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Microcontroller-Based Digital Body Height Measuring Tool with Display Information

Dadang Haryanto*[1], Aneu Yulianeu[2], Andri Sukmaindrayana[3], Agus Ramdhani Nugraha[4]

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Abstract: This study aimed to develop a digital body height measuring device using an Arduino Uno microcontroller, featuring an LCD for displaying information. The tool is designed to simplify the height measurement process, making it more practical and yielding more accurate results. The research employed a research and development approach to create products tailored to the identified needs. Data collection involved needs analysis, literature reviews, and small-scale research. The black box testing method was utilized to evaluate the specific functionalities of the software. The results showed that the digital body height measuring tool, equipped with the HC-SR04 ultrasonic sensor, operates effectively with an accuracy rate of 99.73% and a minimal error margin of 0.009%.

Keywords: *arduino uno, body height, digital measuring tool, display information, microcontroller,*

1. Introduction

Height measurement is one of the important physical measurement activities and is needed in various fields, such as health, education, and certain professions [1]. Height is primarily shaped by a combination of genetic and environmental factors. These influences result in noticeable variations between individuals, especially when comparing different genders and ethnic groups [2]. Professions such as the military, aviation, and modeling often set height as one of the main requirements in the selection process. Although important, the use of manual height measuring tools is still widely found, although this method tends to be less efficient and is often prone to human error, both in the measurement process and in reading the results [3].

Most height measuring devices available on the market still rely on manual systems, requiring an operator to perform the measurements and interpret the results. These tools depend heavily on human involvement for both the measurement process and reading accuracy [4]. This manual method often produces less accurate and consistent data, mainly due to human error factors in reading the scale, such as differences in viewing angles when reading or negligence in adjusting the measuring position properly. In addition, when measurements are taken on a large number of individuals, such as in mass health tests, this manual method becomes less efficient because it requires significant time and effort, which can hinder the process and reduce productivity [5].

The development of technology in the field of electronics and communications has opened up great opportunities for the development of measuring instruments that are more accurate and efficient than conventional manual instruments [6]. Innovation in the form of the use of microcontroller-based technology allows height measuring instruments to operate automatically and produce data with a higher level of precision. This digital system is able to eliminate variations in measurement results that often occur in manual instruments due to human error factors. In addition, this technology also reduces operator involvement in the measurement process, thereby increasing the efficiency of time and energy and minimizing the potential for operational errors that can affect the validity of measurement results.

The working principle of the digital height measuring device developed is based on the use of ultrasonic waves with a certain frequency [7]. Ultrasonic waves have the ability to propagate through various mediums, such as liquids, gases, and solids, without disturbing the human hearing system. In this context, a wave frequency of 40KHz and a sound speed of 344 m/s are used to measure the distance of objects with a high degree of accuracy. The measurement process operates by emitting ultrasonic waves towards the subject's head and calculating the time delay between the transmission and the reception of the reflected waves. This time delay, caused by the waves bouncing back from the object, is then used to automatically and accurately determine the subject's height, ensuring precise results without manual intervention.

This height measurement device is built with Arduino Uno as the primary controller, responsible for processing the measurement data. The processed data is then digitally presented on a Liquid Crystal Display (LCD) screen, which is designed to be adjustable, allowing users to easily read the measurement results [8]. With the use of a microcontroller-based system and digital display, this tool is expected to be able to increase the ease and efficiency in the height measurement process, while producing more accurate and consistent data compared to manual measuring tools.

The main objective of this research is to design and develop a digital height measuring device based on a microcontroller that is able to provide measurement result information automatically. With this tool, it is expected that the height measurement process can be done more practically, accurately, and efficiently compared to the manual method that is still widely used today. The implementation of digital technology in this tool aims to minimize human error, speed up measurement time, and increase the consistency of results, so that it can provide significant benefits in various applications, including mass health checks and candidate selection for certain professions.

2. Literature Review

With the continuous progress in science and technology, numerous innovations in microcontroller technology have surfaced. These advancements are motivated by the growing demand for systems that can streamline real-world applications. Among the fastest-evolving platforms is Arduino, which has the capability to convert traditional systems into more automated and efficient solutions [8]. With today's technological advances, the operation of electronic devices is becoming easier and more practical [9]. Therefore, the creation of a height measuring device based on the Arduino Uno microcontroller with a digital display is expected to simplify the measurement process, make it more practical, and produce more accurate and consistent data [10].

