Intelligent Medical Distance Assistance Device

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Abstract

The objective of this project is to realize and implement a complex system for remote monitoring of vital functions. The IOT-based health care system for the elderly is the cheapest medical device based on the IOT platform for patients and physicians. It provides a solution for measuring body parameters such as ECG, temperature, humidity and pulse. It also detects the location of patients to be sent to a doctor and in case of emergency it is possible to automatically call the emergency number accompanied by the GPS data.

Keywords

Microcontroller • ECG • Temperature • Humidity • Pulse • GPS • GSM • IOT

1 Introduction

According to the latest research it has been found that about 2,000 people die on a monthly basis due to neglect of health. This is due to time constraint and ignorance of health through the increased volume of daily activity.

The objective of this work was to realize and implement a complex system of remote monitoring of vital functions.

As technology is in continuous development, portable medical devices have a great contribution to regular monitoring and checking of health, which is recommended to be done monthly or quarterly for people with chronic pathologies. It is also obvious that the evolution of technology improves the quality of life. The current project wants to provide healthcare over the internet, providing vital cell information on the mobile phone and recording their history. The advantage of this project is that it can be used independently of user technical education and makes it easier to monitor health than available systems. Android apps allow a person to access the information directly on their mobile phone in various contexts, making it easy to handle [1].

The IOT-based health care system for the elderly is the cheapest medical device based on the IOT platform for patients and physicians. Provides a solution for measuring body parameters such as ECG, temperature, humidity and pulse. It also detects the condition of the body and the location of the patients.

The mobile application for the patient and physicians contains a very simple graphical interface for reading all parameters in the mobile phone or anywhere in the world by using Internet connectivity and in case of emergency it can automatically be called emergency number 112 accompanied by patient's GPS coordinates and of his state at that time.

2 Materials and Method

The proposed system is a real-time vital parameter monitor designed to alert/alert deviations from the physiological values of the patient. It also detects the condition of the body and the location of the patients. The mobile application for patients and physicians contains a very simple graphical interface for reading all the parameters in the mobile phone or anywhere in the world by using the internet connectivity made through the GSM module. The basic components of the system are: Arduino Mega control unit, which takes the signals from the ECG module, pulse, temperature, humidity, light, SD module, GSM module, GPS module and Bluetooth module, the display (Fig. 1).

The ATmega2560 microcontroller on the Arduino Mega design plate has a 5 V operating voltage, but with a voltage stabilizer it can power up to 12 V. It has 54 input and output

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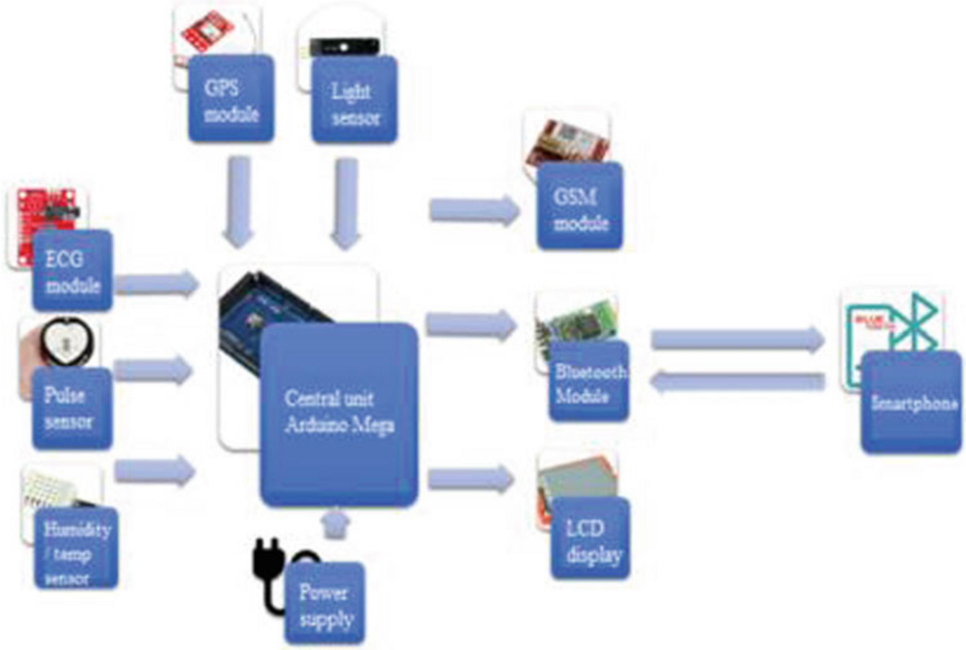


Fig. 1 Device block diagram

pins (external connections), 15 pins of PWM (Pulse-Width Modulation), which we can buy/transfer, but also 16 analog pins. It also has 4 UART pins that are generally used to display information on the display. The flash memory is 256 KB, of which 8 KB occupy the bootloader with a 16 MHz operating frequency (Fig. 2) [2].

