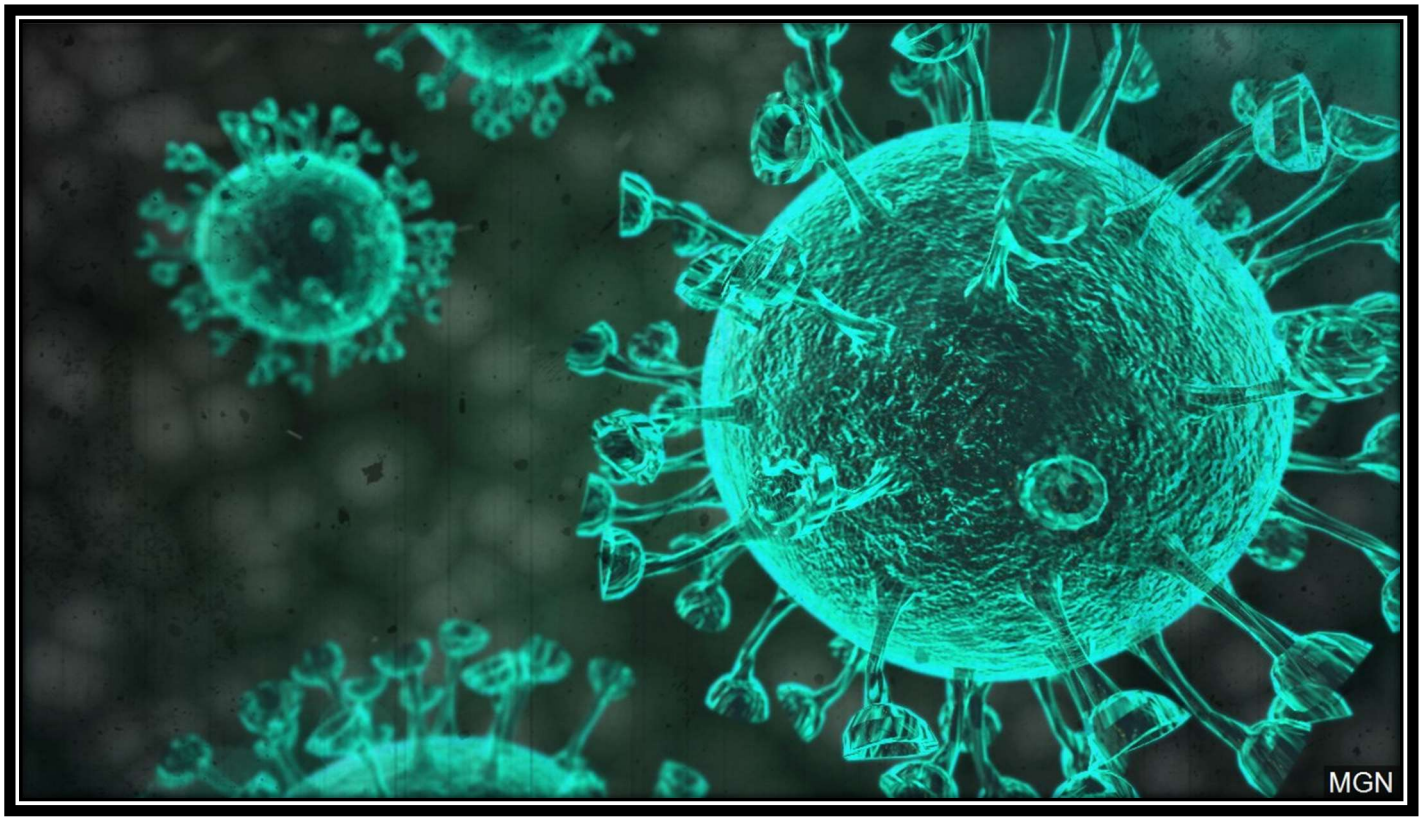
PROJECT IOT 2020/2021

Rapport

Covid 19 Patient Monitoring



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Summary

Introduction:

The World Health Organisation (WHO) has declared the coronavirus disease 2019 (COVID-19) a pandemic[1]. A global coordinated effort is needed to stop the further spread of the virus. A pandemic is defined as “occurring over a wide geographic area and affecting an exceptionally high proportion of the population.”[2].

On 31 December 2019, a cluster of cases of pneumonia of unknown cause, in the city of Wuhan, Hubei province in China, was reported to the World Health Organisation. In January 2020, a previously unknown new virus was identified [3], subsequently named the 2019 novel coronavirus, and samples obtained from cases and analysis of the virus’ genetics indicated that this was the cause of the outbreak. This novel coronavirus was named Coronavirus Disease 2019 (COVID-19) by WHO in February 2020. The virus is referred to as SARS-CoV-2 and the associated disease is COVID-19.

Keeping track of the health status of Covid 19 patients at home is a difficult task during this period of sanitary emergency. Especially old patients should be periodically monitored. Positive people to the virus need to monitored their heart rate, blood oxygen level and body temperature in the eventuality of an increase or decrease of these conditions.

It could be useful to know how to build a device that allows you to monitor the health conditions of the forbearing via IoT, which is rapidly revolutionizing the healthcare industry. The device gives us the chance to track the patient health using Web server.

The aim of the Covid 19 patient monitoring is to check:

- Heart rate of the patient;
- Blood oxygen level of the patient;
- Body temperature of the patient;
- Temperature and humidity of the room in which is the patient. [20]

State of the art

i. Evolution of the products

The first non-invasive oximeters, that appeared, were the ear oximeters, around 1935, when it was proved that the transmission oximetry could be applied to the external ear. However, the major inconvenient of ear oximetry was revealed to be the inability to differentiate light absorption due to arterial blood from that due to venous blood and tissues. Due to the volume of the components involved, the high cost of instrumentation, and the development of technology to solve many of these problems, the ear oximeters is no longer commercialized.