2.1. Concept of Microcontroller

A microcontroller is a compact computing system where the majority, if not all, of its components are integrated into a single IC (Integrated Circuit) chip, often earning it the nickname "single-chip computer." The microcontroller circuitry comprises an IC along with several additional supporting components, enabling it to operate effectively [11].

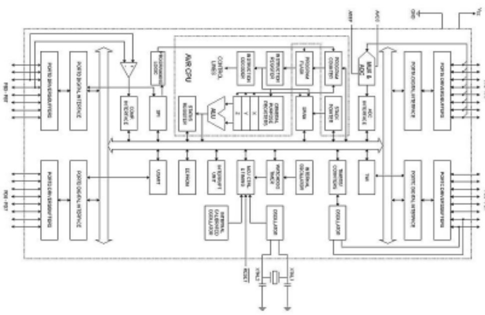

Fig. 1. Microcontroller Architecture

Microcontrollers are innovations in microprocessor and microcomputer technology that are present to meet market needs [12]. This technology uses the latest semiconductor technology, which allows the use of more transistors in a smaller space. In addition, microcontrollers can be mass-produced at a more affordable price, making them accessible to a wide range of people [13-16]. Therefore, microcontrollers are very suitable for controlling various devices that are more sophisticated than PC computers, thanks to their high effectiveness and flexibility [17].

2.2. Arduino Uno Microcontroller Module

The Arduino Uno microcontroller module was developed in 2005 by Massimo Banzi, David Cuartilles, Tom Gianluca, David A. Mellis, and Nicholas Zambetti. The programming language used for Arduino is based on the wiring platform and is influenced by the processing language [18]. The wiring platform, developed by Hernando Barragan in 2003, laid the groundwork for Arduino, while the processing language was created by Casey Reas and Benjamin Fry in 2001. Arduino operates under a standard open-source license that encompasses hardware components (such as circuit schematics and PCB designs), bootloader firmware, documentation, and software. To facilitate programming, the Arduino Integrated Development Environment (IDE) serves as the application used for coding [19].

Fig. 2. Arduino Uno Microcontroller Module

The height measuring device is developed using an Arduino Uno, a microcontroller board powered by the ATMega328 chip. This chip enables the board to efficiently process data and control various components of the device [20]. The Arduino Uno board comprises 14 digital input/output pins, of which 6 are capable of functioning as PWM outputs, in addition to 6 analog input pins. It is outfitted with a 16 MHz ceramic resonator, a USB interface, a power jack, an ICSP header, and a reset button. The board can be powered by connecting it to a computer using a USB cable or by utilizing an external power source, such as an AC-DC adapter or battery [21]. The Arduino Uno communicates with the computer through a USB (Universal Serial Bus) serial port, enabling bidirectional data exchange. This setup allows the Arduino Uno to receive data from the computer as well as transmit data back to it [22]. The primary distinction between the ATMega8535 and ATMega32 is in their flash memory capacity. The ATMega8535 is equipped with 8 KB of flash memory, whereas the ATMega32 offers a significantly larger capacity of 32 KB of flash memory [23].

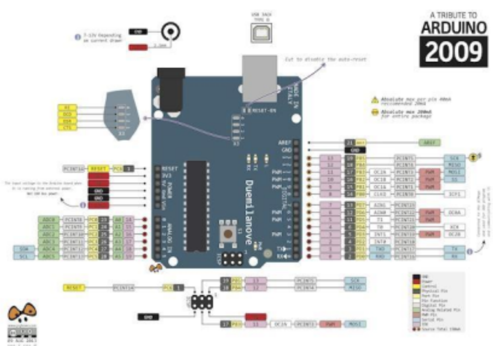

Fig. 3. Arduino Uno Microcontroller Architecture

The Arduino Uno features 14 digital pins, which can operate as either input or output. It also includes a 16 MHz crystal oscillator, a USB port, a power jack, an ICSP header, and a reset button. Operating the Arduino Uno is straightforward: it can be powered by connecting it to a computer with a USB cable or by utilizing an AC-DC adapter or a battery. The board is designed to automatically switch between USB power and an external power supply depending on what is available [24]. The Arduino Uno board is designed to operate within a power supply range of 7 to 12 volts. If the input voltage falls below 7 volts, the 5V pin may function, but it could experience instability. On the other hand, supplying more than 12 volts may cause the voltage regulator to overheat, which could result in damage to the board. For programming, the Arduino Uno employs the C programming language, along with the Arduino Integrated Development Environment (IDE), which is used for writing, verifying, and uploading code [25].

