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Design and Implementation of IoT-Based System for Monitoring Patient Heartbeat

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Abstract

The Internet of Things (IoT) makes the new revolution of the internet, and it is involving all fields of endeavours in which the health care sector is inclusive. IoT makes health care more affordable, secure and patient-centered. The existing technologies and approaches for monitoring patient heartbeat are being used by healthcare practitioners, however, these methodologies are not cost-effective and portable. This work, therefore, presents a portable physiological checking framework that uses ESP88266 WiFimodule to process the heartbeat and displays the patient's heartbeat through an endless checking and control instrument on the Nextion Touch screen. The patient condition and information are stored in a server that achieves remote correspondence using the WiFi Module. Data stored can only be accessed by authorized personnel and as such the diseases are diagnosed by the doctors from a distance. The electrodes are placed on the chest of the patient and the device is powered up, one can then log into the configured Thingspeak to view the graph in real-time, the touch screen also displays the electrocardiogram (ECG) reading a number of heartbeats per minute, which would be compared with the convection. The result is compared with standards to determine the health conditions of the patient. It is established that patient data can be monitored and any changes can be detected and responded to by the doctors.

Keywords: Internet of Things (IoT), Heartbeat, Monitoring, Patient, ESP88266 WiFi module, electrocardiogram (ECG).

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Introduction

The Internet of Things, which is simply called IoT, was first coined in 1999 to mean a system of interconnection of computing, mechanical and digital devices, machines, objects, animals or people with the ability to communicate and interact through the network using embedded systems, sensors, software, and other technologies, without necessarily involving human-to-human or/and human-to-machine communication (Nurdin, 2016). There is tremendous progress in its involvement such that it has become one of the most important technologies of the 21st century (Jain & Ranjan, 2020). Now that we can connect everyday objects—home appliances (home automation like connecting kitchen appliances, energy meter consumption and control), health monitors and telemedicine, City Automation, cars monitor, and baby monitors to the internet through embedded devices. Seamless interaction, communication between man and devices, and machines are achievable over the links with the aid of sensors, IP and controls systems. As the human population increases, the total number of facilities and health personnel could not match the trend of the increase, so doctors and health workers need to travel distances to attend to a patient**.** This convectional method of health care delivery is becoming cumbersome, especially with the cost and risk of travel for health care. As a result of these challenges and with the influence and advances in IoT, basic health monitoring needs to be subjected to IoT to overcome the constraints in conventional methods. Treatment of most heart-related diseases requires continuous monitoring; hence IoT is very useful in this aspect as it replaces the conventional monitoring systems whereby the patient has to visit the clinic, by providing critical information relating to the condition of a patient to be accessible online by the doctor. Therefore, online monitoring of health becomes important to the doctor for correct diagnosis, especially for aged people that are affected by cardiac diseases. The program is such that when the monitored data fall below the traditional value, then the system will alert the doctor. Heart diseases and heart-related problems are on the increase due to reasons such as drug abuse excessive use of alcohol or caffeine, high vital signs, smoking and the global teaming population (Virani *et al*., 2021). There is therefore needed to monitor the heartbeat of a patient using an electrocardiograph module to detect electric signals from the body (in the form of each heartbeat). Then, these signals are converted into waveforms which are later sent to the display screen for easy access and analysis. This work will benefit both doctors and patients in a way that it will reduce the number of times that both parties have to see each other physically; heartbeat information could be accessed remotely by the doctor and the Patient can as well get the doctors' feedback.

Yang *et al*., (2014) presented an intelligent home-based healthcare IoT system where he employs a Medical Box called iMedBox as a health IoT system and a gateway called iGATE as a home healthcare gateway for his home-based healthcare system. Wearable sensors and intelligent medicine packaging called iMedPack are effectively connected to the medical box via a diversified network that is well-suited to numerous wireless principles. The iMedPack is linked to the iMedBox through RFID to assist users with planned prescriptions.

By using loT, Kiholee *et al*., (2014) provided a successful U-healthcare system. The mobile gateway is employed for communication within the loT shown in his article. It sends the collected data to a clinician or a home medical station. By employing a body sensor, mobile phones can collect perceived observations. The mobile is capable of disseminating information that has been verified through multi-purpose gateways and calculating traditional observation. The smartphone transmits observation to be examined during a surveillance centre during this research. The smartphone will use admitted sensor observation to form keywords and send them to the central system.

