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Automated Body Mass Index Assessment Device

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ABSTRACT: Sedentary lifestyles of many individuals have made them prone to many health risks ranging from diabetes, High Blood Pressure (HBP), obesity and other cardiovascular diseases. One simple and smart way of verifying a risk factor is a knowledge of the Body Mass Index (BMI) of an individual. This project aimed at designing and developing anAutomated Body Mass Index Assessment Device to measure and display the BMI of persons. BMI is calculated using the knowledge of the mass or weight in Kilograms and height (squared) in square-meters of the individual. This device is composed of a MHT1, miniature high-capacity compression force transducer which is the load cell, which converts the compression force of the weight to electrical signal, and a HC-SR04 ultrasonic sensor, a distance sensor with the ability to sense objects 13 feet away for the height measurement. These data are routed to the Arduino Nano microcontroller in which the algorithm for the BMI calculation has been programed using C++. The calculated BMI is channeled to the LCD for visual display with prompts for possible action. Application results shows very accurate outputin comparison to approved conventional methods of BMI measurement.

Keywords: sedentary lifestyles, Body Mass Index (BMI)

I. INTRODUCTION

Sedentary lifestyles viz as viz inactivity, lack of exercise and poor diet (nutritional intake) have contributed to an astronomical increase in many chronic nutritional-health diseases and challenges like diabetes, obesity, and cardiovascular diseases and hypertensionwhich have negatively imparted on the life of many individuals, their finances, general wellbeing and even reduction in the economic manpower of the nation, needless to say its toll on the already shaky healthcare system of the country.

The most common means of evaluating a person's health status by establishing the risks factors imminent occasioned by these unhealthy lifestyles is the measurement of the Body Mass Index (BMI) of an individual. The BMI is one method of measuring the body composition thus a veritable tool in indicating the obesity status of persons (Jilantikiri et al. 2022).It is a noninvasive method employed to measure the body fat. It is the ratio of a person's weight (measured in kilogram, Kg) to the square of the person's height measured in metres (m) and can be mathematically represented as

$$\text{Body Mass Inex (BMI)} = \frac{\text{Weight (in Kg)}}{\text{Height (in m}^2)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Thus, the BMI is measured in Kg/m^2. BMI as a measure of the body fat level of a person is computed using the height and weight of a person andrelated to the age of the person. It determines the distribution of the body mass of the person with its height(Madariaga and Linsangan, 2016).Measuring the amount of body fat is vital in understanding the health of an individual in relation to the disease risk the individual is exposed to(Omair et al, 2017).A high BMI poses a great health risk to a person. Through these measurements health officials can determine different health risk related to weight, advice accordingly as well as recommend other health screening to the person, a nutritionist can recommend on the diet of a person and a fitness expert can advice on proper exercise and fitness regime for a person.

Presently, in many health facilities in Nigeria, Nurses and healthcare officials determine the BMI by means of a weighing scale which tells the weight of the person and taking the height by means of a meter rule on a wall and then using a calculator to do the calculation. This method is not only bulky, strenuous and time consuming but is also prone to errors. Hence the need for an automated system which can carry out the measurements simultaneously yet seamlessly and compute the BMI and then display say on a

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readable LCD for easy access. Hence, we propose an Automated Body Mass Index Assessment Device.

II. LITERATURE REVIEW

(Madariaga and Linsangan, 2016) computed the BMI using an Android tablet by obtaining the height of the person using a camera and measuring the weight of the person using a weighing scale or load cell. The person's height was estimated by applying background subtraction to the image captured and applying different processes such as obtaining the vanishing point and applying Artificial Neural Network. The weight was measured using Wheatstone bridge load cell configuration and sending the value to the computer using Gizduino microcontroller and Bluetooth technology after the amplification using AD623 instrumentation amplifier. The application then process the images, reads the measured values and shows the BMI of the individual.

(Omair et al, 2017) developed an automated BMI measuring device using load cells, ultrasonic sensor and PIC microcontroller. The height and weight data were collected from 18 to 75 years old random 100 subjects, 68 males and 32 females, using both analogue and designed digital prototype. The mean analog readings of weight, height and BMI of the studied population were 65.75±14.78 Kg, 1.65±0.1 m, and 23.93±4.34 Kg m-2 respectively. The analog data readings are relatively in agreement with their counterpart digital mean value of weight (62.14±12.92 Kg), height (1.58±0.093 m), and BMI (25±4.65 Kg m-2). The correlation coefficient of the designed BMI instrument and the analog readings has shown the accuracy of 97.9 % (weight), 95.1 % (height) and 97 % (BMI).