The ECG signal acquisition and amplification part is made by SparkFun's AD8232. It functions as an operational amplifier that measures the electrical activity of the heart and produces an analog signal at the output. It also contains filters for smoothing and attenuating noise that may appear during the measure. AD8232 is designed to extract and amplify low-value biopotentors [3, 4].

AD8232 I used pins: LO+, LO−, OUTPUT, 3.3 V and GND, the SDN pin will be used to further optimize the device. The exits to the electrodes will be through the ports RL, LA, RA. In the right hand the electrode will be connected to the RA port, the electrode at the LA port is connected to the left hand, and at the RA the left electrode's electrode (Fig. 3).

In the next step I made the application displaying the ECG signal through MIT App Inventor 2. App Inventor 2 is an open source and cloud-based software, which means it works directly on the browser. We chose this program because it is free and easy to learn, being very intuitive. This makes it easier for the patient to monitor and view the history at any time (Fig. 4).

The XD-58C pulse sensor, a plug-and-play sensor, is designed to work with a development board equipped with at least one analogue pin. This product is useful for collecting heartbeat data in different situations, such as during exercise because it is powered at a 3.3 V low-power voltage. Receiving the signal from the sensor will connect to port A0

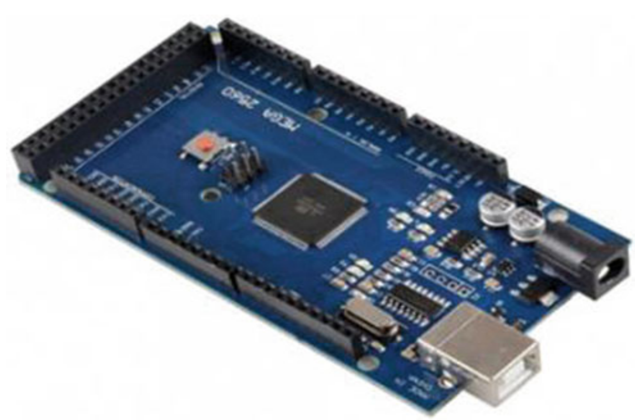


Fig. 2 Arduino Mega 2560

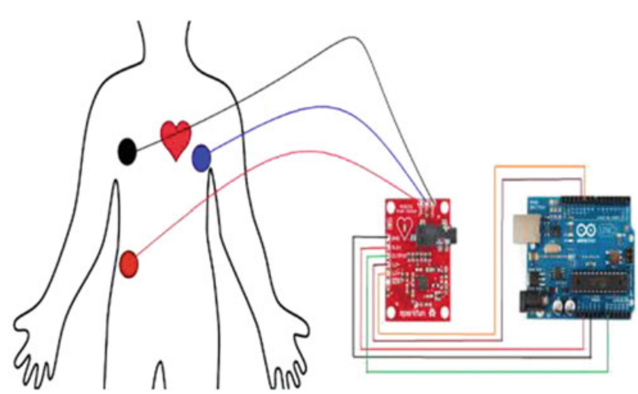


Fig. 3 Operational amplifier AD8232

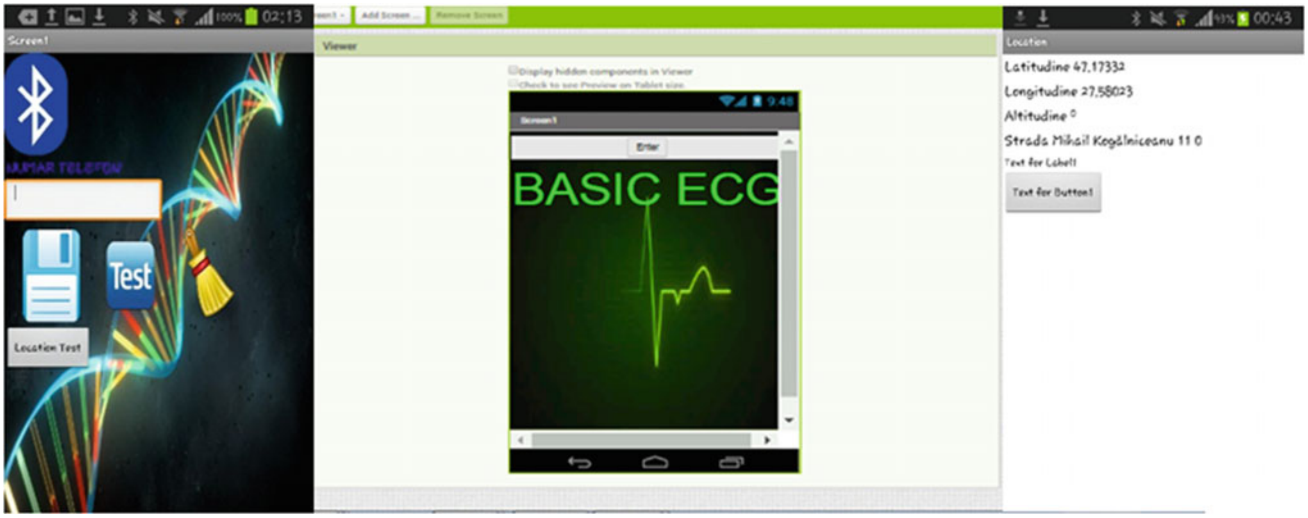


Fig. 4 MIT App Invertor 2

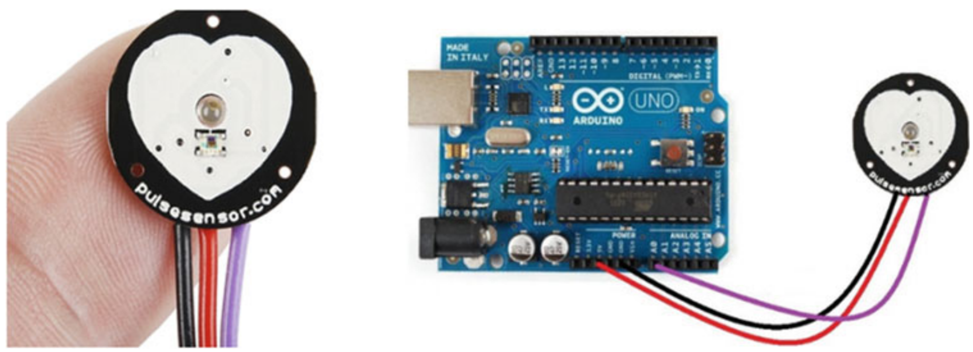


Fig. 5 The pulse sensor XD-58C

of the Arduino development platform. At the same time, it can also be placed on the ear lobe or on the finger without damaging the patient's activity. Pulse monitoring is done in real time (Fig. 5).

The DHT22 sensor is a small, inexpensive and handy humidity and temperature sensor. Use a capacitive moisture sensor and a thermistor to measure ambient air and body surface. It can be placed in the upper limbs, but also in the heart area. It provides a digital signal on the D2 data pin (no analogue pin is needed). It is easy to use, but it takes care of reading the data, but also interpreting it because it returns two types of values read by the sensor, namely temperature and moisture from the body [2] (Fig. 6).

The Master Slave HC-05 Bluetooth Module with a 5 V supply voltage and a 30 mA consumption and to make a connection between the device and a smartphone. It has 4 control pins out of which 2 are power supply and 2 communication. Communication with the Arduino development platform is a serial UART based on the SDA and SCL ports. It has a 10-m range and automatic reconnection. For the display itself, an application was developed in MIT App Inventor 2 [3] (Fig. 7).

