DESIGN, CONSTRUCTION AND PERFORMANCE STUDY OF AN ELECTRONIC BODY MASS INDEX INSTRUMENT

[1]Isola G. A., [1]Akinloye M. K., Ayanlola P. S., Aremu A. A., Omoboyo A. S., Matiluko A. B.
gaisola@lautech.edu.ng, mkakinloye@lautech.edu.ng, apsholar@gmail.com

[1]Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
Corresponding Author: gaisola@lautech.edu.ng

ABSTRACT

The design and construction of an electronic Body Mass Index (BMI) has been carried out in this study. The design calculates the BMI automatically by overcoming marginal errors. The design incorporates the functions of PING))) sensor, digital weight sensor into the system. C programming code was writing in programming a microcontroller that controls the whole design. The measured height and weight are processed by the programmed microcontroller which then generates BMI being display on a Liquid Crystal Display (LCD). The designed system was used to estimate the BMI of eight individuals of different gender. The performance evaluation of the system was compared with the four groups category cited by World Health Organization in the BMI chart.

Keywords: Electronic BMI, Performance Study, PING))) sensor

INTRODUCTION

The increasing prevalence of overweight and obesity has been a public health concern globally (Morris, 2005). This has been one of the major risk factors for chronic diseases like diabetes, cardiovascular diseases, musculoskeletal disorders, cancer, depressive symptoms, suicidal behaviours, disability, and premature death (Dave et al., 2009 and WHO, 2011). However, obesity assessment in most population studies has been based on Body Mass Index (BMI) determined from self-reported height and weight and fairly rarely from measured data (Nearkasen et al., 2013).

Body Mass Index is a statistical value derived from the weight and height of an individual. It is globally useful and the only reliably tool Physicians used in estimating healthy status of human. It expresses the ratio of the body mass to the square of the body height. It is a criteria indicator that quantifies the amount of tissue mass in an individual (Burban et al, 2012). The BMI is a widely used method compared to other body fat detection techniques due to its inexpensiveness and ease of calculating health risks related to obesity (Nearkasen et al., 2013). Two individuals having same weight might not float on the same level due to the difference in body fat composition.

The BMI is a measure for health related professional and investigators in some cases where risks of death are high for the overweight person. Studies have shown that an individual with coronary heart problems are one of them. Similarly, as human body fat increases, this may block the veins thereby leading to different health problems (NHLBI, 2014). Developing certain diseases and mortality in related to human weight and health can be link to the BMI. As the body fat increases, the BMI also increases and this is an indication of a future related illness (Garabed, 2007).

The commonly accepted BMI categories are: underweight (below 18.5 kg/m^2), normal weight (18.5 to 25 kg/m^2), overweight (25 to 30 kg/m^2) and obese (above 30 kg/m^2) (WHO 2011).Several existing technologies have help in distinguishing between a healthy and unhealthy human being. However, most of these technologies determine the weight and height separately (Burban et al., 2012 and Nearkasen et al., 2013). Thus, the study design, construct and test the performance of an electronic BMI instrument that calculates the BMI automatically and overcomes marginal errors. It is relatively easy, cheap and non-invasive method for establishing BMI status.

MATERIALS AND METHODS

Components specification

The concept of this research is to design and construct an easy to operate, user friendly electronic BMI device that determine an individual height and weight through a particular sensor. Calculates the BMI through the programmed microcontroller and displays the output on the LCD screen shown in Figure 1. The components for this design are as described below:

i. **Sensor**: The sensors employed in the construction are: The Parallax PING))) ultrasonic distance sensor shown in Figure 2 and Glass Digital Personal Scale QF-2003B, shown in Figure 3.

The PING))) sensor works by transmitting an ultrasonic (well above human hearing range) burst and providing an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width, the distance to target can easily be calculated. The PING))) sensor was employed in this work because it provides precise, non-contact distance measurements from about 2 cm to 3 meters. It is very easy to connect to microcontrollers. It is powered by a 5 V DC supply and operates in any lighting condition.

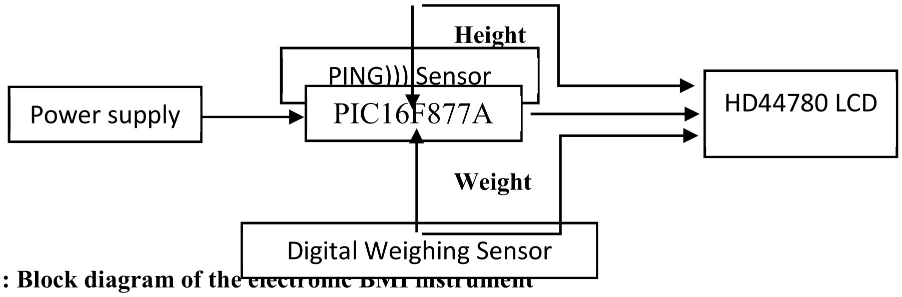

Figure 1: Block diagram of the electronic BMI instrument

Figure 2: Parallax PING))) ultrasonic distance sensor

The digital weighing scale is a 6mm tempered safety glass platform, auto zero resetting and auto off. It contains a low power and overload indicator. The maximum load capacity of the scale is 180kg and is powered by a cell battery.