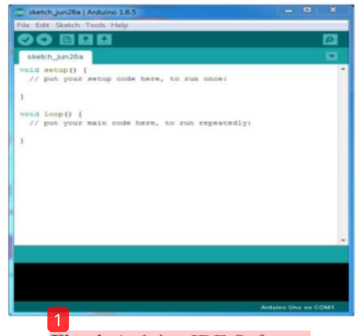

Fig. 4. Arduino IDE Software

2.2. Ultrasonic Sensor Module

Ultrasonic sensors are used to provide feedback to control systems by detecting the output through sound wave reflection [26]. These sensors function by converting sound waves into electrical signals and vice versa. The principle behind ultrasonic sensors is fairly straightforward: they emit ultrasonic waves, which are reflected off objects, allowing the sensor to calculate the distance to the object based on the time taken for the wave to return. A piezoelectric device generates these ultrasonic waves, typically with frequencies between 40 kHz and 400 kHz.

Fig. 5. Ultrasonic Sensors

The piezoelectric crystal in the sensor contracts or expands depending on the polarity of the applied voltage, a phenomenon known as the piezoelectric effect. These changes cause a diaphragm to vibrate, which in turn emits ultrasonic waves into the surrounding air. When the waves hit an object, they are reflected back to the sensor's receiver, causing the diaphragm to vibrate again and generate an electrical signal with the same frequency as the original wave.

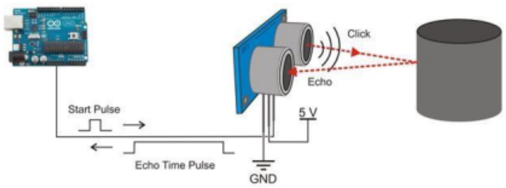

Fig. 6. Ultrasonic Sensor Working Principle

The intensity of the electrical signal generated by the receiving sensor is influenced by the distance to the detected object as well as the effectiveness of the transmitter and receiver sensors. By utilizing the reflection method, the sensor measures the distance by timing how long it takes for the ultrasonic wave to travel to the object and return. This distance is calculated using a formula that considers the speed of sound in air along with the total time taken for the wave's round trip.

The Liquid Crystal Display (LCD) is an electronic display that functions using CMOS logic technology; it does not emit light independently but relies on an external light source for visibility. Instead, it reflects ambient light in the case of front-lit displays or transmits light from a backlit source. The primary function of an LCD is to present data visually, such as characters or letters [27]

$$s = 0{,}5.v.t$$

Information:

s = distance between the object and the sensor (m)

v = speed of sound in the medium is 344 m/s

t = travel time (seconds)

2.3. Liquid Crystal Display (LCD) Modules

The Liquid Crystal Display (LCD) is a type of electronic display that operates using CMOS logic technology, which does not produce light on its own. Instead, it reflects ambient light in the case of front-lit displays or transmits light from a backlit source. The primary function of an LCD is to present data visually, such as characters or letter [27].

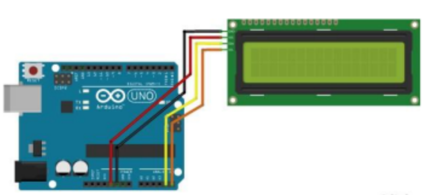

Fig. 7. Liquid Crystal Display (LCD)

An LCD consists of a layer of organic material placed between two transparent glass plates with indium oxide electrodes. These electrodes form segments, such as in a seven-segment display. When voltage is applied, the long organic molecules align themselves according to the electric field, allowing light to either pass or be blocked. The display includes a vertical light polarizer in the front and a horizontal one in the back, along with a reflective layer. The sections where light is blocked appear dark, forming the desired characters on the screen.

In the LCD module, a dedicated microcontroller manages the display of characters by utilizing various types of memory. These include Display Data Random Access Memory (DDRAM), which stores the characters to be displayed, Character Generator Random Access Memory (CGRAM) for creating custom characters, and Character Generator Read Only Memory (CGROM), which contains predefined character patterns. Additionally, the microcontroller controls a command register to receive instructions and a data register to handle the character data [28]. LCD modules have various control pins, such as the RS (Register Select) pin, which distinguishes between command and data input, and the R/W (Read/Write) pin, which determines whether the module is reading or writing data. Additionally, the E (Enable) pin regulates data transfer, while the VLCD pin controls the display's brightness. The module operates with a power supply voltage of 5 volts.