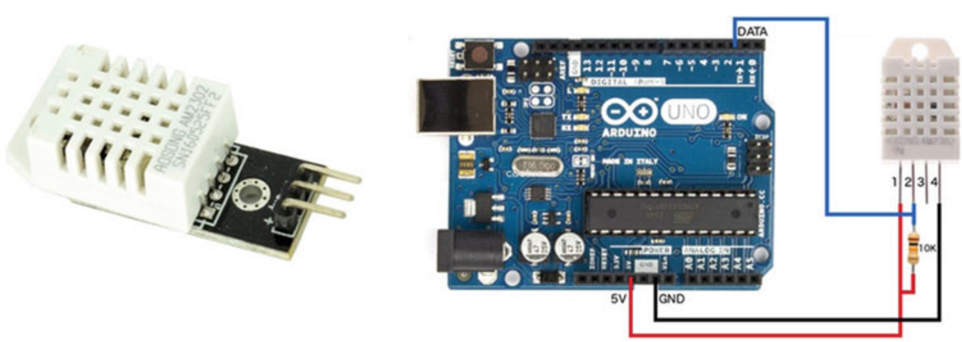


Fig. 6 Humidity and temperature sensor DHT22

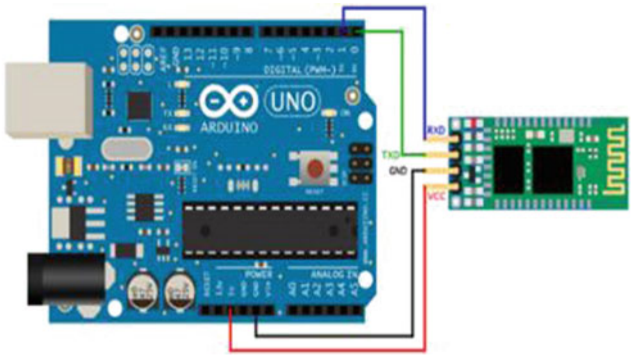


Fig. 7 Bluetooth module HC-05

The GPS module used uses radio waves and satellite navigation to determine the position. It emits satellite signals. The position (latitude, longitude, altitude) is calculated by knowing the position of at least four satellites receiving the GPS signal at different times. Normally, three satellites are sufficient to determine the three coordinates (space position), and the fourth satellite is used to minimize errors. It communicates via serial transmission of RX and TX ports from the microcontroller, and feeds at a voltage of 5 V [5, 6] (Fig. 8).

The SIM800L GSM module is powered at a voltage of 3.4–4.4 V and communicates with the Arduino development platform via the serial UART interface. It has the role of having a continuous internet connection of the entire device via the 3G or 4G network, but also sending an emergency message to the emergency service. In the urgent message there is information about the patient's condition and the location provided by the GPS module.

The connection of the mode is as follows: The VCC pin on the module can be connected to 3.3 V on Arduino either on an external battery and on the GND at the table. The RST port will be linked to D2 to be able to reset the mode

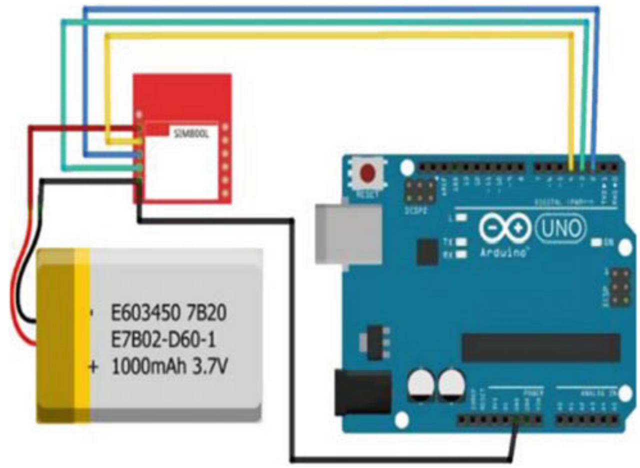
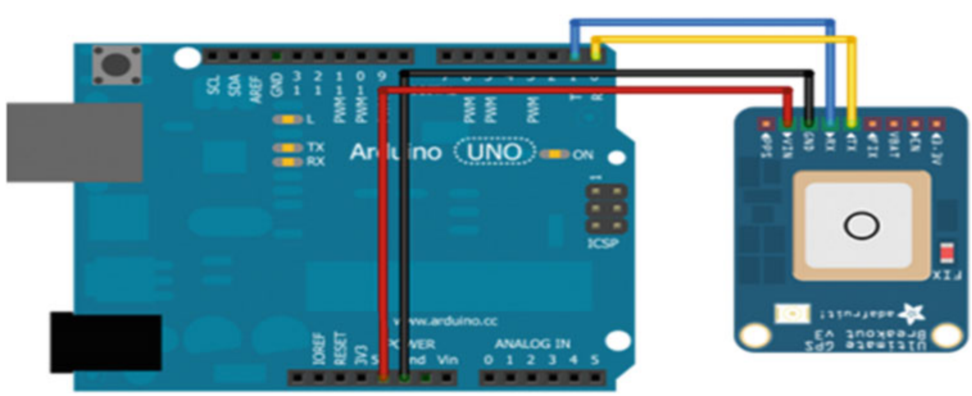