Laser oximetry is a new non-invasive method to evaluate determine the oxygen saturation on targeted areas of tissue, through a continuous wave optical spectrometer operating in the near-infrared spectrum. Nowadays, there are small oximeter for measure the oxygen saturation on extremities of human body such as finger. A modern pulse oximeter incorporates the electronics and sensor into one single unit.

In recent months, the oximeter has jumped to the forefront of the news because it has proved invaluable towards the Covid-19 subjects under observation. Through the test (oximetry) it is in fact possible to suspect a severe complication, that is to say that if a drop in oxygen concentration in the circulatory stream should occur it would be the unequivocal signal that a patient is harbouring interstitial pneumonia, therefore a sign that the subject monitored is worsening to the point that ambulance transport with access to the emergency room or intensive care is required. In fact, the most used one is the pulse oximeter that also measures the body temperature. In exceptional cases, this last can contain also a room thermometer. [10][13][16]



Related to the body temperature, there are different kinds of thermometer. The most used in this virus period is the infrared thermometer, which doesn’t need to be touched. Some countries use it to monitor the people health in public places.

The first thermometer was 30 cm long and taking a patient's temperature could take up to half an hour. Subsequently the thermometer assumed the dimensions it has today, allowing an accurate and at the same time rapid measurement. We used analogic mercury thermometers until 2009,

then they were withdrawn due to the toxicity of the mercury itself. The latter, accurate and reliable, had the only drawback of being tiring enough to lower after the measurement. In recent years, the need to reduce the time required for measurement has become widespread. In fact, digital electronic thermometers are faster in temperature measurements and the digital display is easier to read. While, infrared thermometers measure the heat generated by surfaces and cavities. The main advantage of this type of thermometers is their speed; it only takes a few seconds to measure the temperature. [12]

ii. Market study

On the healthcare market, many devices are available to monitor these states:

- Pulse oximeter, which is a non-invasive medical device, that measures the oxygen saturation in the peripheral arterial blood and at the same time the heart rate, those helping to identify the possible presence of the first signs of pneumonia, one of the most serious symptoms of Coronavirus.
- Thermometer, which is a measuring instrument, that measures the body temperature. High fever, in fact, is one of the most common symptoms of Covid 19.
- Hygrometer thermometer, which measures the room temperature and humidity. Many diseases are related to humidity: asthma, general respiratory diseases, often depend on the quantity / quality of the air.

Pulse oximeter

The prices of a pulse oximeter range, roughly, from about 20 euros to about 200 euros. A low-cost device will be the choice of those who will use the device occasionally, because it doesn't suffer from diseases, that require constant monitoring. Whereas a higher cost will be preferred by those users who are looking for reliability and solidity from a device they will use frequently. The choice is subjective. [10][7][8]

Pulsossimetro, Monitore di Battito Cardiaco Portatile con LED Display, FED e CE Certificato per Misurazione di Pulsazione (PR) e Saturazione di...

★★★½☆ ˇ2

20,09€

Pulsossimetro PULOX PO-600 saturimetro portatile con sensore esterno

★★★★☆ ˇ16

199,90€

Thermometer

Before purchasing this product, it is very important to know the different types on the market and what they stand out for. Each type has a different degree of accuracy and a specific area of use, so the most suitable purchase choice will depend on your personal needs. The prices vary from 3 euros to 1000 euros. [7][8]

Raggi Infrarossi Riconoscimento Facciale Termometro Senza Contatto Telecamera Termica Misurazione Temperatura Macchina Presenze...

999,00€

5,50 € di spedizione

Nowakk Termometro, Termometro digitale con corpo lcd in abs a testa quadrata impermeabile ad alta precisione

★★★☆☆ ˇ1

3,28€

Spedizione GRATUITA

Generalmente spedito entro 2-3 giorni.

Sponsorizzato

Wawech Termometro febbre infrarossi 2 in 1 Termoscanner professionale per febbre Misuratore temperatura corporea Termometro...

★★★★★ ˇ183

39,99€ (39,99 €/unità)

Online it is possible to find a pulse oximeter, which measures also the body temperature, but the prices tend to rise significantly. [9]

Hygrometer thermometer

Keeping the temperature in the house optimal is extremely important, as is constantly ventilating the room. If there are no sources of air in the most experienced areas, it is advisable to rely on the hygrometer in order to keep everything under control. The hygrometer is a very convenient, inexpensive and simple to use tool, excellent for avoiding unpleasant conditions. Especially in the presence of children, the elderly and asthmatics, keeping humidity under control is a necessity that should not be underestimated for any reason.[11]

The prices vary from 2 euros to 300 euros. [7][8]

Cosye Classic Homeuse Indoor Outdoor 2 in 1 Mini igrometro a Umido accurato Termometro di umidità Misuratore di Temperatura...

1,98€

Igrometro Monitorare Weather Station Coperta Professionista con PC Link della Famiglia Termometro Radio igrometro Pressione...

310,11€

ThermoPro TP49 Mini Igrometro Termometro Digitale Termoigrometro da Interno per Casa Monitor di Temperatura e umidità per Ambient...

3.522

9,99€

Norms and regulations

Since in our project we use different devices together, the regulation of each of them are also valid for our IoT device.