Abba and Garba (2019) designed a system that was ready to sense and skim the heartbeat rate of its user and transmit the sensed data through the web. The system components were soldered on a breadboard and cased inside a plastic container with the middle pulse sensor stretched, soon clipped on the fingertip of the system's user. Ashikur *et al*., (2019) reviewed IoT-based smart health monitoring systems. This review aimed to highlight the common design and implementation patterns of intelligent IoT-based smart health monitoring devices. It considered their merits and demerits associated with such systems.

Design Methodology

This section represents the design consideration for the heartbeat health monitor device.

A lot of factors were examined in determining the choice of materials and the appropriate model to use in order to achieve optimum performance of the system. Part of the factors for hardware requirements are speed, type of materials, power rating, accuracy etc.

The Hardware components used in this design and implementation include ESP88266 WIFI module, Nextion Touch Screen, AD8232 ECG sensor, 3D printer, 5V Power Adapter, Push button and Pin connectors

ESP8266 (NodeMCU) board provides the platform for the Internet of Things (IoT) applications. The firmware supports the ESP-12 module and executes on Express-if Systems. The board is integrated with the AD8232 ECG analog sensor which uses AD8232 IC to achieve extraction, amplification, and filtration of the ECG signals. The Nextion HMI displays the combination of components and Software. Stripped Vero board is used to implement the circuit rather than the regular dotted board in order to achieve a neater circuit. The entire system is enclosed in a 3D printed plastic casing exposing only, buttons, port and touch screen. The system is designed to extract, amplify, and filter small ECG signals within the presence of noisy conditions, like those created by motion or remote electrode placement. The AD8232 Single Lead pulse Monitor acts as an operational amplifier that assists in easily obtaining a transparent heart signal.

The design block diagram is shown in figure 5 below.

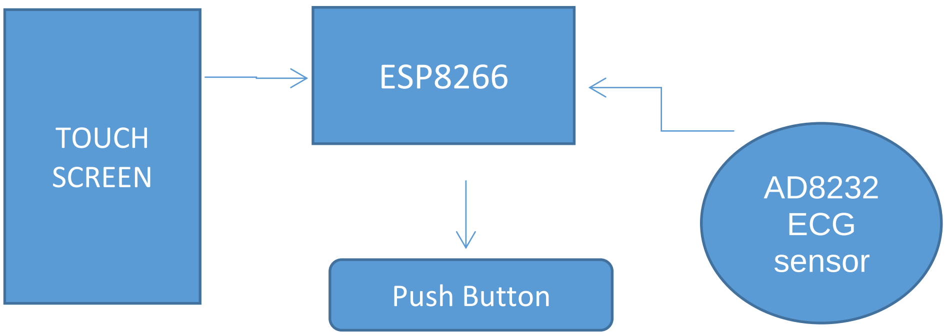

Figure 5: Design Block Diagram

ESP8266 can interface with such systems to supply Wi-Fi functionality via its SPI / SDIO or I2C / UART interfaces. The ESP8266 module used in this specific design and implementation is ESP32-WROOM-32, which contains the ESP8266 SoC, non-volatile storage, high-precision discrete components, and a PCB antenna that gives outstanding RF performance in space-constrained applications. The ECG data is being sensed through an AD8232 biometric pulse sensor which then sends the information to the network employing a Wi-Fi module, as this process involves simple yet effective architecture along with efficiency and it is cost-effective. The very fact that we are stressing the cost-effectiveness is due to the very fact that it will cause greater reaching achievement using this technology. The Thingspeak is used for the aggregation, visualization, analysis and communication of live ECG data streams in the cloud.

System Implementation and Testing

The design implementation is as shown in the circuitry and application in figure 6.
The following steps were taken to implement the research work:

Step One: Prepare and assemble all the hardware components

This involves grabbing the plastic case and coupling all hardware components as shown in the figure 7 below.

