Medical device for monitoring patients

(Belly Fat Reader)

Lochana Abhayawardana
Department of Electronic Engineering
Hochschule Hamm-Lippstadt
Lippstadt, Germany
lochana.abhayawardana@stud.hshl.de

***Abstract*— Nowadays high obesity is a common issue for both men and women. This is maybe because of their busy lifestyle and no time to think about their personal health. Consuming a high amount of sugar, calorie foods, higher usage of alcohol, and smoking may lead to gathering fat around the human bellies. Furthermore poor sleep, higher stress levels and lack of physical exercise may lead to belly fat.**

Even though the term might sound dated, the "middle-age spread" is more relevant than ever. Women tend to gain more fat as they reach their middle years, more so than men. It is common for extra pounds to accumulate around the midsection.[1] Genetic factors are also responsible for the majority of inter-subject variance in central abdominal fat in non-obese individuals. Insulin resistance, diabetes, and cardiovascular disease may be inherited in families with abdominal obesity.[2]

In order to lose belly fat, people tend to abstain from food, follow eating plans, eat less fast and processed food items, and do more physical exercises. But, there is one problem that is hard to find an answer. That is how to track his or her progress in losing fat. Weighing with a scale sounds a good and common answer but, the scale measures the person's whole body weight, not the belly fat. This paper is about the answer we found, how to measure belly fat more faster and with higher accuracy.

Keywords*— *obesity, lifestyle, health, foods, sleep, stress, genetic, inherited, abstain, track, progress, accuracy

I. INTRODUCTION (*HEADING 1*)

Our solution to this problem was to use Near-Infrared technology to measure visceral fat, which is largely responsible for belly fat. Through the use of this technology, our 'Belly Fat Reader' can measure belly fat levels more accurately. The app 'Belly Fat Reader Smart app' allows the user the users to read measurements, keep track of fat levels etc...

II. BELLY FAT READER (BFR) DEVICE

Belly Fat Reader is a smart device used to measure belly fat. It is a compact device of 80*60*30 mm. The device should be connected to a dedicated app called Belly fat reader. The app is available in Android, IOs and windows platforms. It can keep track of the user fat reducing progress.

A. The use-case of this device/app

The device is able to get highly accurate value of the visceral fat gathered in around human belly area.
User can keep a record and monitor his/her belly fat reducing progress.

B. Targeted groups

- Person who has high obesity - the BFR app can be connected to the doctor (the family doctor has a full analysed report of the user)
- Fitness centre (gym) - Fitness trainers can track the user fat reducing progress daily. They can update the user's meal plan or training plan according to it.

III. MAIN ELEMENTS

Belly Fat Reader is containing with two main elements.

1. Belly Fat Reader Device(BFR)

BFR device is used to take the measurements of belly fat and Transfer DATA to the mobile App. The BFR device is connected to BFR app via Bluetooth.

IV. HOW DOES THE DEVICE WORK

The user should download and install the BFR app. When the user uses the device for the first time, he/she should create a user profile in order to sync DATA within our servers. (All the data from the user will be encrypted and stored in secured servers). Users can either use social logins or sign up with their email addresses. After this step, the app will be directed to add a new device page. The user should turn on the device (described below) and keep it less the one-meter close to the smartphone. After a few seconds, the BFR device icon should appear on the screen. The user should select it and the BFR device is paired to the BFR app.

Now the user can start with getting the measurement process. BFR device has only one button and one LED. The user should press and hold the button for three seconds. The LED is started blinking in blue colour. That means the BFR device is turned on and entered into pairing mode. After it gets connected to the smartphone, the LED turns into steady blue. Then the user should hold the BFR device on his/her belly and light press the button. The LED will blink in green for three seconds and turn into steady blue colour. That represents the scan is completed and measurement data has been transferred to the BFR app. The task of the BFR device is completed. The user can either long-press the button or leave the device for 3 minutes, then the device will automatically switch off.

The user can view his/her results of belly fat level from the mobile app. If the user's fat level is at a healthy level he/she gets normal feedback. But if the results are at in critical level, he/she will get a warning and ask permission to share the results with your doctor and the doctor can provide you instructions. Also, the user can keep a track of the history of the fat level and the app provides some useful tips on how to reduce belly fat, etc..