- ***Pulse oximeter:***
  Use in suboptimal conditions can lead to reading errors which can distort the displayed results. In particular:
  - the vasoconstriction (ie the decrease in the calibre of the blood vessels), of the peripheral districts, such as that of the fingers, lead to a decrease in the blood flow detectable by the probe, which therefore processes false data;
  - the pulse oximeter allows to know only the percentage of haemoglobin saturation, while it does not reveal information on which gas is bound;
  - hypotension: the reading becomes less and less reliable when the systolic level falls below 55-60 mmHg;
  - Anaemia: in patients suffering from anaemia, a possible hypoxemia condition may be hidden and not detected by the oximeter;
  - body temperature: below 35 ° C there is a reduction in the read values of the device;
  - movements of the person: they can create missed readings of the pulsatile wave that cannot verify its shape;[15][16][18]
- ***Thermometer:***
  - Do not bend the tip of the thermometer or bite it. [14]
- ***Hygrometer thermometer:***
  - The hygrometer thermometer is also used to improve energy savings through the regulations in force on the Minimum Environmental Criteria (CAM).[17]
  - Do not use or store the meter in an environment of high temperature, humidity, subject to explosions, flammable or with strong magnetic fields. Operation of the meter may result deteriorated if subject to high humidity or wet.
  - Do not use the meter if its surface is wet or if your hands are wet.
  - Do not use the device if the environmental conditions (temperature, ambient humidity ...) do not found within the limits indicated in the specifications.
  - Do not expose the probe to high humidity and high temperatures when the structure is cold because it could generate condensation which would affect the measurement results. If so, check, allow the probe to dry before taking new measurements.[19]
- ***General:***
  - Portable and mobile radio frequency communications equipment can affect the operation of the electromedical instruments.
  - All devices must be kept out of the reach of children.[14][15][18]

The devices are certified according to the following standards:

- ***Pulse oximeter:***
  EN60601-1: Medical electrical equipment Part 1: General requirements for basic safety and essential performance[27]

EN60601-1-2 : Medical electrical equipment - Part 1-2: General requirements for basic safety and essential performance - Collateral Standard: Electromagnetic disturbances - Requirements and tests[28]
DIN EN ISO 80601-2-61 : Medical electrical equipment - Part 2-61: Particular requirements for basic safety and essential performance of pulse oximeter equipment (ISO 80601-2-61:2017, Corrected version 2018-02) [29][30] [21]

- ***Thermometer:***
  DIN EN ISO 13485 : Medical devices -- Quality management systems -- Requirements for regulatory purposes [31][32] [13]
- ***Hygrometer thermometer:***
  DIN EN 60 751 : Industrial platinum resistance thermometers and platinum temperature sensors [33] [22]

All the previous norms are European one, certified by CENELEC or ETSI or CEN. In summary, CENELEC is European Committee for Electrotechnical Standardization, which is responsible for European standardization in the area of electrical engineering. Together with ETSI (European Telecommunications Standards Institute) and CEN (European Committee for Standardization), it forms the European system for technical standardization.[23][24][25] Usually the European norms are indicated by EN. The norms DIN EN are accepted by the CENELEC and CEN.[26]

Description of the project:

Our Project is based on the resolution of a major problem encountered during this health crisis: the monitoring of patients from home, affected, but asymptomatic, or at risk of contracting the coronavirus, without the eventual visit of a doctor, in cases where there are no clinical conditions that arouse suspicion. Medical visits from house to house or in health centres can create two problems in turn: lack of staff to cope with the emergency and the creation of new outbreaks in the event that a patient or a doctor is infected.

There are numerous solutions to these problems. Our consists in the creation of a single device capable of monitoring some symptoms from home that may represent the onset of the virus in the patient considered. This is possible thanks to the measurement of three vital signs:

- Heart rate of the patient;
- Blood oxygen level of the patient;
- Body temperature of the patient.

The doctor treating the patient in question will therefore be able to access this information at any time and whenever these parameters change substantially, arrange for a visit to the patient in the manner deemed most appropriate. In fact,