Fig. 9 The GSM module and connection configuration

according to the written program. The RX and TX pin connected to D3 and D4 are data communication between the Arduino development board and the whole module. The commands for initializing and verifying the function of the mode are made immediately when the whole device is switched on so that if signal connection errors or invalidation of the SIM card are transmitted as a warning message to the patient [4] (Fig. 9).

The LCD display has 2.8 inches and a resolution of 320 × 240 pixels. It works at 3.3 and 5 V. The shield contains a resistive touchscreen and also has an SD card slot on which txt data can be saved, but uploads bmp-sized images to display on the display. These data saved on the SD card can be interpreted later by a specialist. It is compatible with several Arduino development platforms, by default with Arduino Mega. The screen has a background light control pin, which helps save energy, so it can automatically turn off the lighting side to reduce power consumption [2] (Fig. 10) [7, 8].

Fig. 8 The GPS module



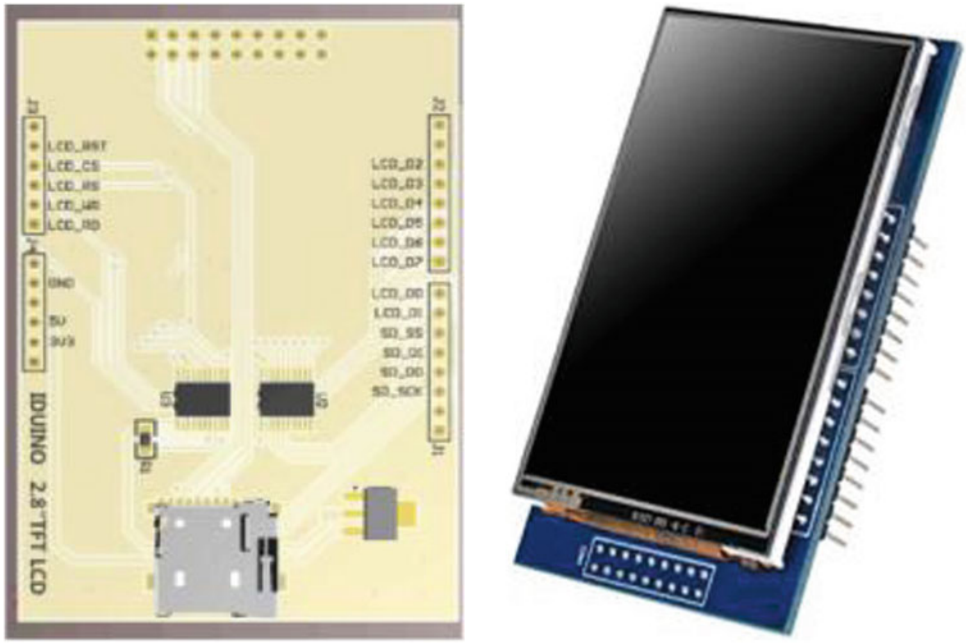


Fig. 10 LCD display

To be able to schedule it, you must attach the manufacturer's libraries where all the connection ports are defined for both the display side and the data save side of the SD card. These libraries access different ports of the way communication between the LCD and the Arduino plate is made. Supports memory cards with up to 16 GB capability to create folders for txt and bmp files. In order to be easier then interpreting them.

The light sensor aims to save the energy and battery of the device by putting the screen on stand by after a 5 min inactivity, but also when the device is covered. The sensor works at a 5 V voltage with extremely low power consumption and is based on the reflection between an IR led and a phototransistor. The IR light will emit a light that the phototransistor will receive when it reflects at a distance of 0–4 cm. With a small signal, the sensor also has an operational amplifier and a filter to amplify and filter the input signal for better signal capture accuracy (Fig. 11).