(Baladad et al, 2016) carried out a study to calculate the weight and height measurement and display its BMI measurement automatically upon entering in the system jamb and save the BMI measurement in the system's database. The design combined the functions of aultrasonic proximity sensor and weight sensor in one system and developed software embedded in two microcontrollers which control and manipulate the whole system of the design project. It utilized the hardware tools which include ultrasonic proximity sensor, weight sensor, Gizduino ATMEGA328 and sensor Amplifier while for the software requirements include Windows 7, SQL Server Management Studio, Microsoft Visual Studio(.NET), Microsoft Visual Studio, and Arduino (software). After several testing of program to the gizDuino, the software programs were distributed to the Microcontroller Unit (MCU). After uploading the software, it was interfaced to the hardware to test its functionality. A series of tests conducted revealed its accurate results compared to manual computation of BMI. There are however some limitations in this design; the system is not suitable for person weighing 90kg and above,it can only accommodate one person at a time,and is not suitable for people with dwarfism and for people with mannerism movement.

(Varma et al, 2015) designed a microcontroller based automated Body Mass Index (BMI) calculator with LCD display. The project hardware consists of a weighing machine, used to calculate the body weight of a person, calculated in kilograms and a height sensing mechanism an LDR, used to calculate the height in meters. The weighing machine converts the mechanical force exerted by the weight of the person into an electrical signal. The weight is calculated by the LDR, when dark light falls on it due to the presence of the person, its resistance value decreases and a high output voltage is obtained. These data are manipulated through the microcontroller and the result displayed on the LCD, with a message sent to the person via the GSM module to the person on his BMI with advice on solution.

III. SYSTEM DESIGN

This section presents the proposed BMI assessment device system design. The key components and their functions at creating an intelligent and robust system for the measurement of BMI is presented.

The assemblage of materials for the design and fabrication of the BMI assessment device include:

a. Mide steel 1.5mm for green panel
b. Mide steel 1.8mm for the body
c. Patreax box 3/6
d. 20/4 LCD Display
e. 12 Volt power adaptor
f. Ultrasonic sensor
g. 350kg load cell
h. 1.5mm electric cable
i. Buzzers for alarm system

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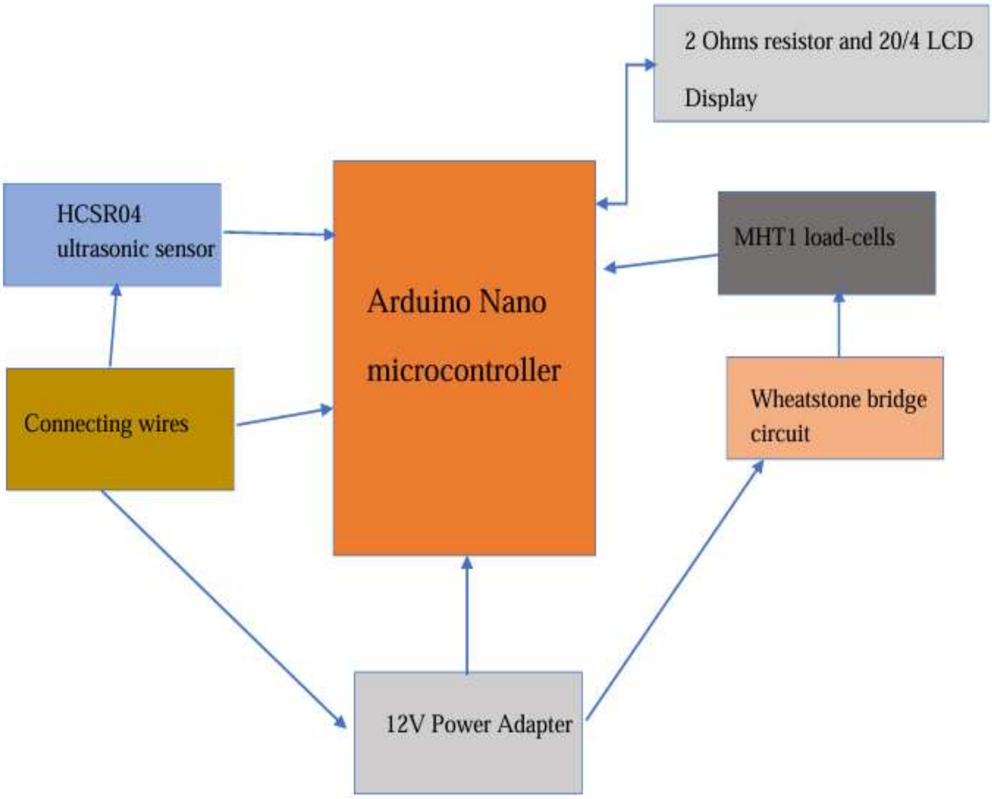