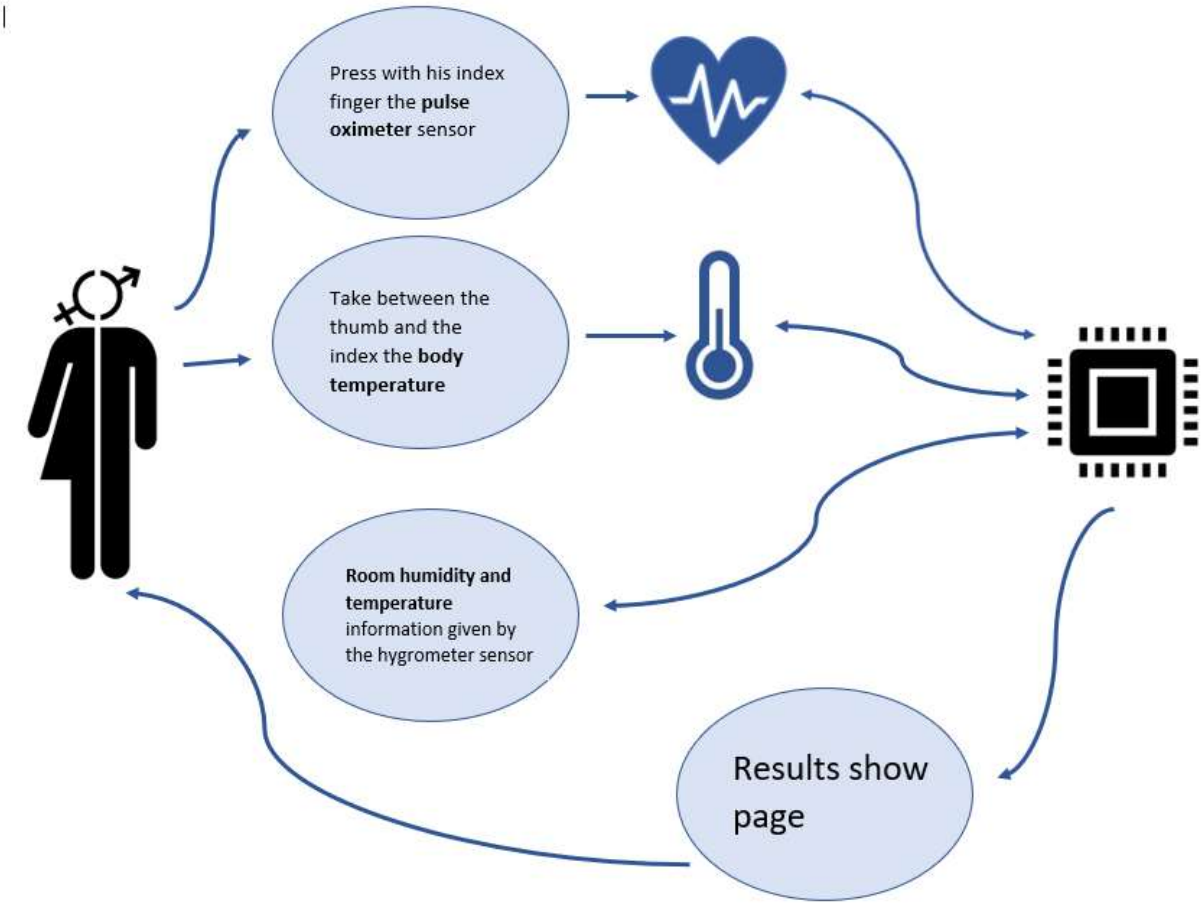
our device must allow those with the right information to be able to view the parameters considered with a simple internet connection at any time.

The device must therefore be composed of three sensors, each with a different and specific task:

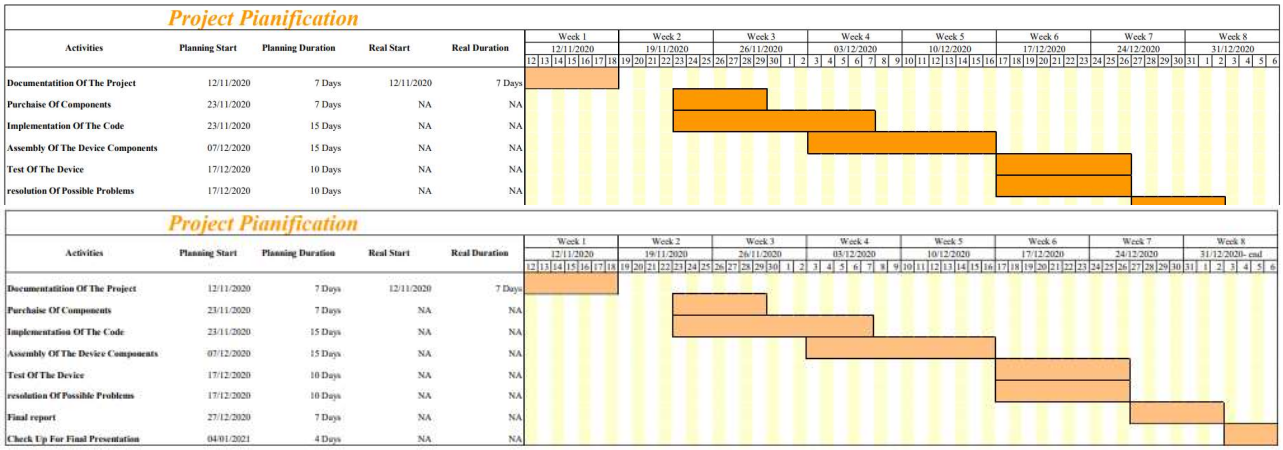
- Pulse Oximeter Sensor, used to monitor heart rate and oxygenation;
- Temperature sensor, is used to monitor the patient's body temperature;
- Temperature and humidity sensor, is used to monitor the temperature and humidity of the room where the patient is, as these conditions could bring significant changes in the parameters previously described.

The device will input all the above parameters and then bring them back to a single web page, by entering the IP address.

PERT diagram



GANTT Diagram



	1. Not done yet
	2. Done

This diagram represents the least of tasks and estimated duration. It can be very useful for ourself organization. It will be updated during the progress of the project according to the evolution of the situation.