The power supply side of the device was powered by a 5 V voltage charging module, consisting of a Li-Ion battery with a capacity of 2200 mA. The complete system has an autonomy of 8–10 h. The percentage of the battery is displayed on the display, but also by warning lights when the battery is discharged or in the charging process. The device can be charged to any type of charger with a USB plug as it has a Micro-USB connection (Fig. 12) [9, 10].

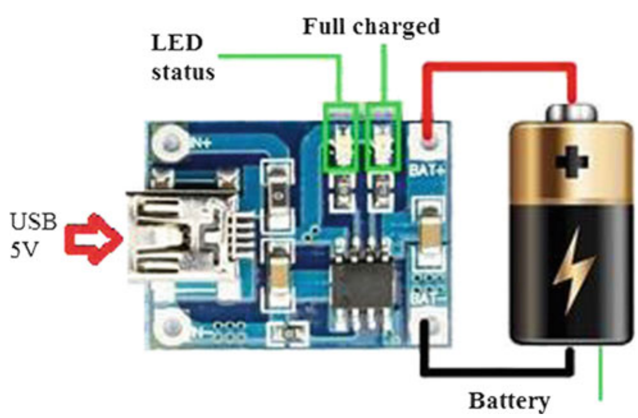


Fig. 12 Power supply

Fig. 11 The light sensor

3 Results

The source code of the system, in addition to the functions related to the acquisition and processing of biosensors, contains a series of code lines dedicated to the user interface. It has been desired to obtain a device which does not require complex technical knowledge in use. The graphical interface has been entirely created and includes several submenus.

Once the device is powered on, it will show if we want to start or put it on standby. This is done by pressing the two buttons on the side, one for validating the startup and moving to the next step and the other for the invalidation to put the whole system in the standby mode (Fig. 13).

Using the ECG module, we obtained a series of signals that correspond to the physiological route in a trunk that were first displayed on the computer through the Processing software to get a better picture and then be displayed on the display. This software contains libraries that can process signal processing as it can implement signal processing functions such as Fourier Transform or Sampling [11] (Fig. 14).

Calibration of the signal was done using the Metron PS420 heart simulator to highlight the symptoms and illnesses of some cardiac pathologies (ventricular fibrillation, myocardial infarction).

The values recorded by the pulse sensor were taken over by the microcontroller and processed with the aid of some algorithms to be displayed. The temperature at which determinations were made ranging between 36.96 and 37.01 °C, with a humidity of approximately 33.4%.

The system designed and built works according to the established requirements. So we've also built a 3D design and print carcass. 3D realization was done in Autodesk Fusion 360. It is a discreet, portable device that can be used at home, in the office or on a walk (Figs. 15 and 16).