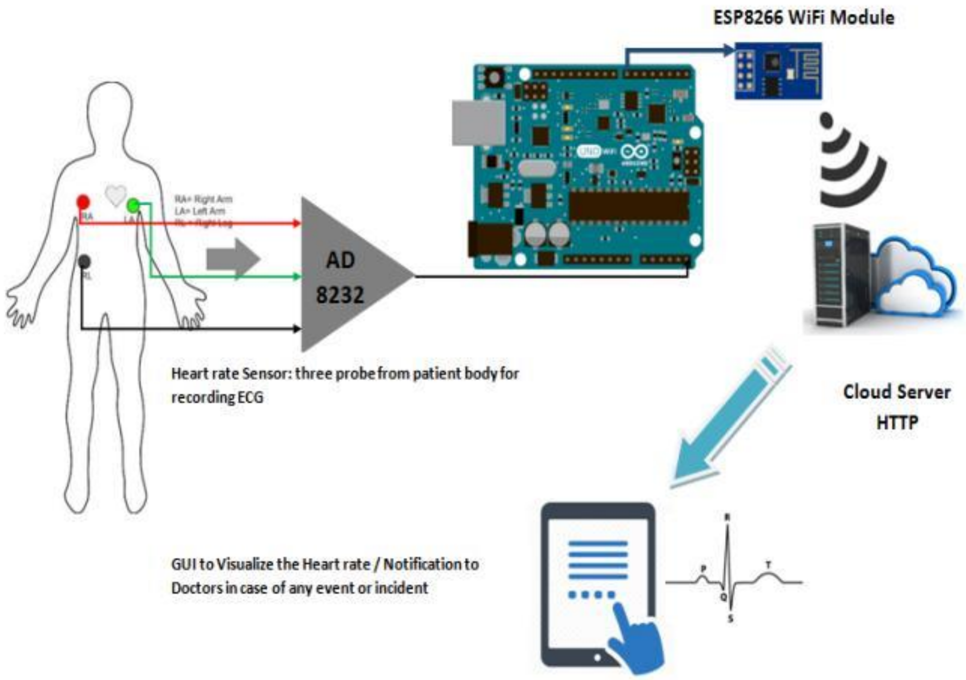

Figure 6: IoT in ECG Healthcare Application

All components were soldered to a stripped Veroboard, and necessary connections as seen in the diagram were made. After putting all components in place, the research work was enclosed in the 3D printed case.

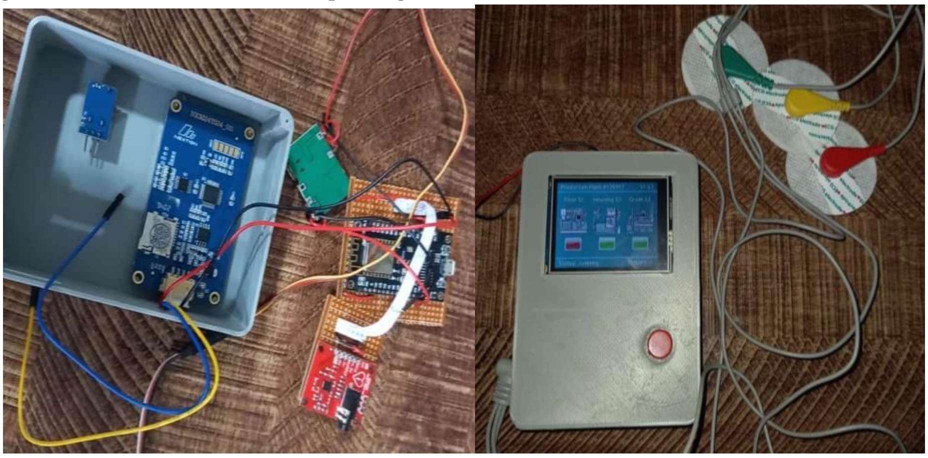

Figure 7: Coupling the Hardware

Step Two: Design Using CAD Software

The second stage was to design the device using Computer-Aided Design (CAD) software; Fusion 360 as shown in figure 8 below as was used as it is easy to use and has a free version. The enclosure is also designed, and the model was exported and sliced using CURA which is a slicing software that prepares and generates code from a 3D model that can be sent to a 3D printer. Finally, the entire circuitry was assembled as

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designed and the Model was printed. Figure 8 shows the Fusion 360 Interface.