3. Literature Review

The research employed a research and development (R&D) methodology aimed at creating new products based on the findings of the study [29]. The creation of these products was motivated by a thorough needs analysis. The research process and data collection involved performing a needs assessment, reviewing pertinent literature, and executing small-scale studies. In the planning stage of the research, specific objectives were set, and the required resources were identified. The initial stages of product development included designing the product, outlining the development processes, and identifying the facilities and infrastructure needed for testing. Field testing involves evaluating the effectiveness and adaptability of the product designs by engaging with users. The testing utilized the black box testing method, which is designed to test the functionality of the software without considering the internal processing [30]. This method focuses on the output generated from specific input conditions and evaluates whether the software meets the intended functional requirements. By analyzing the output, researchers were able to assess the program's ability to meet user needs and identify potential errors in the system.

3.1. Body Height Measuring Tool Block Diagram

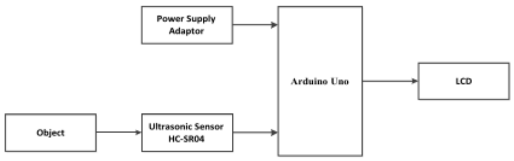

Fig. 8. Schematic Block Diagram

The body height measuring device functions by utilizing a sensor to ascertain an individual's height. Below is a block diagram illustrating the hardware design of this device. The system features an input component, specifically the HC-SR04 ultrasonic sensor. This sensor gathers measurement data, which is subsequently processed by the Arduino Uno microcontroller. The processed data is then displayed on a Liquid Crystal Display (LCD), allowing the user to view the final measurement result.

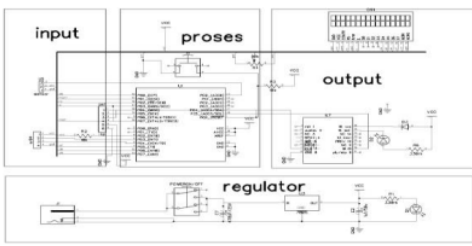

Fig. 9. Architectural Schematic Block Diagram

4. Results and Discussion

4.1. System Analysis Results

Traditionally, body height measurement is still conducted manually using various types of tools and materials. Most commonly used height measuring devices are not automated. There are several ways to measure height manually, such as using a measuring tape or a ruler mounted on the wall. Various types of height measurement devices that are often encountered include wall-mounted rulers, jungle-themed height charts, Nordic growth charts, and stature meters.

4.2. Analysis of Tools and Materials Used in Research

Before initiating the research process, it is crucial to assemble and prepare all necessary tools and materials to ensure a seamless workflow. The development of a height measuring device requires various electronic components, such as a 16x4 Liquid Crystal Display (LCD), a potentiometer, an Arduino Uno microcontroller, and an HC-SR04 ultrasonic sensor. Evaluating the equipment requirements encompasses both hardware and software elements. A computer is essential for uploading the program codes to the Arduino Uno microcontroller, which acts as the central controller for the entire system, connecting all electronic components. The Arduino Uno features ports for linking the HC-SR04 ultrasonic sensor module and the LCD using jumper wires. The HC-SR04 ultrasonic sensor functions as a distance measurement tool, sending and receiving ultrasonic waves to accurately measure distances. The LCD serves as the output display, showcasing the measurement data processed by the microcontroller. A potentiometer is employed to adjust the voltage and contrast of the LCD, ensuring clear visibility of the information displayed. Furthermore, an adapter is necessary to supply power to the Arduino Uno microcontroller. The Arduino IDE software functions as a coding platform, allowing for error checking and compilation of the code before it is uploaded to the Arduino Uno via a USB connection. This thorough arrangement guarantees that all components operate cohesively, enhancing the overall functionality of the device.

4.3. Design Results of the Height Measuring Tool

The design phase concentrates on creating a prototype of the height measuring device, which will later be implemented. This design process is crucial for optimizing the tool's construction, as it precisely outlines the materials and components needed to build the height measuring device. By specifying the necessary specifications and configurations during this phase, the likelihood of overlooking any critical elements is minimized, thus streamlining the transition to the assembly stage. This thorough preparation ensures that the assembly process can proceed efficiently and effectively, ultimately leading to a functional prototype ready for testing and refinement.

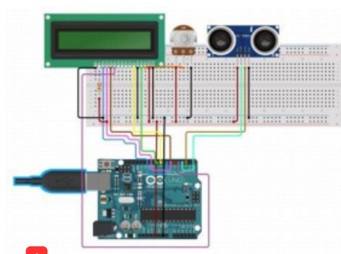

Fig. 10. Body Height Measuring Tool Design

In the design of the body height measuring tool, as illustrated in Figure 6, the components used include a 16x4 Liquid Crystal Display (LCD), a potentiometer, an Arduino Uno microcontroller, an HC-SR04 Ultrasonic Sensor, and a breadboard. These components work together to measure and display body height accurately.