Figure 1. Block diagram of the proposed BMI Assessment Device

The design is composed of a weight sensor, represented by MHT1 load-cells configured in a Wheatstone bridge circuit, which utilizes internally mounted SR-120 foil-type strain gauges for precise weight measurement; an essential parameter of the BMI device, The HCSR04 ultrasonic sensor module crucial for height measurement. By emitting and measuring the reflection of ultrasonic waves, this sensor ensures accurate height measurements, a critical input for the BMI formula, The Arduino Nano microcontroller which is the brain of the proposed design. It is a compact and powerful real-time embedded system development board which processes data from the weight and transonic sensors, executing a pre-programmed algorithm for automatic BMI computation. Its programmability allows for customization and adaptation to specific BMI calculation requirements.

The RCD display module, provides an intelligent user interface, displaying height, weight, and BMI measurements in a clear and user-friendly format. This visual representation is instrumental in aiding individuals in understanding and interpreting their health metrics.

To ensures continuous operation of the BMI machine in both indoor and outdoor settings, regardless of the availability of public power supply, an automatic two-way backup power supply module, supported by a 12volt power adaptor, is integrated. This will enhance the operational flexibility of the device. The complete module is housed in a mechanical assembly which provides physical protection for the automatic BMI components.

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(a) (b) (c)

Figure 2: MHT1 load cell HC-SR04 ARDUINO NANO

IV. RESULTS AND DISCUSSION

The compact design with a green panel for weight measurement, a 184cm trunk to accommodate the individual’s height, a sensor for measurement of height, an LCD screen for instant display of results and thepower source.

Figure 3: The Automated BMI Assessment Device

To determine the performance and measurement accuracy of the Automated BMI Device, a series of measurements were conducted on 10 randomly chosen persons aged between 18 and 36 years at the University of Port Harcourt in Nigeria. Measurements obtained from the device were compared with those obtained manually using a commercial floor-type HANA manual weighing machine (i.e., analog weighing machine), as well as the manual height measurements using 25-meter length tape on the persons.

The results from the comparison of the developed Automated BMI Device with the manual BMI methods show that while the manual method involves certain calculations to ascertain its result, which may take some time and error prone, the developed device automatically displays the results based on the WHO-approved BMI parameters. The device categorizes individuals into different BMI ranges, including underweight (0-18), normal weight (18.5-24.9), overweight (25-29.9), and obesity (30 and above). These parameters are based on established BMI categories and serve as a valuable tool for health monitoring and assessment. Furthermore, the BMI device is designed to give off an alarm when it measures obesity, alerting the individual of the potential health risk and referring them to a physician for further evaluation. This feature enhances the BMI machine's utility as a health monitoring tool, providing proactive alerts for individuals to seek medical attention, when necessary, thus contributing to early intervention and health management.

This visual display is instrumental in aiding individuals in understanding and interpreting their health metrics, enhancing the user experience, and facilitating effective health monitoring.

V. CONCLUSION

Sedentary lifestyle by many individuals either knowingly or not has contributed greatly to health risks, chief amongst them is cardiovascular diseases, others are diabetes, obesity, and hypertension which have sent many to their untimely graves. As a way curbing and mitigating theses health challenges an Automated Body Mass Index Assessment Device was developed. The BMI is the most common means of evaluating a person’s health status by establishing the risks factors imminent occasioned by unhealthy lifestyles. The device is equipped with a load cellfor weight measurement, an ultrasonic height sensor and programmed to automatically calculate the BMI of any individual and display obtained result on a LCD. The unit will help to reduce errors associated with manual calculation of BMI as obtained in our health institutions, reduce man-hour wastage as well as eliminate stress in service delivery.

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