Development of Automatic Health Testing Measurement Model for High School Students in West Java

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Abstract. The main objective of this research is to develop the accuracy of health test equipment to measure height, weight, and heart rate to support the qualification of graduation standards at competitions. Any competency competitions that include high school students as participants must be fully followed by students who have qualified passing standards following predetermined conditions in which one of the qualifications is a health graduation test. The focus of the object under study was to obtain the validity of the height, weight and heart rate assessment as the assessment data to measure the health graduation standard in a competency competition. The acquisition of these data will be done by an empirical method of quantitative approaches through comparison techniques, measurement, and calculation technique through field observations. The importance of the three objects of this study was analyzed because it impacts the feasibility of a student to follow the race so it is expected to minimize the of error and cheating. The emergence of these problems cannot be separated from the small standard of accuracy resulting due to how to get data and techniques to operate the system is still manual so often the mistakes and cheats that affect the low quality of the race. Therefore, this study developed a model of automatic health test testers that can be integrated digitally through the touchscreen LCD and smartphone device. The goal is to make it easier for users to operate the system and obtain data access speed with a guaranteed accuracy value of less than 2%. The final result of the test and measurement for 5 students as the object of research showed the average measurement error for height, body weight and heart rate below 2%, so it can give positive contribution and validity of the data that is responsible in determining the graduation of a student candidate competitor of high school student competence. The results of the development of this measuring tool model make it easier for people to know the level of graduation accurately and have an impact on the smaller number of errors during a health test and are able to reduce fraud.

1. Introduction
The main target in this research is to develop accuracy of testing on height, weight, and heart rate in an integrated manner to provide accuracy values in supporting the final results of the medical test that are specific to high school competition activities in West Java. These test values are measured based on the BMI standard values taken from the average value of human body weight.

Indonesia is one of the countries that has the fourth most populated in the world after China, India, and America and almost 40% are in the productive age population where 15% are teenagers who have first and high-level education [1]. These teenagers are important resources for the nation as an investment in the future to produce quality future generations, especially in their skills. Health tests are one of the requirements that must be passed by each prospective participant. The parameters of this test are usually height, weight and heart rate, which is an average measurement method manually [2]. Not all of these assessments can be fulfilled because there are often problems with the accuracy of health testing devices and how to operate them so those accurate testing standards are needed by minimizing
the percent of measurement errors [3]. This problem is the reason in this research, it is necessary
to develop a hardware model of integrated automated health testing equipment for competency
applications for senior high school students. Modeling of measuring instruments has previously been
made and developed such as measuring height, weight, and heart rate even though it is operated
manually. Previous tests showed that the results of the feasibility of height and weight testing were
91.25% [4]. Whereas based on the results of the second research for the same test object, it shows
the results of the percent error respectively 1.90% and 1.75 with the standard feasibility of measuring
instruments by 80% [5]. For other reasearches related to heart rate testing, the results of the analysis
show that the quality of the heart rate can be measured from the intensity of the pulse as an indicator in
determining the condition of heart health independently [6]. The hypothesis he presented will be the
material of development in this study with a different method approach, namely quantitative engineering
methods. The model that will be developed later is expected to provide integrated information related
to important data, namely height, weight and heart rate, which are acquired in realtime and accurately
with a target error rate of under 2%. The goal of this research is to provide ease and speed of access to
data on the final results of the health test process.

2. Method
The method used is an empirical quantitative engineering method that focuses on strengthening the
information data collected based on field observations and comparative studies as a first step in planning
the development of this testing tool model which will be implemented in the form of hardware. Analysis
of the test results is done through a descriptive method approach to map problems that arise
systematically to make them easier to understand. The stages of problem solving in detail can be
described as follows (Figures 1 and 2):

a. Observation of Problems
   At this stage, mapping problems that often arise to identify problems and data requirements needed
   in the process of making a system model.

b. Data Collection
   All data obtained from the field are then grouped based on primary and secondary data sources to
   strengthen existing information. Primary data grouping itself is carried out referring to the results of
direct observation of researchers in the field while secondary data grouping is done referenced from
   the results of comparative studies based on reference sources such as book literature and results of
   studies that have been done before by taking several relevant issues with the object of this research.

c. Design
   The stages of system design start from: first, the selection of electronic component specifications
   according to system requirements. Second, design a drawing scheme and electronic circuit. Third,
   the simulation process. The purpose of this stage is to get the initial shape of the system model before
   it is fabricated into ready-made hardware.

d. System Manufacturing
   The first step is the manufacturing of PCBs from designed electronic circuits. Second, the process
   stage of integrating and connecting between series to make the hardware system in order to get the
   standard test equipment according to the characteristics expected by the user.

