



Automated Body Mass Index Calculator with Dietary Indication

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ABSTRACT

Body mass index, or BMI, is a weight-to-height measure of body ratio and can provide insight into disease risk. This paper focuses on creating an automated body mass index calculator with dietary indications, which will automatically measure, calculate, and monitor a user's BMI, provide a proper dietary indication, and send an email reminding the user of the next scheduled BMI check. This study comprises a Raspberry Pi, Arduino Uno, sensors, and modules. Python is the language used in writing the software, while the database management system utilized is MySQL. Upon deployment of the system at the University of Mindanao, students, employees, and visitors served as users. Results show that the system helped users maintain their BMI through dietary indication. The system also encourages users to check their BMI monthly through email reminders. With the use of a two-sample t-test, results taken from 20 individuals showed that there was no significant difference between the standard and system-generated BMI data. Thus, the automated BMI calculator with dietary indication was accurate in reading and computation.

Keywords: *body mass index, dietary indication, email reminder, height, weight.*

INTRODUCTION

Body mass index, or BMI, is the usual method for obesity measurements. It is a weight-to-height measure ratio and can provide insight into disease risk. Although BMI is inapplicable as a single disease risk indicator, it does help. It is one of the health aspects that help physicians treat possible diseases. However, it becomes a struggle for people to measure their BMI values because of little to no time, and not everyone owns a weighing scale and a measuring tape (Haritosh et al., 2019).

Nowadays, most major health associations generally use BMI as the first-level measure of adiposity. As a screening device, BMI is easy to calculate from measured or self-detailed weight and height. It is a generally used method due to its cheapness and simplicity of computing health risks (Gonzalez, Correia, & Heymsfield, 2017). The formula for BMI is kg/m^2 , defining body fat classification in different countries, populations, races, and ethnicities (Misra & Dhurandhar, 2019). The rapid growth of science and technology led to automating the conventional ways people complete their tasks efficiently, increasing the level of productivity and the effectiveness of doing work. The automation of measuring BMI is made possible through technologies like the



ultrasonic sensor (height) and the load cell (weight) (Musta et al., 2018). A previous study shows that an HC-SR04 Ultrasonic Sensor can be used as a height detector and can measure a distance from 2cm to 400 cm. It contains a transmitter, receiver, and control circuit (Sreeja, 2018). Another study uses a laser to measure and is attached to the extended upper plane surface. The laser device is placed at the end of the plane surface to proximate its measurement. A data collection device is electronically attached to receive signals from the laser measurement device (16/217582, 2018). An application of the load cell is when researchers from the University of College Cork used a load cell to develop a system that monitors the bee colony's health through the weight of its beehive (Fitzgerald et al., 2015).

Furthermore, another study measures a person's BMI using a PIC18F452 microcontroller. It used a weighing scale to acquire the person's weight, while the person's height was measured using a Light Dependent Resistor (LDR). The microcontroller processes the values obtained, and on an LCD screen, it displays the BMI result. The GSM module sends a message containing the BMI results to the person (Dipika, 2015). Another study, conducted at the Lyceum of the Philippines University, measured BMI. The project used equipment instruments incorporating an ultrasonic proximity sensor, weight sensor, Gizduino ATMEGA328, and sensor amplifier. While for the software necessities, it consists of Windows 7, SQL Server Management Studio, Microsoft Visual Studio (.NET), Microsoft Visual Studio, and Arduino (Baladad et al., 2016).

Although numerous systems for automating BMI are present, limitations are still evident. Automated calculators were only able to calculate BMI; but no proper dietary indications were given to the user. Another limitation is that users are unaware of when they should check their BMI next, leading them to forget it. These factors motivated the researchers to proceed with the study.

This study aimed to create a device that automatically calculates the user's BMI, provide analysis and a dietary indication directed to the user through email, and send an email reminder weekly. The subsequent BMI checking is a day before the scheduled date for the user. To achieve the general objective of the study, the researchers set the following specific objectives: (1) design and fabricate a device that measures users' height and weight; (2) create software that computes a user's BMI and classify it, provide analysis and send the dietary indication to the user through email, and send an email reminder a week and a day before the scheduled date for the user's subsequent BMI checking; and (3) conduct a statistical analysis on the system's accuracy.