Table 1

. Tool Testing Results Against Object

No	Body Height Manual (cm)	Gender	Body Height On Tool (cm)	Error (cm) cm	%
1	172	Man	174	+2	0,012
2	155	Woman	156	+1	0,006
3	165	Woman	167	+2	0,012
4	164	Woman	165	+1	0,006
5	169	Man	170	+1	0,006
6	175	Man	176	+1	0,006
7	170	Woman	172	+2	0,012
8	167	Man	168	+1	0,006
9	150	Woman	152	+2	0,013
10	173	Man	175	+2	0,012
		Average		+1,5	0,009

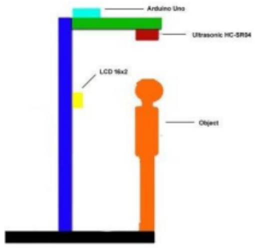

Fig. 11. Body Height Measuring Tool Prototype Design

4.4 Results of Installation of Materials and Tools to the Arduino Uno Microcontroller

The components are connected to the Arduino Uno microcontroller using jumper cables to establish proper connectivity. The +5V (VCC) pin on the Arduino Uno is connected to terminal 1 of the potentiometer, which regulates the positive voltage, while the Ground pin is linked to terminal 3, managing the negative voltage. Terminal 2 of the potentiometer is connected to the VEE pin of the LCD, allowing for adjustments to the display's light intensity. Additionally, the HC-SR04 ultrasonic sensor is connected to the Arduino Uno through jumper cables, utilizing its four essential pins: VCC for power, ECHO for receiving the signal, TRIG for sending the trigger signal, and GND for grounding. This configuration ensures that all components function correctly and effectively within the system.

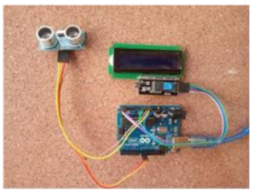

Fig. 12. Results of Installation of Tools and Materials

4.2. Results of Body Height Measuring Tool Test

The testing of the body height measuring tool utilized the Blackbox testing method, which focuses on evaluating the system's output based on various input data without examining the internal workings of the software. This approach is essential for assessing the tool's functionality and ensuring that it operates as intended. By observing the execution results against expected outcomes, this testing method helps to identify any discrepancies or errors in the measurements, thereby validating the reliability and accuracy of the height measuring device. If errors are detected, the magnitude of the error in the tool's performance can be assessed. The tool was tested directly on 10 individuals. After conducting tests on 20 people, the results were compiled and are presented in Table 1.

5. Conclusion

The analysis and findings regarding the digital body height measuring tool based on the Arduino Uno microcontroller reveal that the device, which utilizes an HC-SR04 ultrasonic sensor, effectively functions as a substitute for traditional manual height measurement techniques. The research and subsequent testing indicated that this tool operates proficiently, achieving an impressive accuracy of 99.73% and a minimal error margin of just 0.009%.

In terms of future developments, this body height measurement tool holds potential for further enhancements. One possible extension could involve integrating voice commands to improve user interaction. Additionally, the device could be refined to allow data transmission via smartphones or computers, enabling measurements to be stored in a database for easy access and analysis. These improvements could broaden the tool's applicability and ease of use in various settings, making it a more versatile solution for height measurement tasks.

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PAGE 1

Article Error You may need to use an article before this word. Consider using the article **the**.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

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P/V You have used the passive voice in this sentence. You may want to revise it using the active voice.

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PAGE 3

Wrong Form You may have used the wrong form of this word.

Article Error You may need to remove this article.

Proper Nouns You may need to use a capital letter for this proper noun.

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Possessive Review the rules for possessive nouns.

P/V You have used the passive voice in this sentence. You may want to revise it using the active voice.

Proofread This part of the sentence contains an error or misspelling that makes your meaning unclear.

Missing "," Review the rules for using punctuation marks.

PAGE 5

Missing "," Review the rules for using punctuation marks.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Wrong Article You may have used the wrong article or pronoun. Proofread the sentence to make sure that the article or pronoun agrees with the word it describes.

Proofread This part of the sentence contains an error or misspelling that makes your meaning unclear.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

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Possessive

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Confused

Article Error You may need to use an article before this word.

PAGE 6

Missing "," Review the rules for using punctuation marks.

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Missing "," Review the rules for using punctuation marks.

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