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```
tft.println("IoT DEVICE");
tft.setTextColor(ILI9341_RED);
//tft.setCursor(0,100);
 V1= analogRead(1);
 tft.drawRect(1, 40, tft.width()-1, 82, ILI9341_BLUE);
 tft.drawRect(1, 150, tft.width()-1, 170,ILI9341_BLUE);
 tft.setTextColor(ILI9341_YELLOW, ILI9341_BLACK);
 tft.setTextSize(2);
 tft.setCursor(35, 45);
 tft.println("PULS");
 tft.setCursor(150, 45);
 tft.println("TEMP");
 tft.fillRect(2, 62, tft.width()-5, 37, ILI9341_BLACK);
 tft.setTextSize(3);
 tft.setTextColor(ILI9341_GREEN,ILI9341_BLACK );
 tft.setCursor(30, 72);
 tft.print(BPM);
 tft.setTextColor(ILI9341_YELLOW,ILI9341_BLACK);
 tft.setTextSize(2);
 tft.print("BPM");
 float temperatura = readTempInCelsius(10,A5);
 tft.setTextSize(3);
```

Fig. 13 Source code

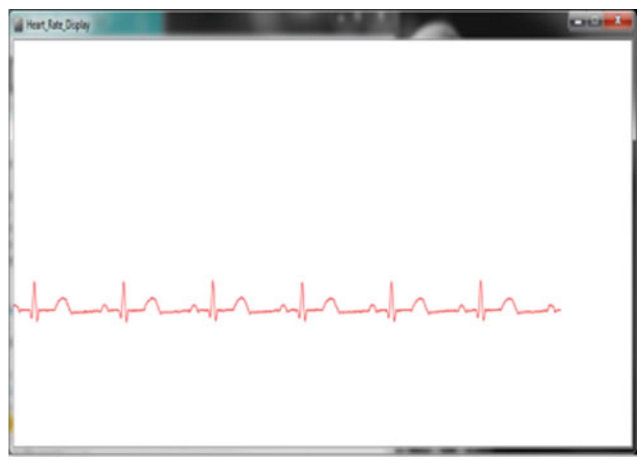
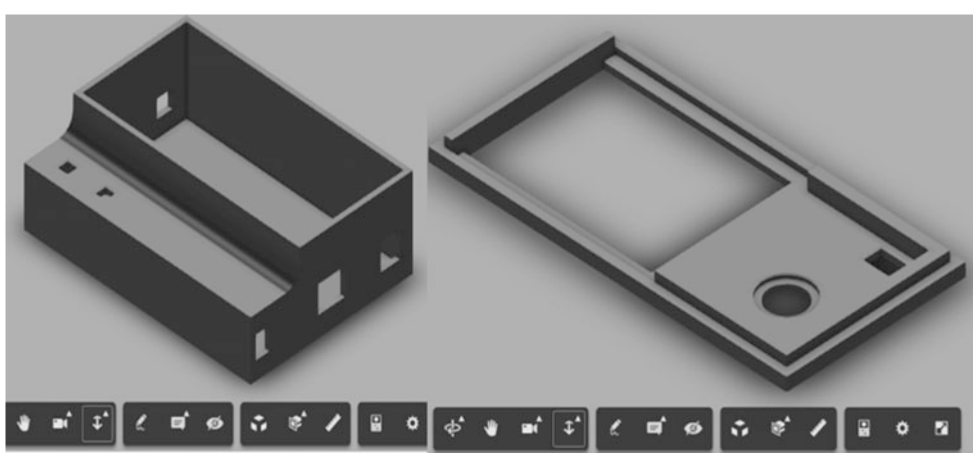


Fig. 14 ECG signal

Fig. 15 3D device design



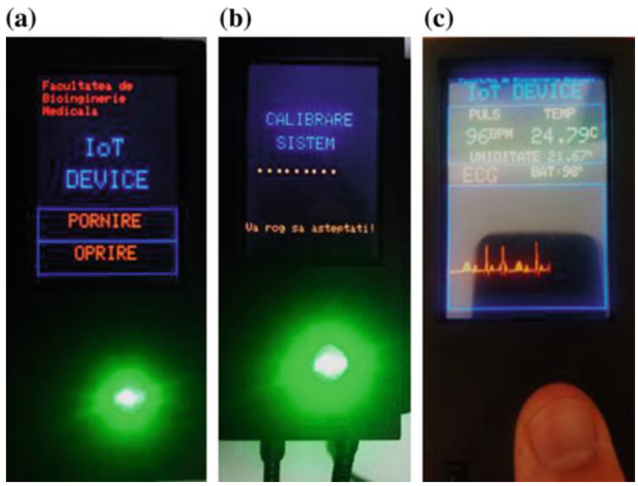


Fig. 16 **a** Device startup menu, **b** calibration menu, **c** monitoring menu

4 Conclusions

Preliminary results have shown that the device is capable of taking the signals obtained from the attached modules so that we finally have a complete set of data for the functional evaluation of the patient.

Optimization of the device is to achieve accuracy of real-time data but also a patient's safety that can be medically supervised remotely, any alteration of its status being immediately signaled to allow a rapid medical response.

In the future, we want to associate the equipment with an accelerometer in order to have a clearer picture of the positioning of the assisted subject in space.

The system is easy to use, without discomfort, being a discreet, portable device that can be used at home, in the office or on a walk with an autonomy of up to 8–10 h.

The development of such a system is a field of research involving medical and engineering knowledge, medical bioengineering being the basis of research in this area of knowledge.

Future Research Directions:

- On the hardware side, by optimizing the components used, you could make a miniaturization of the entire system so that it is more reliable. In this respect, the current modules can be replaced with some SMD-type more efficient, thus minimizing the energy consumption.
- Addition of additional sensors in order to increase the parameters.
- On the software side, develop additional functions for more elaborate analysis and processing for ECG analysis.
- The development of electrodes from a material with low resistivity, with the shape and size appropriate for these types of recordings.

Increase system fidelity using approved components to capture the signal.

Conflict of Interest The authors declare that they have no conflict of interest.

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