Use cases

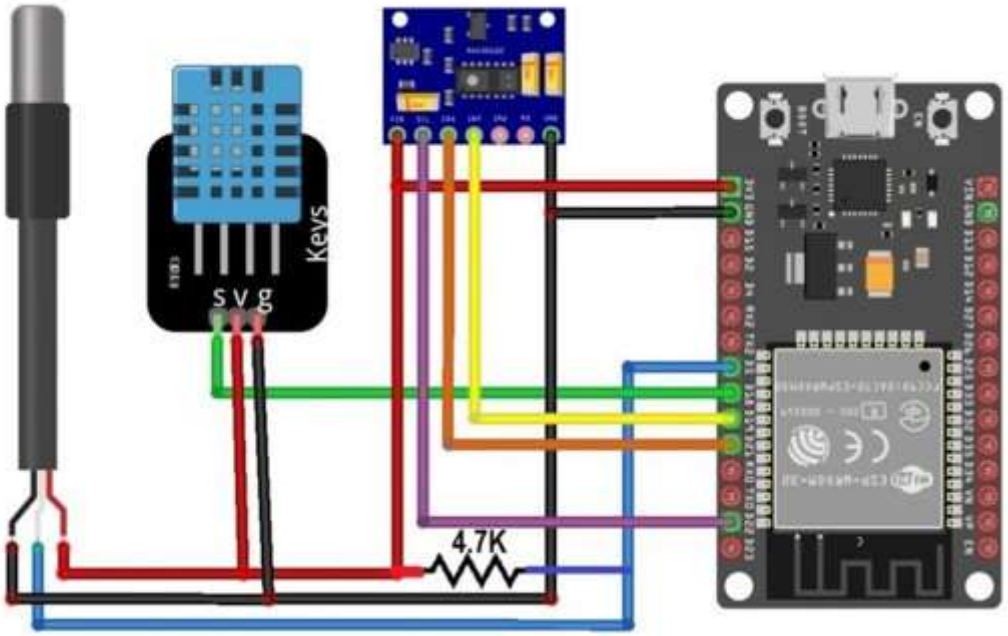
It could be useful to know how to build a device that allows you to monitor the health conditions of the forbearing via IoT, which is rapidly revolutionizing the healthcare industry. The device gives us the chance to track the patient health using Web server.

The aim of the Covid 19 patient monitoring is to check:

- Heart rate of the patient;
- Blood oxygen level of the patient;
- Body temperature of the patient;
- Temperature and humidity of the room in which is the patient. [37]

An example of use of this device is to allow interested person (as the patience, his family, his doctor, ...) to access to these results using a simple IP address.

Circuit diagram



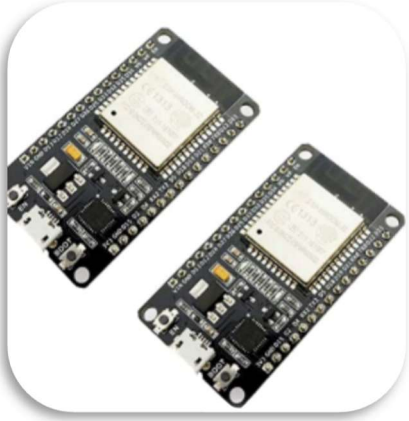
[47]

Materials

List of the components of the project

- *ESP32 Board*
- *Pulse Oximeter Sensor MAX30100/MAX30102*
- *DS18B20 Sensor*
- *DHT11 Sensor*
- *Resistor*
- *Connecting Wires*
- *Breadboard*

Technical study:

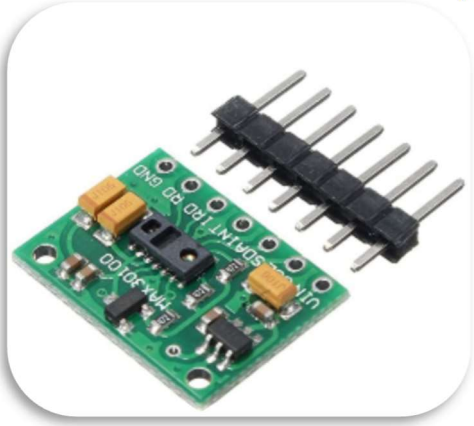


ESP32 Board

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. It is perfect for our project, because it is a union of more Arduino components that otherwise we had to take. [38]

Pulse Oximeter Sensor MAX30100/MAX30102

The MAX30100 is an integrated pulse oximetry and heartrate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analogical signal processing to detect pulse oximetry and heart-rate signals.



The device has two LEDs, one emitting red light, another emitting infrared light. For pulse rate, only the infrared light is needed. Both the red light and infrared light is used to measure oxygen levels in the blood. When the heart pumps blood, there is an increase in oxygenated blood as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the pulse rate is determined.

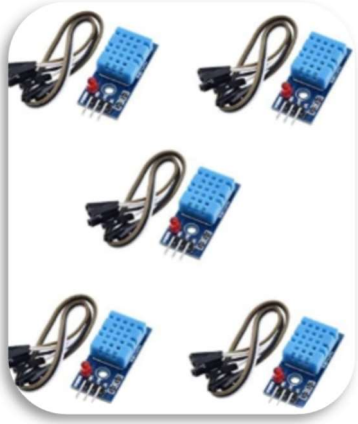
It turns out, oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light. This is the main function of the MAX30100: it reads the absorption levels for both light sources. [39].

DS18B20 Sensor

This is a pre-wired and waterproofed version of the DS18B20 sensor. Handy for when you need to measure something far away, or in wet conditions. The Sensor can measure the temperature between -55 to 125°C (-67°F to +257°F). The cable is jacketed in PVC.

Because it is digital, there is no signal degradation even over long distances. [40]

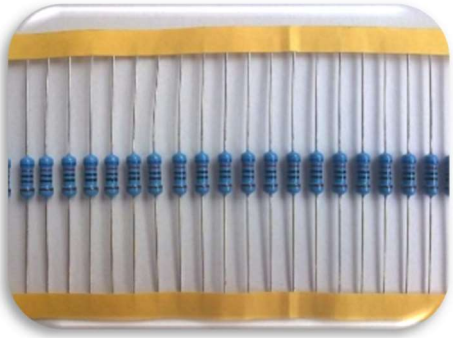
DHT11 Sensor



The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin.