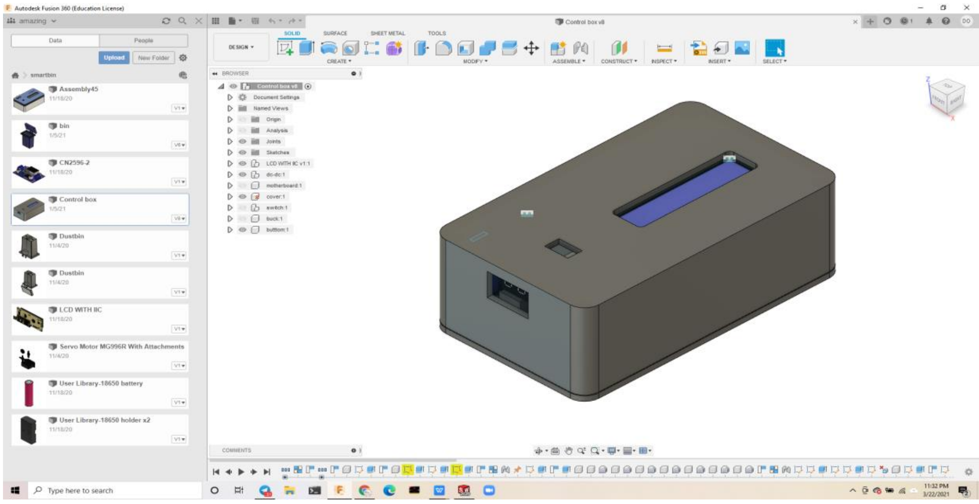

Figure 8: Fusion 360 Interface

Three-Dimensional Printer

Three-dimensional manufacturing, also referred to as 3D printing, is the technique of making three-dimensional solid items from a file. Three-dimensional manufacturing technologies are used to create 3D printed objects. An object is made during a three-dimensional technique by laying down successive layers of fabric until the fabrication is complete. Each of those layers is often viewed as a cross-section of the item that has been lightly cut. Complex shapes can be produced using 3D printing even with fewer materials as compared to traditional manufacturing approaches. In this design and implementation, a 3D Printer is used to print the assembled parts as shown in figure 9 below.

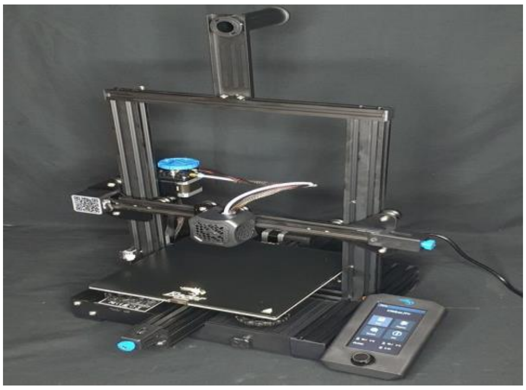

Figure 9: 3D Printer

Step three: Programming and connecting to the internet

After uploading the above code to ESP, we Opened Thingspesk and created a new account to open the dashboard. When the dashboard is opened;

- ✓ Click on the "+" sign located at the top right corner of the screen to make a new widget.

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- ✓ then select a line chart from the widgets.
- ✓ Select the variable desired to display the information. Thingspesk allows you to customize the name, colour, period of data to be displayed etc.
- ✓ After choosing click the green tick mark.
- ✓ Select the device and sensor. That is, it

After all the setup; the line chart will show the ECG graph like the images shown in figure 10 shows the ECG wavelength while figure11shows heartbeat per minute wave length while figure 12 shows how electrodes are connected to a body.