Blue (blinking)	(device turned on), entered pairing mode
Blue(steady)	Connected to the smartphone via Bluetooth (normal state)
Green(blinking), for 3s	Measurement taking, will go back to the steady blue state. That means the measurement has been taken, synced with the app and went back to the `normal state'
Red (blinking)	Battery low
Red (steady)	Device is charging
Green (steady)	Fully charged
yellow(blinking)	Device is updating

Table.1 LED light configuration

Furthermore, this device needs to be charged only once in 3 months. When it is charging The LED will illuminate red colour. When it is fully charged it shows green.

V. TECHNICAL DETAILS

- Near-Infrared Technology

Near-Infrared (NIR) refers to electromagnetic wavelengths that range from about 780 to 2500 nm. A pulse oximeter uses NIR measurements to determine a person's health status by measuring tissue chromophores. A spectral range of approximately 650 to 1100 nm is used for our real-time tissue measurements. Utilizing 8-wavelength NIR LEDs (Light Emitting Diodes), we can measure tissue absorption and scattering to calculate oxyhaemoglobin, deoxyhaemoglobin, water, and lipid.

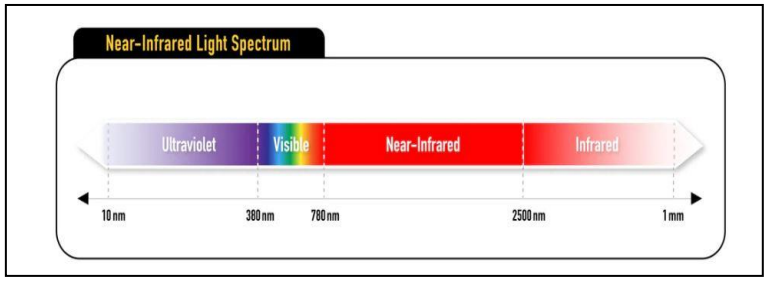


Fig. 1. NIR light spectrum

- The Belly Fat Reader device

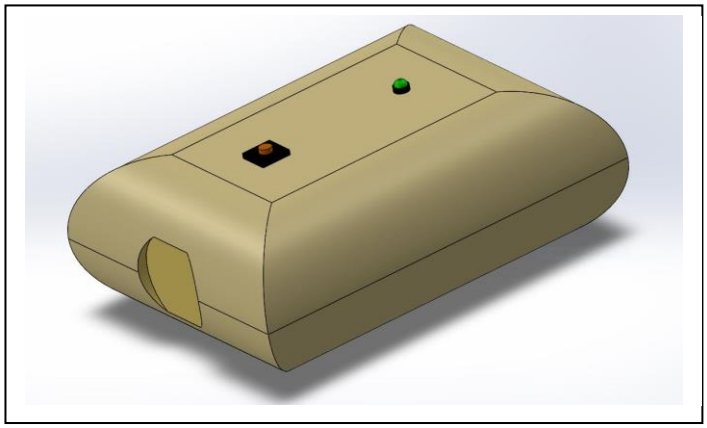


Fig. 2: How the BFR device look like

- Hardware Specification

a) RGB LED: Only one RGB LED is enough to indicate Turning on, Turning off, pairing with a smartphone, taking the measurements, and indicating if the battery is low when installing a software update functions.

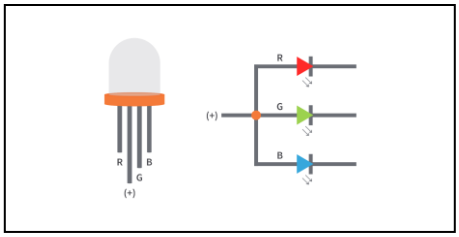


Fig.3. LED

b) Push-button: Push-button will be needed to turn on/off the device, to take the measurements

Fig.4. Push button

c) ESP32 microcontroller: The reason to use this specific microcontroller is it is so cheap, it has a built-in Bluetooth Modular

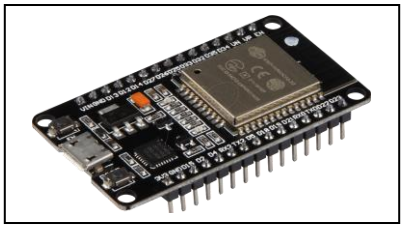


Fig. 5. ESP32 microcontroller

d) NIR Sensor (Qwiic AS726X): Low cost, uses I²C protocol, Low gate count, only need two pins to implement

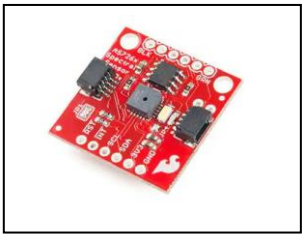


Fig. 6. NIR sensor

e) Battery: LiPo Battery: No need for a voltage regulator, micro USB port to charge the battery

Fig.7. LiPo Battery

- Redundancy

  Users previous measurement data is stored either in mobile device storage or in the cloud. In case of error from read data from the mobile storage, the app is capable to get the data from the cloud. In order to get more accurate measurements the device get three measurement simultaneously and its average is consider as the final measurement.