It is fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using the library, sensor readings can be up to 2 seconds old. [41][42]

Resistor



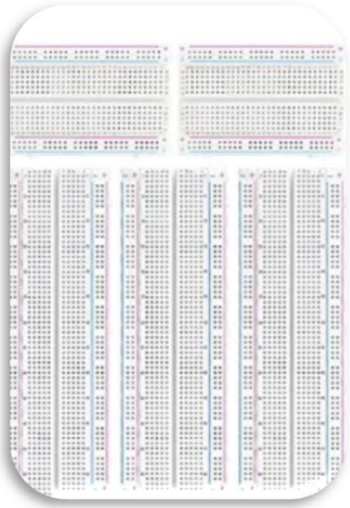
A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. [43]

Connecting Wires

A jump wire is an electrical wire, or group of them in a cable, with a connector or pin at each end, which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment. [44]

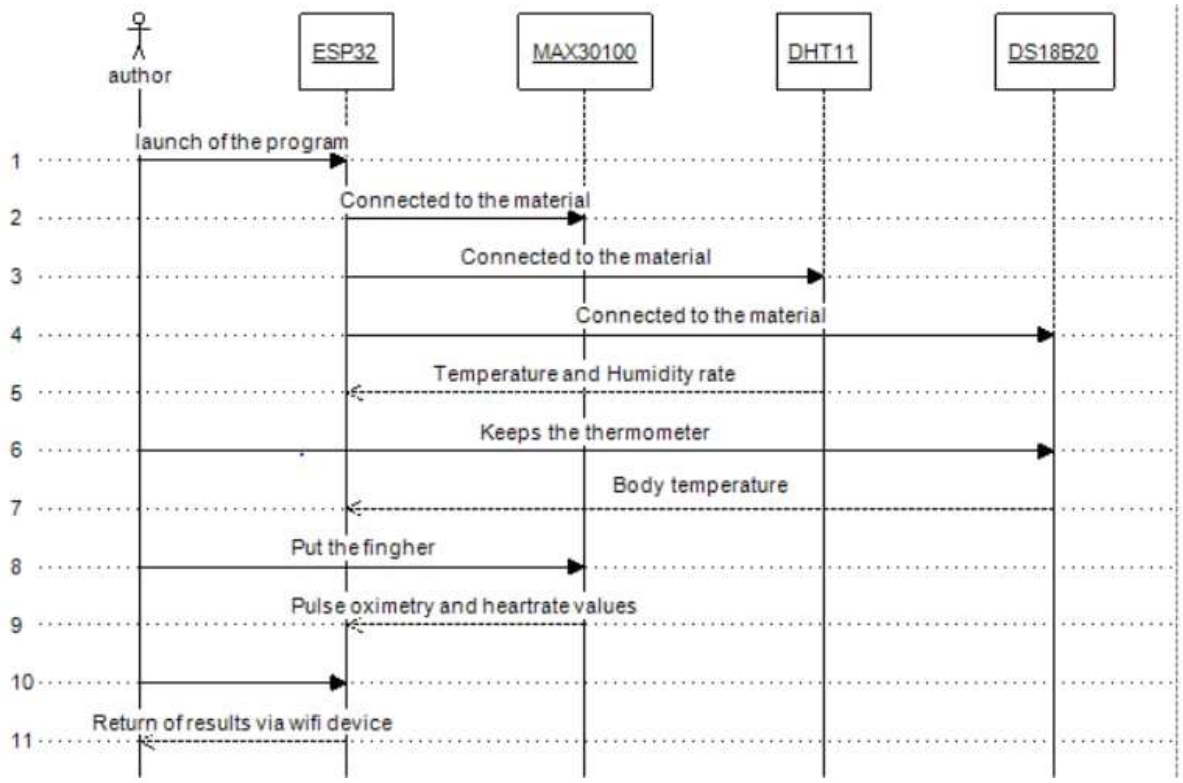
Breadboard



A breadboard is a construction base for prototyping of electronics.

The solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also popular with students and in technological education. [45]

Technical solution, Sequence diagram



To use the device the user has to press with his index finger the pulse oximeter sensor, MAX30100, and, simultaneously, take between the thumb and the index the body temperature sensor, DS18B20. The device will receive the collected data as input, taking also the room humidity and temperature sensor information, DHT11, automatically. At the end the user has to insert the IP, given by the device, ESP32, to connect to the results show page. [34][35][36] [46]

Hence, the sensors data are stored in the ESP32 memory, then they are sent via Wifi at regular intervals to the IP address.

Software solution explanation

Code

It is possible to find the code at the following link: https://how2electronics.com/iot-based-patient-health-monitoring-esp32-web-server/

During the implementation we encountered problems with this code and, moreover, with a sensor, MAX30100.

Following these problems, we have decided to create multiple devices, which codes are shown below.

sketch_jan14a

```
#include <WiFi.h>
#include "DHT.h"

// Uncomment one of the lines below for whatever DHT sensor type you're using!
#define DHTTYPE DHT11 // DHT 11

// Replace with your network credentials
const char* ssid = "AndroidAP4692";
const char* password = "1492b9f2fa7b";

WiFiServer server(80);

// DHT Sensor
const int DHTPin = 18;
// Initialize DHT sensor.
DHT dht(DHTPin, DHTTYPE);

// Temporary variables
static char celsiusTemp[7];
static char fahrenheitTemp[7];
static char humidityTemp[7];

// Client variables
char linebuf[80];
int charcount=0;

void setup() {
// initialize the DHT sensor
dht.begin();

//Initialize serial and wait for port to open:
Serial.begin(115200);
```

PROVA_ESAME

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>

#define REPORTING_PERIOD_MS 1000

char auth[] = "WWhnQ-RbFa1hopd6b1VlWIIswWeSUnE5";
char ssid[] = "AndroidAP4692";
char pass[] = "1492b9f2fa7b";