This study plays a significant role for people without much time to manually check their BMI and are unaware of a proper diet and often forget to check their BMI regularly. The following statements are the constraints that help researchers discard irrelevant undertakings that can hamper the study's progress. The subjects of the study were composed of users only within the range of 5 to 7 feet in height. The system's design could only accommodate users within the given height range. This study only focused on measuring and calculating a user's BMI to classify it to its respective BMI range and provide a dietary indication. Thus, its scope only applies to BMI alone. Predicting



disease risks, fat mass, and fat-free mass is out of grasp and, therefore, should not be relied on by the system.

METHOD

Research Design

Used in this study was an applied research approach. Before the fabrication, a trade-off between the two designs was made concerning sustainability, manufacturability, economics, and usability. The analysis established the best design based on the study's objectives.

Hardware Design

An HC-SR04 Ultrasonic Sensor Module was used as a height sensor because it is easy and cost-efficient (Kim & Choi, 2016). Attached at the top of the hardware's pole was a flat rectangular containing the sensor. A four-wired load cell, with two excitation wires (power and ground) and two signal wires (positive and negative signal), was used as the weighing sensor of the system (Xiu & Yang, 2018). It has a maximum weight capacity of 200 kilograms, which was suitable for the system. The HX711 served as the load cell amplifier. HX711 amplifies the signal from the load cell into the Arduino Uno. It increases the accuracy of reading the strain gauge resistance (Hanumyahaya et al., 2019). The system uses an RC522 RFID Reader Module as the system needs a login feature using the RFIDs of users. It can read the data inside the RFID cards in its range (Chatterjee et al., 2019). The Arduino receives value from the load cell and sends it to the Raspberry by serial communication. The connection between the two is a USB cable (Tank et al., 2017). Since the system needed a device that could communicate with sensors, store information in a database, and display the necessary data, using Raspberry Pi is the recourse.

Software Design

The programming language is Python, and Tkinter is used for the system's Graphical User Interface (GUI). Python was the best language because the system used a Raspberry Pi (Ball, Naik, & Jenkins, 2018). The database management that is used by the system is MySQL. The application is utilized for various purposes, including information warehousing, online business, and logging applications. The most widely recognized use for MySQL, in any case, is with the end goal of a web database (Zhang, Ning, & Yang, 2016).

Methods and Procedures

The system starts with the idle home page, where the user can choose to close the program or not. If the user closes the program, it will automatically terminate and close upon pressing the X (close) button. If the user chose not to end the program, it would simultaneously detect RFID within the RC522 RFID Reader Module range and check the dates on the database. The system endlessly monitors the dates on the database to identify the user/s who is/are scheduled a week and a day before their BMI checking. Once identified, the system will send an email reminder to the user indicating his BMI checking schedule. At the same time, if an RFID is detected, it will check whether it is



already an existing user. The user will proceed to the login menu if it is already registered. If the RFID is not registered, the user will be asked to input the necessary information and be directed to the login menu afterward.

The user can go directly to the BMI menu on the login menu, view their previous data in a graph, or log out. On the BMI menu, obtaining the user's height and weight takes place. The system will compute it to identify the BMI, BMI class, target BMI, and target weight of the user, which will display on the LCD screen. BMI is calculated based on the weight in kilograms divided by height in meters squared. Table 1 is used to classify the user's BMI based on standards. The basis of the classification is the standards of the World Health Organization. Suppose the user is unsatisfied with the results and wishes to repeat the process, a reset button is available that will clear the data so that the user can go back to checking height and weight. Once satisfied with the results, the user can proceed and view the dietary indication or go back to the login menu.