e. Testing and Measurement
   At this stage, testing and measurement tools are carried out to obtain certainty and validity of data
   information related to height, weight, and heart rate that determines the feasibility of the system
   model designed.

f. Data Analysis and Processing
   Data from the results of tests and measurements were previously processed and analyzed to
determine overall system performance.

g. System Evaluation
   The system that has been fabricated and tested, the results can be evaluated to obtain feedback from
   users so that in the future it can be further developed.
Literature Review

Collecting data

System Design

Manufacture

Testing and Measurement

Data Processing

Evaluation

- Comparative Study
- Primary Data Source
- Secondary Data Source

- Simulation Design
- Circuit Design
- Hardware Design

- Eligibility of System
- Accuracy Value
- Development of System

Figure 1. Stages Process of Research Method
Determination of component specifications based on the system model designed. There are three stages related to this, such as modeling block diagrams, electronic circuit design and selecting types of electronic components such as ultrasonic sensors, load sensors, pulse sensors, and microcontrollers. These sensors each represent the amount to be tested and measured while the Arduino microcontroller functions as a digital data processor (see Figure 3).

Figure 2. Design System Method
Identification of the ideal height measured can be seen from the size of the standing body position with legs attached to the floor, then the position of the head upright, and height is done in a standing position with a perfect attitude without using footwear as shown in Figure 4. Whereas for identification of testing on body weight the ideal is based on the nutritional value of a person expressed by the Body Mass Index (BMI) as shown by equation 1 [1].

\[
BMI = \frac{\text{Body Weight}}{(\text{Body Height})^2} \quad (\text{kg/m}^2)
\]  

(1)

For heart rate specifications, the calculation process is carried out by taking a sample based on the R-R wave interval of the heart rate signal period which is used to determine the heart rate value per minute as indicated by equation 2 [1].

\[
Heart\ Rate = \frac{60}{\text{Interval R-R}}
\]  

(2)

**Figure 3.** Design Diagram Block

**Figure 4.** Ideal Height Measurement
Modelling and Simulation Test
The specifications of the information data that were received previously were then modeled for the tool structure as shown in Figure 5 and then simulated using a microcontroller software program to be tested and see the ability of the system to produce standard health test values according to the specified specifications. At this stage of the process, the elements involved include software to run the microcontroller, load cell sensor, ultrasonic sensor and fingertip pulse sensor, and several operational amplifiers as signal conditioners. Data processing is performed by an Arduino microcontroller to be displayed on LCDs and smartphone devices.

![Figure 5. Automatic Health Measurement Modeling](image)

3. Results and Discussion
Tests and measurements are carried out to obtain data on the performance of the system designed. From these results will then be discussed and analyzed according to the method used so that it can be concluded the feasibility standard test tool for each object measured based on the results of the calculation of percent error [7, 8].

\[
\text{% error} = \frac{\text{measurable value} - \text{standard value}}{\text{measurable value}} \times 100\% \quad (3)
\]

3.1. Weight Testing
Tests and measurements of the weight of the participants of this competition using a load cell sensor with a maximum weight capacity of 200 kg on the test object of 5 students through a comparison method by comparing the standard digital measuring instrument for manual scales as a reference with a tool designed to determine the percentage of errors according to the limit values listed in Table 1 [9, 10].
Table 1. Body Mass Index Threshold in Indonesia

| BMI Values | BMI   | Categories                      |
|------------|-------|---------------------------------|
| < 17.0     | thin  | weight loss weight level        |
| 17.0 – 18.4| thin  | mild weight loss                |
| 18.5 – 25.0| Ideal | weight ideal                   |
| 25.1 – 27.0| fat   | lightweight overweight          |
| > 27.0     | obesity | overweight weight level    |

In addition to ensuring that accuracy is obtained through a quantitative approach method where equation 3 can be applied based on standardized value information from body mass index criteria as shown in table 1 so that a participant's eligibility can be passed by minimizing errors such as the test results shown in the Table 2.

Table 2. Weight Test Results

| Participants | Weight Measurement Results | Averages (kg) | Error (%) |
|--------------|---------------------------|---------------|-----------|
|              | Data 1 (kg) | Data 2 (kg) | Data 3 (kg) | Data 4 (kg) | Data 5 (kg) |             |           |
| 1            | 53.8        | 53.9        | 53.8        | 53.7        | 53.8        | 53.8        | 0.00       |
| 2            | 55.4        | 55.3        | 55.3        | 55.4        | 55.4        | 55.3        | 0.00       |
| 3            | 50.5        | 50.6        | 50.5        | 50.5        | 50.6        | 50.5        | 0.00       |
| 4            | 47.1        | 47.1        | 47.0        | 47.2        | 47.1        | 47.1        | 0.21       |
| 5            | 55.9        | 55.8        | 55.9        | 55.9        | 55.8        | 55.8        | 0.00       |

The results of the analysis of the test data as in Table 2 above show that as many as 5 times the measurement for each object of repayment produces a maximum error percentage of 0.21% or an average accuracy of 99.8%. Therefore, the error target to be achieved is by below 1%.