2. Belly Fat Reader App

BFR App acts as the interface between the User and the device. The BFR device should connect to a smartphone which has the `Belly Fat Reader app' Installed. The app is available both on android and iOS platforms.

2.2 The user interface

Since all the data have been transferred to the BFR, app user can see and interact with the system with mobile phone display and the touch input. If the user touch /tap the boxes with words (touch button), he/she can interact with the system.

E.g.: back button in the figure 11 (bottom left corner)

- This figure discribes the moment that the BFR device sends measurement data to the app. The app is able to analizes data and notify the user that he/she in the healthy region*.

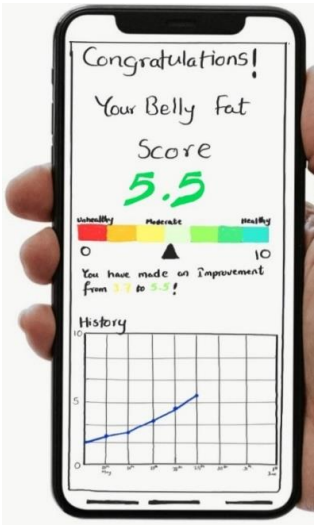


Fig. 8. User's belly fat score

- Here you have an option to view your weekly or monthly progress.

Fig. 9. Weekly report

- The app will notify you If your belly fat level is in an unhealthy region*. If the user presses the ‘contact your doctor’ button, he/she can contact the doctor

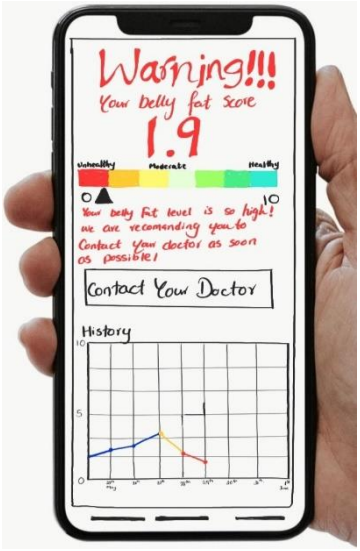
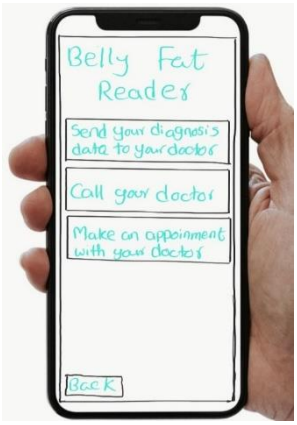


Fig 10. Warning

- Here the user has three options, in order to contact the doctor



- Fig.11. Connect your doctor

- The doctor reviews the patient’s diagnostics data, the doctor can provide instructions either as a text message or with a document as an attachment.

Fig. 12. Doctor’s screen

VI. DIAGRAMS

In order to realize the functions of the BFR device and the app, we need diagrams.

- The Requierement diagram is used to describe text-based requirements and the relationships between requirements.

- The Use-Case Diagram

In this use case diagram, we show how a system performs use cases and what actors invoke and participate in them. The system performs in collaboration with its actors, such as users and doctors, and provides this black box view of the services it provides.