Upon viewing the dietary indication, the user can now choose whether to save the BMI data, email the BMI data, or go back to the BMI menu. If the user decides to save the BMI data, the program will identify first if the previous BMI data saved has been kept 28 days ago or not. If yes, the BMI data will be saved directly to the database. If not, the system will ask the user to overwrite the previous BMI data or not. If the user chooses yes, it will proceed to overwrite the last BMI data and save the new one. If the user selects no, it will continue displaying the dietary indication. Suppose the user chooses to email the BMI data. In that case, the user's email address will be acquired, and the BMI data will be automatically sent through email. If the user decides to return, the display will return to the BMI menu. On the BMI menu, the user can choose to view the previous BMI data, wherein a graph will be displayed containing the monthly BMI data of the user. The graph helps the user to compare monthly BMI data and identify changes in the user's BMI. Afterward, the user can go back to the login menu, wherein the user can log out, and the display will return to the idle home page.

Table 1
BMI Classification based on the Standards of the World Health Organization

BMI VALUE	CLASSIFICATION
less than 16.5	Malnourished
16.5 - 18.4	Underweight
18.5 - 24.9	Normal
25 - 29.9	Overweight
30 and above	Obese

RESULTS AND DISCUSSION

Actual Design of the Automated BMI Device

Figure 1 shows the system's hardware containing the components used in calculating the height and weight of the user and the black box containing the other components used by the system. The rectangular enclosure containing the ultrasonic sensors can be automatically adjusted depending on the height range of the user. The device's platform can withstand a maximum capacity of 200kg, which is also the maximum capacity of the load cell. All data are displayed on the 7-inch touchscreen LCD.



Figure 1. Sample Photo of the Actual Device



Software Design of the BMI System

The second objective of this study is to create software that will compute and classify a user's BMI. It provides analysis and a dietary indication a user can receive through email. It sends an email reminder a week and a day before the scheduled date for the user's subsequent BMI checking.

Shown in Figure 2 is the BMI Menu GUI of the system. The BMI menu contains a user has acquired height and weight, displayed together with the computed BMI, classification, and analysis (if applicable). The analysis only applies to BMI classifications under OBESE, OVERWEIGHT, UNDERWEIGHT, and MALNOURISHED. The analysis provides the user with an ideal weight and BMI to achieve a normal BMI classification.

The BMI classification and age determine the dietary indication suitable for the user. The user's age is considered in providing a correct dietary indication because the body's need always depends on the person's age. Shown in Figure 3 is the identified proper dietary indication of the system based on the user's BMI classification and age.

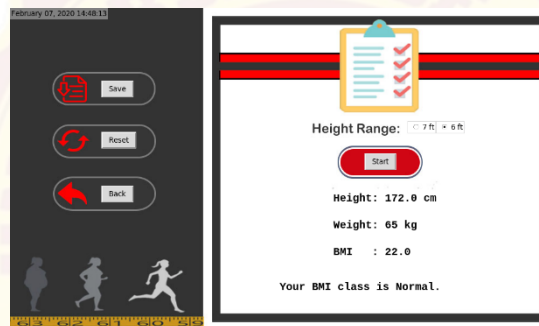


Figure 2. The User Interface as Displayed on the Device's LCD Screen

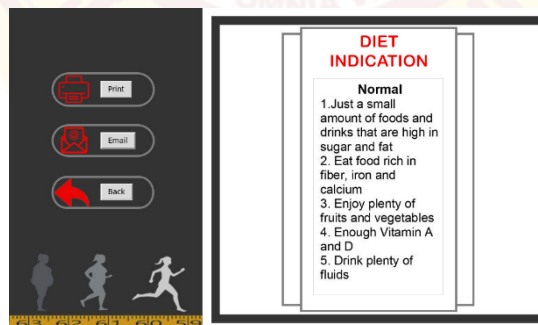


Figure 3. Dietary Indication based on the Resulting BMI Classification

Another feature of the software is sending the user's BMI data and dietary indications through email. This feature helps the user record their BMI data and obtain a copy of the dietary indication, which they can use as a guide in achieving a healthy and normal body and BMI. Shown in Figure 4 is a sample email containing the BMI data and dietary indication of the user.