Figure 3: Glass Digital Personal Scale

ii. **Microcontroller**: The PIC16F877A microchip was employed in this work. It is powerful and easy to program microchip that generates pulse to the PING))) sensor. It has both the program and data memory for storage. The microchip is powered by a 5 V DC supply. The microchip was programmed using C programming language through an Arduino board.

Figure 4: ThePIC16F877A microcontroller

iii. **Iron pole and bar:** The Iron pole and bar were smitten to design shape so as to serve a frame and hole for the other components.

iv. **Connecting wire**: This is used in connecting the circuit for all the component design.

v. **LCD monitor**: The HDEE780 LCD device was employed as the display monitor. It is cheap and readily available for use.

Design and Construction

Figure 4 show the assembly of all the components earlier described in sub-section 2.1. The digital weighing scale was mounted on 20 x 20 mm metal flat bar to provide a firm support for the digital weighing scale. Two 180cm long iron pole was thereafter fastening to the flat metal. The PING))) sensor was couple to the ceramic plate attached at the top of the poles. This was done so as to have a good capture of an individual height. The programmed microcontroller unit and the LCD screen was position in between the PING))) sensor and the digital weighing scale. This was done so that an individual undergoing BMI test will have a grip of the likely BMI result.

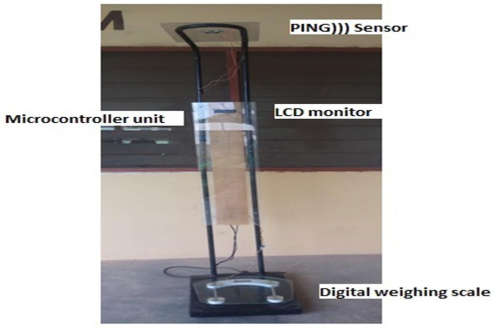

Figure 4: The constructed electronic BMI

2.3 Test and Performance

The constructed instrument was connected to 220V A.C. supply through an adapter that regulates the voltage to 12V D.C. The 12V D.C. is further regulated to 5V D.C.by the inbuilt voltage regulator of the already programmed microcontroller. After the microcontroller had been power with the required voltage, the microcontroller triggers the PING))) sensor by sending a low-high-low pulse which activate the sensor. The PING))) sensor detects objects by emitting a short ultrasonic burst and then listening for the echo. Under control of a microcontroller, the sensor emits a short 40 kHz ultrasonic burst. This burst travels through the air, hits an object and then bounces back to the sensor within a time frame of 200 μs.

The PING))) sensor provides an output pulse to the host that will terminate when the echo is detected; hence the width of this pulse corresponds to the distance to the target. This pulse duration represents the round trip distance between the sensor and the object height being measure. The weighing scale detect an individual weight, send the report to the microcontroller. These value measured will then be send to the programmed microcontroller for storage and further processing in estimating the BMI. Thereafter, the three parameters (weight, height and BMI) are seen display on the LCD monitor. The instrument was thereafter used to determine the BMI of eight individuals of different gender.

3 Results

The values obtained for the performance evaluation of the instrument are as presented in Table 1. The table show the manually computed BMI and that generated by the constructed device for each of the individual tested.

3.1 Discussion

The mean BMI value obtained for the estimated and generated BMI is 22.51. This show that the device constructed operate efficiently by overcoming marginal error that may occur during programming and designing of the device. Furthermore, the values obtained show that the device operates within the four groups categorised cited by WHO in the BMI chart. With this result, it is recommended that individual that falls under the overweight and obese categories should incorporate the consumption of more fruits into their food dietary, limit the intake of carbohydrates and regular body fitness exercise is required. While those individual that fall underweight are advice to consume more balance diet food.

Table 1: Results for the Observed candidates BMI using the device.

Candidates	**Weight (kg)**	**Height (m)**	**Estimated BMI (kg/m^2)**	**Device BMI (kg/m^2)**	**Categories**
A	55.70	1.63	20.96	21.00	Normal
B	90.00	1.65	33.06	33.10	Obese
C	75.00	1.75	24.49	24.50	Overweight
D	65.00	1.70	22.49	22.50	Normal
E	50.00	1.75	16.33	16.30	Underweight
F	73.00	1.75	23.84	23.80	Normal
G	45.00	1.75	14.69	14.70	Underweight
H	62.00	1.60	24.22	24.20	Normal
	Mean		**22.51**	**22.51**	

CONCLUSION

There is no doubt that the appropriate medical information derived through this device would save lives. Protocols should be designed carefully, according to each system's capability, patient's size, and clinical indication for the scan. The constructed device provides accurate determination of human BMI and this will play an important role in the diagnostic evaluation of patients who are obese.

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