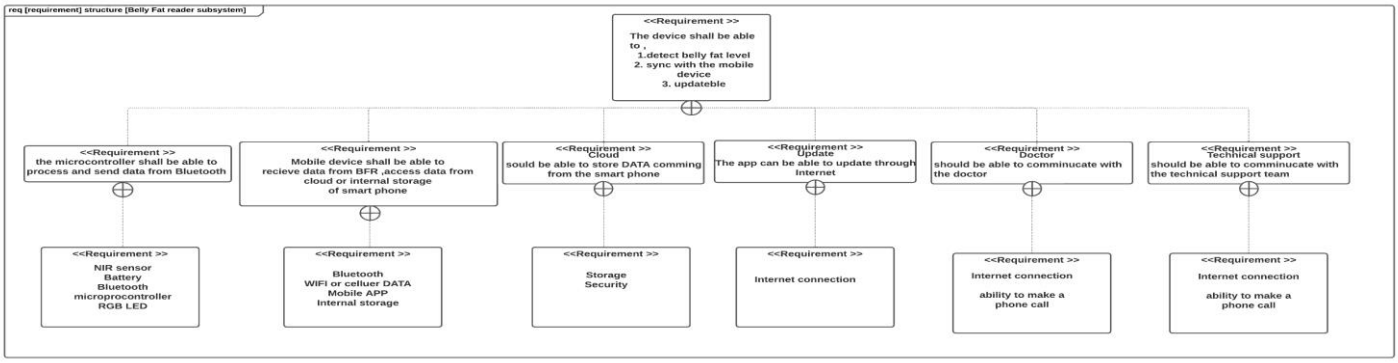


Fig. 13. Requirement diagram

- Sequence diagram will preciously specify the process of taking the measurements and how the app works in timely manner.

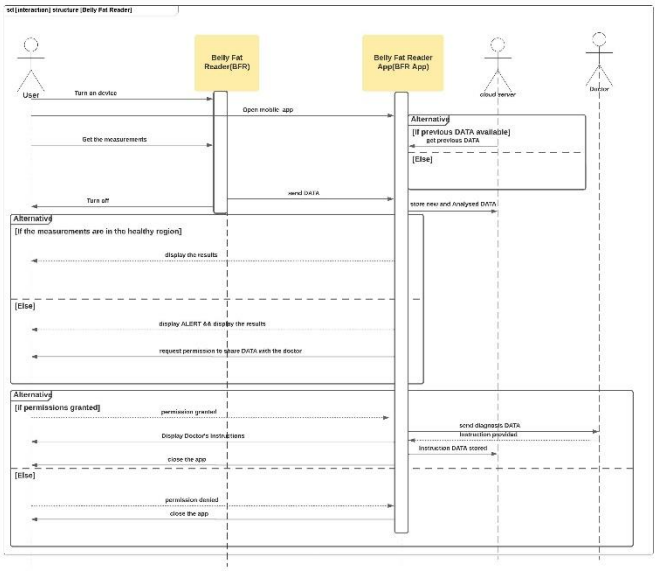


Fig. 14. Sequence diagram

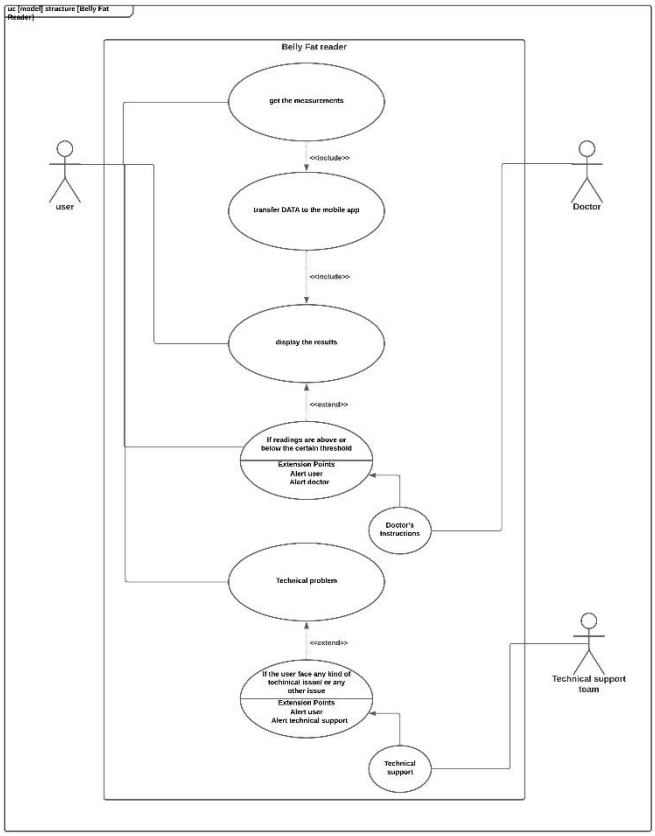


Fig. 15. Use-case diagram

VII. Discussion

A. Concept

If people wanted to check their belly fat level they can buy skinfold calipers. But, to use this equipment the user requires basic anatomy Knowledge. Or the user should do one of those tests, Duel Energy X-ray Absorptiometry (DXA) or Air Displacement or Bioimpedance Spectroscopy (BIS) [3] The accuracy is higher but, it has some level of issues such as Exposure to radiation , The advice of a doctor is essential for the test and the tests may be highly expensive.
Therefore our concept is to build a device which is compact, easy to use , ability to use in daily base, affordable and ability to seek medical advice directly.