Figure 4. Dietary Indication based on the Resulting BMI Classification

The last feature of the software system is an email reminder. An email reminder is sent to the user to inform them of their following schedule for BMI checking since the user's BMI is set to check once a month. The system sends an email reminder a week and a day before the schedule.

Shown in Figure 5 is a sample email reminder for a user scheduled for a BMI check in a week. It contains the notice that the user is scheduled for another BMI. On the other hand, shown in Figure 6 is a sample email reminder for a user scheduled for a BMI checking in a day. It also contains the notice that the user is scheduled for another BMI, including the date and place.

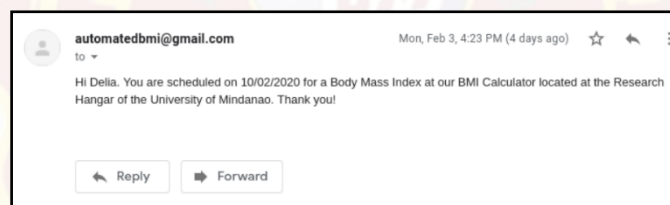


Figure 5. Sample Email Reminder (a week before)

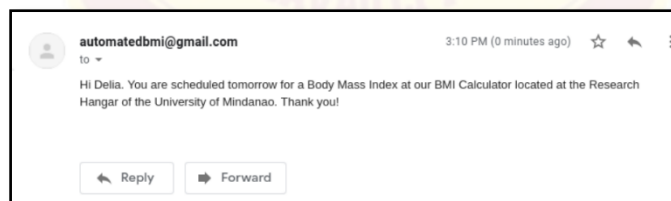


Figure 6. Sample Email Reminder (a day before)

Functionality Testing and Analysis

Data were gathered from the 20 subjects. The subject's actual weights were acquired manually using a weighing scale. In contrast, the actual heights of the subjects were measured through a measuring tape. The corresponding BMI value was manually computed based on the standard BMI formula. Afterward, the system-



generated BMI data were also acquired. The 20 subjects used the device, and their heights and weights were measured. The BMI data were also automatically computed and recorded.

The comparison of the standard and system-generated BMI data is illustrated through a box plot in Figure 7. The graphical representation shows that the standard and system-generated BMI data have little to no difference, indicating that the system-generated calculations were accurate. A two-sample t-test was made, and it showed that the results of both devices were the same.

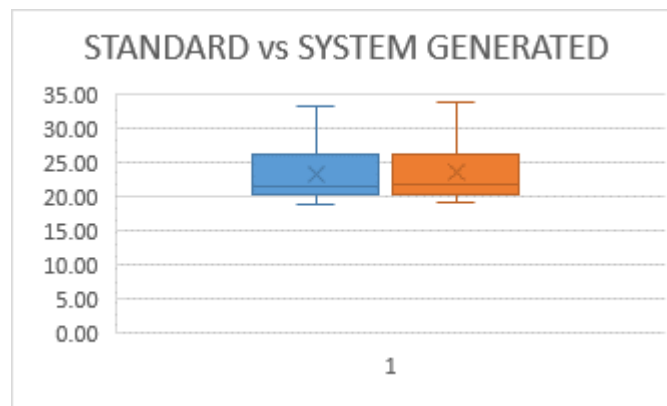


Figure 7. Box Plot Representation of the BMI Data of the 20 Subjects on Standard and System Generated

CONCLUSION

In conclusion, an automated BMI calculator was successfully built and could measure the users' height and weight efficiently, which benefited every user. It was also able to accurately compute the BMI, provide a correct analysis, and provide an appropriate dietary indication for the users. The dietary indications were beneficial to users in maintaining or obtaining their desired BMI value. The email reminder was also a great aid to the users as they were able to check their BMI because it was regularly.

For future work, it would be better to create a more efficient height sensor for the system wherein users do not need to adjust the hardware manually. Since the present study only used an ultrasonic sensor with difficulty reading the top of the head, we recommend using other sensors.

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