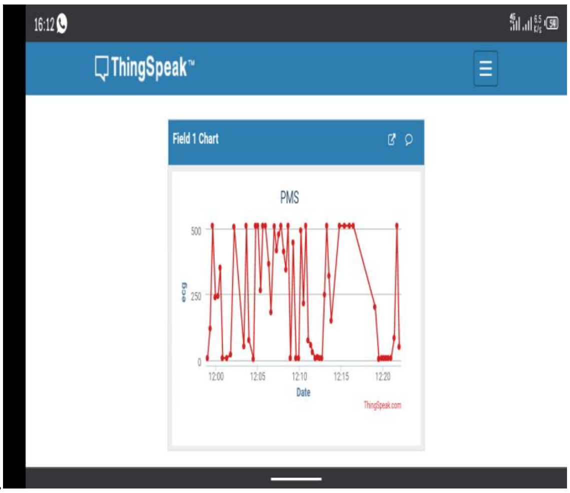

Figure10: Online Result Display Showing ECG Wavelength

Figure11: Online Result Display Showing Heartbeat per Minute Wavelength

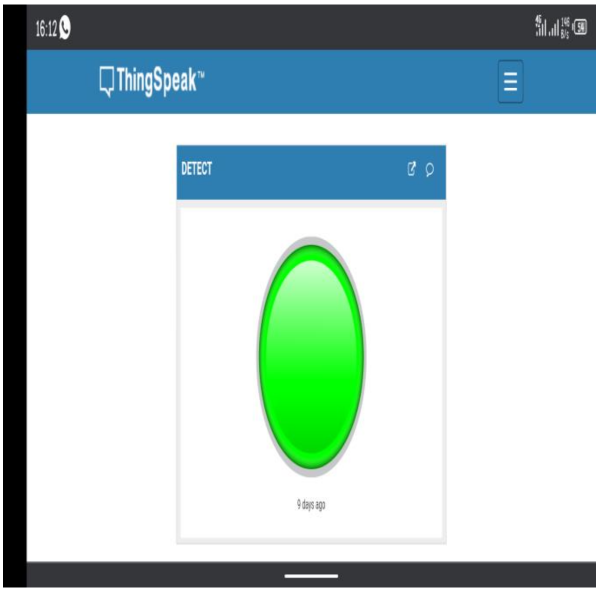

Figure 12: Online Result Display Showing Connection of Electrodes with a Body

Testing and Results

Testing

Operational Guide

The electrodes are attached as seen in figure 12 below and the device is powered up, one can then log into the configured Thingspeak to view the graph in real-time, also take note that the touch screen will also display the ECG reading.

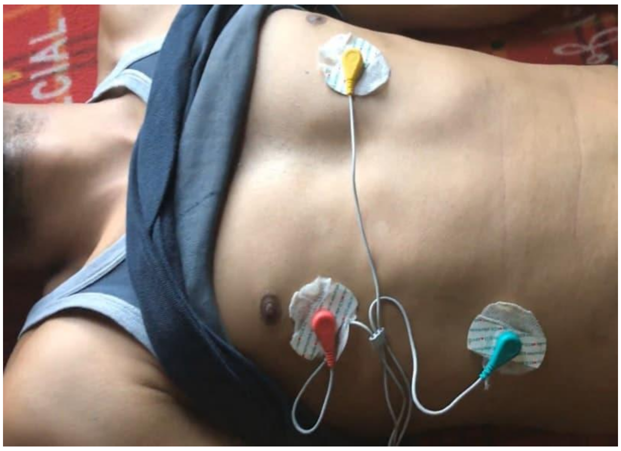

Figure 13: Connection of Electrodes

Whenever an individual decides to make use of the heartbeat monitoring system, it's mandatory to ensure that the device is connected to a hotspot which has its name and password pre-set by the user. The system automatically starts up from the offline mode as shown in figure 13 below. Therefore, it is also mandatory to change from offline mode to online if the individual wants the data to be uploaded online.

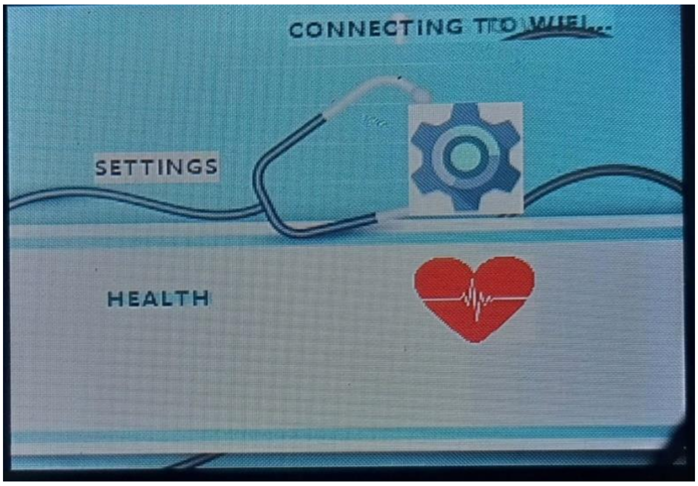

Figure 14: Startup page

Results

Once the electrodes are connected to a human's body, electrical signals are sent from the body to the device causing the device to start giving a display of the signal that is being sent in form of wavelength. Also, through the signal gotten from the body, the device will be able to detect the number of heartbeats per minute.