B. Initial Problem

Despite the concept, finding the right technology was difficult. NIR technology was discovered after some research.

C. Improvement

To ensure the user's safety, availability, reliability, and security, the requirements, and design were iterated throughout the development phase.
The main objective of the study was to measure visceral fat in the abdomen. Additionally, the NIR sensor is capable of estimating oxyhemoglobin, deoxyhemoglobin, water, and lipid by measuring tissue absorption. As a result, the app can be improved to analyze these data and display them to the user in a more user-friendly way.

VIII. Conclution and Future Direction

A. Overview

- In this project development of a device that detects belly fat level took place. The device is compacts and able to use in daily base because it's simple and minimalize design.
- Users data is strictly protected with encrypted data. Certain amount of user's data can be accessed to his/her trainer or the doctor under advance permission of the user.
- With keeping the regulation of government on medical device in the requirement, the device modeled safe for the user.

B. Future Direction

- In the future upgrades, it is possible to add some functions like other lipid levels and H_2O , HbO_2 levels.
- Data analyzing algorithm can be improved in order to get more accurate results and reducing more measurement time.
- Current sensor can be improved or replaced with upcoming better one.

A. Abbreviations and Acronyms

- BFT – Belly Fat Reader
- NIR – Near-Infrared Technology
- App – application (mobile application)
- I^2C - Or I2C, a serial communication protocol allows the data to transfer bit by bit along a one single wire.

C. Authors and Affiliations

The author's name is Lochana Abhayawardana. He is an Electronic Engineering student from the technical university Hochschule Hamm-Lippstadt.

D. Figures and Tables

Table 1: LED light configuration	Created by the author in order to explain what means from the LED colors and its blinking
Fig 1. NIR light spectrum	https://shop.olivehc.com/pages/near-infrared-nir-technology
Fig 2. How the device look like	Created by the user in SOLIDWORKS
Fig.3. LED	https://create.arduino.cc/projecthub/lewiskell/common-anode-rgb-led-4a5ece
Fig. 4. Push button	https://www.exp-tech.de/en/accessories/buttonsswitches/4342/mini-push-button-switch-x20
Fig. 5. ESP32 microcontroller	https://www.reichelt.com/de/en/development-boards-esp32-wi-fi-and-bluetooth-module-debo-jt-esp32-p219897.html?r=1
Fig.6. NIR sensor	https://www.exp-tech.de/en/sensors/light/8347/spectral-sensor-breakout-as7263-nir-qwiic
Fig. 7. LiPo Battery	https://diyi0t.com/best-battery-for-esp8266/
Fig.8. User's belly fat score	Hand drawn by the author
Fig. 9. Weekly report	Hand drawn by the author
Fig. 10. Warning	Hand drawn by the author
Fig 11. Connect your doctor	Hand drawn by the author
Fig.12. Doctor's screen	Hand drawn by the author
Fig. 13. Requirement diagram	drawn by the author
Fig.14. Sequence diagram	drawn by the author
Fig. 15. Use-case diagram	drawn by the author

ACKNOWLEDGMENT

Words cannot express my gratitude to my professor, Ali Hayek and my supervisors Christopher Beck and Charles Steinmetz for their invaluable patience and feedback.

It would also be unfair to not include my classmates and my roommate for their new ideas, their late-night feedback sessions, and their moral support. In addition, I want to express my gratitude to the librarians, research assistants, and participants in my study at the university, who impacted and inspired me.

Lastly, I would be remiss in not mentioning my family, especially my parents, spouse. Their belief in me has kept my spirits and motivation high during this process.

REFERENCES

[1] The President and Fellows of Harvard College, " Abdominal Fat and what to do about it", Haward Medical School, June 2019, https://www.health.harvard.edu/staying-healthy/abdominal-fat-and-what-to-do-about-it.

[2] D G Carey, T V Nguyen, L V Campbell, D J Chisholm, P Kelly, "Generic influences on central abdominal fat: a twin study", National Library of Medicine, August 1996, https://pubmed.ncbi.nlm.nih.gov/8856394/#:~:text=Conclusion%3A%20The%20majority%20of%20inter,resistance%2C%20diabetes%20and%20cardiovascular%20disease.

[3] Grant Tinsley, Healthline ,April 2018, https://www.healthline.com/nutrition/ways-to-measure-body-fat#TOC_TITLE_HDR_2