XGBoost-based classification models capable of detecting children's nutritional status with a very high accuracy rate (above 99%). A comprehensive evaluation showed that these models are reliable, stable, and do not experience overfitting, as shown in Table 1 below.

Table 1. Overfitting Gap

Model	**Final Training Accuracy**	**Final Validation Accuracy**	**Difference (Overfitting Gap)**
TB/U	0.995	0.966	0.037
BB/U	0.997	0.979	0.016
BB/TB	0.996	0.964	0.038

Table 1 shows the implementation of the model into a modern and efficient FastAPI, which has proven that the results of this study are ready to be integrated into real-world applications. This system has great potential to assist health workers in conducting stunting screening more quickly and efficiently, supporting stunting prevention efforts in Indonesia.

Evaluation in the Arduino program is an important step in the development of electronic projects that use the Arduino board . It is a process to assess the performance, reliability, and efficiency of the program that has been implemented in Arduino. Evaluation in Arduino programs also plays a role in identifying and solving problems that may arise during project operation (Ardianto, D, et al., 2024). It allows developers to identify bugs and actual results.

The digital height and weight measurement system using the Arduino Uno works by integrating several key components that interact with each other. This process can be likened to a small team working together to produce accurate data. The mechanism begins with a weight measurement when a person stands on a scale. The load cell detects the pressure and converts it into a very small electrical signal. This signal is so weak that it cannot be read directly by the Arduino. This is where the HX711 module plays a crucial role. This module acts as an "amplifier" that receives the signal from the load cell and amplifies it into a strong digital signal. The Arduino Uno then reads this amplified digital signal . However, the read value is still a raw value that needs to be converted. Through a pre-calibration process, the Arduino uses a conversion formula to convert the raw value into common units of weight, such as kilograms or grams.

For height measurements, which are processed when weight is measured, the HC-SR04 ultrasonic sensor plays a role. This sensor sends ultrasonic sound waves upward, which are inaudible to the human ear. These waves bounce back after hitting an object, such as a person's head. The sensor then measures the time it takes for the sound waves to return.

Figure 4. Classification Report

Figure 4 shows a digital height and weight measurement system using an Arduino Uno, which works by integrating several interacting main components. This process can be likened to a small team working together to produce accurate data. For height measurements, which are processed while weight is being measured, the HC-SR04 ultrasonic sensor plays a role (Umiatun, U, et al., 2021). This sensor sends ultrasonic sound waves upward, which are inaudible to the human ear. These waves bounce back after hitting an object.

4. CONCLUSION

This research successfully demonstrated that the integration of Arduino Uno-based hardware and software can produce a functional system. The Arduino Uno hardware is capable of automating anthropometric measurements (weight and height) with greater accuracy than manual methods, thereby reducing the potential for human error. This mobile-based application can predict stunting status with high levels of accuracy, precision, and recall. Its ability to handle complex data and prevent overfitting makes it an ideal choice for healthcare applications. This system not only improves detection accuracy but also accelerates the screening process. With automated measurements and instant analysis, healthcare workers and parents can save time and obtain results quickly. The final validation accuracy shows that the BB/U model = 0.966, TB/U = 0.979, BB/TB = 0.964. These results prove that the XGBoost algorithm is very suitable for detecting stunting in toddlers.

This application makes a significant contribution to stunting prevention efforts in Indonesia.

With this mobile application, parents and healthcare workers can monitor toddler growth independently and regularly, not only during Posyandu (Integrated Service Post) appointments. The early warnings provided by the application enable faster nutritional and health interventions, thereby reducing the risk of long-term growth retardation.

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