The display in figure 15 shows the wavelength of the electrical signals gotten from the body and also shows the number of heartbeats per minute

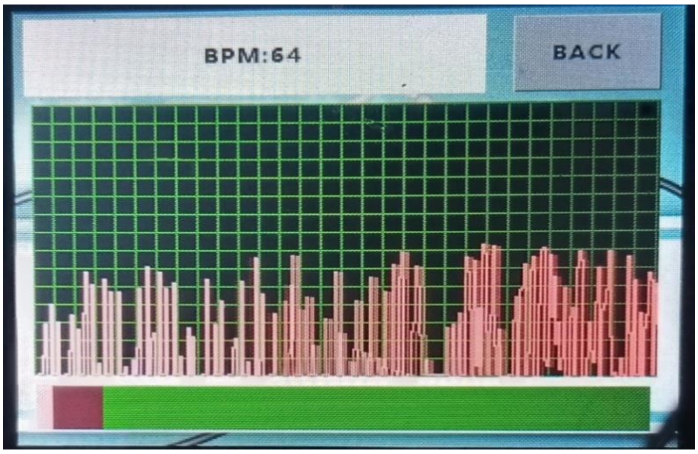

Figure15: Offline Result Display (When Connected to a Living Being)

Figure 16 shows the display screen when there is no signal received from the electrodes. This implies that either the electrode has been removed from the body or the patient is dead (because the device can sense the signals only when the heart is still beating).

Figure16: Offline Result When the Electrodes are not Connected to a Patient or the Patient is Dead

Figure 17: Offline Display of the Online Mode

Conclusion

Having a patient IoT- based health monitoring system that is accessible to everybody, especially as the global population is increasing with fewer medical practitioners to attend to healthcare issues has proven to be a very good idea and its ability to upload its data online gives the patient peace of mind that the data is saved as it is being monitored by a professional doctor, assuring the patient that when there is any form of abnormal changes in the data uploaded, the doctor will detect it by comparing the result with standards to determine the health condition of the patient and react to it as soon as possible. And this improves the well-being of the patient. Being a cost-effective and portable deceive, it would be recommended for households, especially in remote areas as means of their heartbeat health monitors. It is also recommended that an improvement in the design and implementation is made by using a complex filtering process to stabilize the AC source to eradicate the issue of fluctuation when the device is connected to an AC source. The device can also be connected to AC using adapters, and for better output, a more reliable internet link is recommended.

References

Jain, A., & Ranjan, S. (2020). Implications of emerging technologies on the future of work. *IIMB Management Review*, *32*(4), 448-454.

Ashikur R., Md. Milon, I., Md.Rasheed,I., Muhammad, S. & Sheikh N. (2019). Developing IoT Based Smart Health Monitoring Systems: A Review 12 December 2020 from https://doi.org/10.18280/ria.330605.

Hassanalieragh, M., Page, A., Soyata, T., Sharma, G., Aktas, M., Mateos, G., ... & Andreescu, S. (2015, June). Health monitoring and management using Internet-of-Things (IoT) sensing with cloud-based processing: Opportunities and challenges. In *2015 IEEE international conference on services computing* (pp. 285-292). IEEE.

Kiho Lee, Yvette E. Gelogo & Sunguk Lee (2014). Mobile Gateway System for Ubiquitous System and Internet of Things Application September 2014 International Journal of Smart Home 8(5):279-286.

Nurdin, M. R. F., Hadiyoso, S., & Rizal, A. (2016, September). A low-cost Internet of Things (IoT) system for multi-patient ECG's monitoring. In *2016 International Conference on Control, Electronics, Renewable Energy and Communications (ICCEREC)* (pp. 7-11). IEEE.

Virani, S. S., Alonso, A., Aparicio, H. J., Benjamin, E. J., Bittencourt, M. S., Callaway, C. W., ... & American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. (2021). Heart disease and stroke statistics—2021 update: a report from the American Heart Association. *Circulation*, *143*(8), e254-e743.

Abba, S., & Garba, A. M. (2019). An IoT-based smart framework for a human heartbeat rate monitoring and control system. *Multidisciplinary Digital Publishing Institute Proceedings*, *42*(1), 36.

Yang, G., Xie, L., Mäntysalo, M., Zhou, X., Pang, Z., Da Xu, L., ... & Zheng, L. R. (2014). A health-IoT platform based on the integration of intelligent packaging, unobtrusive bio-sensor, and intelligent medicine box. *IEEE transactions on industrial informatics*, *10*(4), 2180-2191.