3.2. Heart Rate Testing

The technique of measuring the heart rate in this process uses a pulse test through the Pulse Sensor by attaching it to the participant's fingers. The heart pulse signal that comes out of the photoplethysmograph (PPG) is an analog data movement that represents the voltage value. This sensor responds to relative changes in light intensity.

Table 3. Category Human of Heartbeats

| Heartbeats per minute | Status   |
|-----------------------|----------|
| < 60                  | Bradycardia |
| 60 - 100              | Normal    |
| > 100                 | Tachycardia |

If the amount of light on the pulse sensor remains constant, the impact of the resulting signal value will remain constant. This change is seen when more light is detected then the signal will increase (less light intensity). Green LED light as a detection source is reflected to the pulse sensor which changes in each heart rate that is read through an indication of the number of pulses on the participant's finger. When the heart pumps blood, each beat has a pulse wave that is kind of like a shock wave that travels along the arteries to the capillary network where the sensor position is attached. Utilizing this type of light sensor can detect heart rates can be more accurate. Certainty to obtain the value of accuracy used
the comparison method. Digital measuring devices are used to measure blood pressure, blood oxygen levels, and heart rate. The results of testing and measuring the heart rate for 5 participants were shown in Table 4 and Figure 6 [9].

| Participants | Out Amplitude (Volt) | Frequency (Hz) | Period (mS) | Maksimum Amplitude (Volt) |
|--------------|----------------------|----------------|-------------|--------------------------|
| 1            | 4.88                 | 1.41           | 710.4       | 5.00                     |
| 2            | 5.08                 | 1.51           | 664.0       | 5.00                     |
| 3            | 5.08                 | 0.90           | 688.0       | 5.00                     |
| 4            | 4.84                 | 1.13           | 881.6       | 5.00                     |
| 5            | 4.84                 | 1.13           | 881.6       | 5.00                     |

**Figure 6. Heartbeats Testing Grapic**

### 3.3. Height Body Testing

Height testing was carried out using an ultrasonic sensor HC-SR04 which can detect a maximum height of 200 cm and produce accuracy above 90%. The test method is done by testing the calibration of this ultrasonic sensor using a regular meter as a reference measurement tool where the results can be seen in Table 5 and 6, as well as Figure 7 [10].
Table 5. Callibration Linearity Ultrasonic Testing

| Ultrasonic (cm) | Reference Meter (cm) | Percent Error (%) |
|-----------------|----------------------|------------------|
| 10,05           | 10,00                | 0,50             |
| 15,10           | 15,00                | 0,66             |
| 20,16           | 20,00                | 0,80             |
| 25,16           | 25,00                | 0,63             |
| 30,17           | 30,00                | 0,56             |
| 35,20           | 35,00                | 0,56             |
| 40,25           | 40,00                | 0,62             |
| 50,35           | 50,00                | 0,69             |
| 55,40           | 55,00                | 0,72             |
| 70,55           | 70,00                | 0,77             |
| 80,63           | 80,00                | 0,78             |
| 90,75           | 90,00                | 0,82             |
| 100,90          | 100,00               | 0,89             |

Figure 7. Grapic of Callibration Ultrasonic Testing
Table 6. Height Body Testing

| Participants | data 1 (cm) | data 2 (cm) | data 3 (cm) | data 4 (cm) | data 5 (cm) | Average (X) | Percent Error (%) |
|--------------|-------------|-------------|-------------|-------------|-------------|--------------|------------------|
| 1            | 161,60      | 161,80      | 161,40      | 162,10      | 161,80      | 161,70       | 0,21             |
| 2            | 162,10      | 162,00      | 161,90      | 161,90      | 162,00      | 162,00       | 0,00             |
| 3            | 162,00      | 161,90      | 161,90      | 162,00      | 162,00      | 162,00       | 0,00             |
| 4            | 160,90      | 161,00      | 160,90      | 160,90      | 161,00      | 161,00       | 0,24             |
| 5            | 172,30      | 172,30      | 172,00      | 172,00      | 172,00      | 172,12       | 0,06             |

4. Conclusion
The development model of the device can already display the accuracy of height, weight and heart rate data automatically with error percent respectively of 0.37%, 0.21%, and 1%. This device is capable of displaying these data via an LCD touch screen that has many menu choices accompanied by a description of whether or not a prospective participant passed.

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