// Connections : SCL PIN - D1 , SDA PIN - D2 , INT PIN - D
PulseOximeter pox;

float BPM, SpO2;
uint32_t tsLastReport = 0;


void onBeatDetected()
{
    Serial.println("Beat Detected!");
}

void setup()
{
    Serial.begin(115200);

    pinMode(19, OUTPUT);
    Blynk.begin(auth, ssid, pass);
```

termometro_esame_2

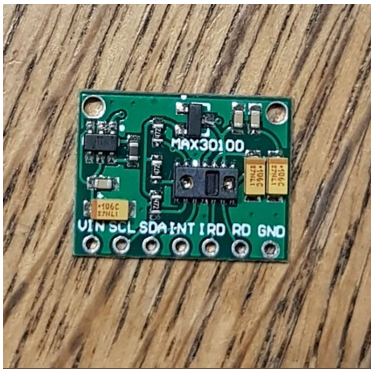
```
/*********
  Rui Santos
  Complete project details at https://RandomNerdTutorials.com
*********/

#include <OneWire.h>
#include <DallasTemperature.h>

// Data wire is plugged TO GPIO 4
#define ONE_WIRE_BUS 5

// Setup a oneWire instance to communicate with any OneWire devices (not just Maxim/Dallas temperature ICs)
OneWire oneWire(ONE_WIRE_BUS);

// Pass our oneWire reference to Dallas Temperature.
DallasTemperature sensors(&oneWire);

// Number of temperature devices found
int numberOfDevices;

// We'll use this variable to store a found device address
DeviceAddress tempDeviceAddress;

void setup(){
  // start serial port
  Serial.begin(115200);

  // Start up the library
  sensors.begin();

  // Grab a count of devices on the wire
  numberOfDevices = sensors.getDeviceCount();
```

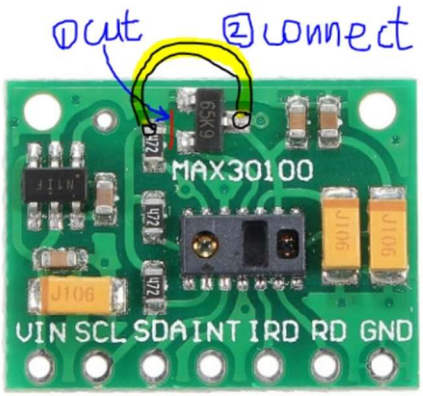
Encountered problems

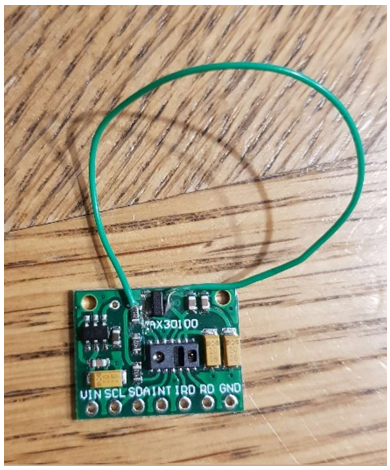
During the implementation we encountered problems with this code and, moreover, with a sensor

Another problem encountered during the project execution is related to the MAX30100, which has design problem. The SCL and SDA pins are pulled-up via the 4.7k ohm resistors to 1.8V! This means it won't work well with microcontrollers with higher logic levels.

A possible solution can be to cut the path in the place of the red cross and make a jumper as shown by the yellow line.







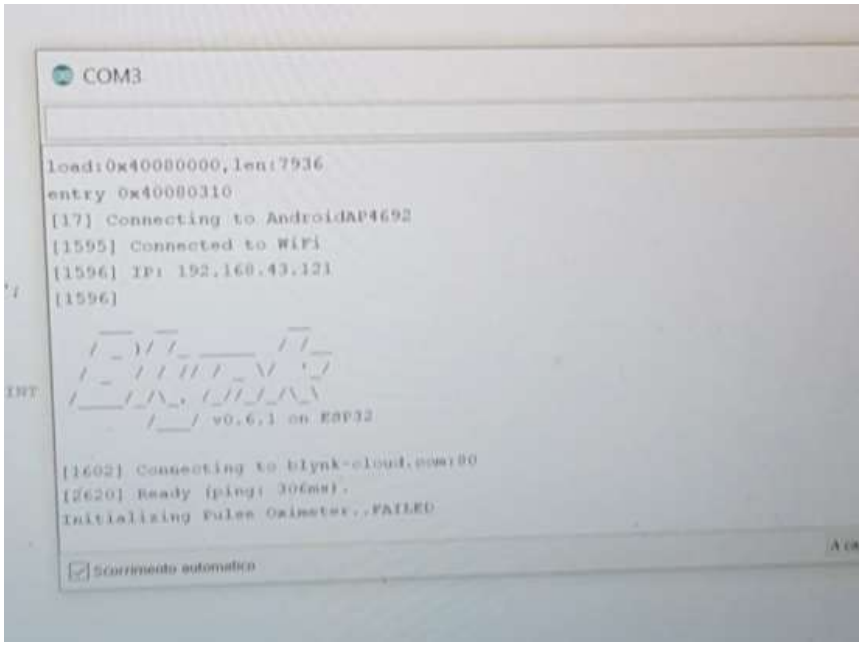
Conclusion

The results of the codes are:


```
Temp C: 28.69 Temp F: 83.64
Temperature for device: 0
Temp C: 28.81 Temp F: 83.86
Temperature for device: 0
Temp C: 28.94 Temp F: 84.09
Temperature for device: 0
Temp C: 29.00 Temp F: 84.20
Temperature for device: 0
Temp C: 29.25 Temp F: 84.65
Temperature for device: 0
Temp C: 29.25 Temp F: 84.65
Temperature for device: 0
Temp C: 29.06 Temp F: 84.31
Temperature for device: 0
Temp C: 24.75 Temp F: 76.55
```

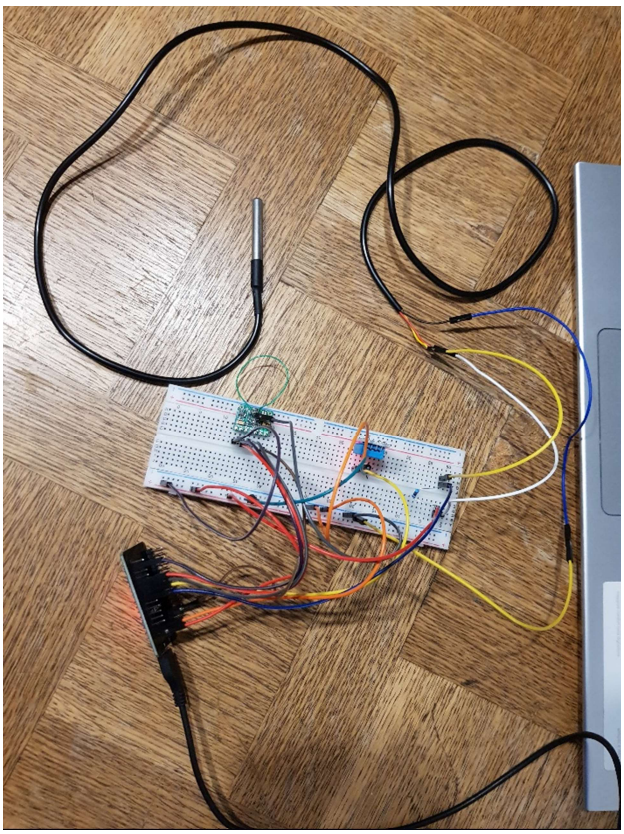
Despite several attempts and the modification made, we have not yet been able to solve the problem with the MAX30100.

In fact, as it is possible to see from the image, the code fails, because the sensor doesn't read the pulsations.



The final project looks like this:

Even if we didn't obtain the expected results, we are convinced that this project, if completed, can be of great help in various situations of health problems.



References:

1. https://en.wikipedia.org/wiki/Coronavirus_disease_2019
2. https://www.merriam-webster.com/dictionary/pandemic
3. https://en.wikipedia.org/wiki/Timeline_of_the_2019%E2%80%9320_coronavirus_pandemic_in_November_2019_%E2%80%93_January_2020
4. https://www.esperimentanda.com/come-realizzare-un-pulsossimetro-con-arduino-per-livello-di-ossigeno-in-dispnea-polmonite-da-coronavirus-covid19/
5. https://randomnerdtutorials.com/esp32-ds18b20-temperature-arduino-ide/
6. https://how2electronics.com/micropython-esp32-with-dht11-humidity-temperature-sensor/
7. https://www.amazon.it/
8. https://www.amazon.fr/
9. https://www.forniturесanitarieats.com/pulsossimetro-saturimetro-palmare-display-28-lcd-con-sensore-adutli-a-clip-sonda-temperatura-e-batteria-ricaricabile
10. https://www.quotidiano.net/cronaca/saturimetro-valori-normali-1.5712570
11. https://edilmia.com/2018/02/12/igrometro-perche-averlo-quali-modelli-migliori/
12. https://www.farmaciacorbelletta.it/termometro-storia-ed-evoluzioni/
13. https://core.ac.uk/download/pdf/144017578.pdf
14. https://corman.it/pdf/Omron/Termometri/Termometro-ecologico-foglio-illustrativo.pdf
15. https://www.gimaitaly.com/DocumentiGIMA/Manuali/IT/M35085IT.pdf
16. https://it.wikipedia.org/wiki/Pulsiossimetro
17. https://biblus.acca.it/focus/benessere-termoigrometrico-e-comfort-termico/
18. https://www.my-personaltrainer.it/benessere/saturimetro.html
19. https://www.pce-instruments.com/italiano/slot/5/download/138785/man-igrometro-pce-wm-1-v1.0-it.pdf
20. https://en.wikipedia.org/wiki/Coronavirus_disease_2019
21. https://www.marigopharma.it/wp-content/uploads/2020/05/sk-pulsossimetro-YM101.pdfFddf
22. https://www.jumo.ch/web/products/apps/productdetailpage?pdpId=907020
23. https://en.wikipedia.org/wiki/European_Committee_for_Standardization
24. https://en.wikipedia.org/wiki/ETSI
25. https://en.wikipedia.org/wiki/European_Committee_for_Electrotechnical_Standardization
26. https://it.wikipedia.org/wiki/Norma_DIN
27. https://standards.globalspec.com/std/9882440/EN%2060601-1
28. https://www.cenelec.eu/dyn/www/f?p=104:110:195000122278101::::FSP_ORG_ID,FSP_PROJECT,FSP_LANG_ID:1257161,44445,25
29. https://www.techstreet.com/standards/din-en-iso-80601-2-61?product_id=2083516
30. https://www.iso.org/standard/67963.html#:~:text=ISO%2080601%2D2%2D61%3A2017%20is%20applicable%20to%20pulse,for%20those%20environments%20of%20use.
31. https://it.wikipedia.org/wiki/ISO_13485
32. https://www.iso.org/standard/59752.html#:~:text=ISO%2013485%3A2016%20specifies%20requirements,customer%20and%20applicable%20regulatory%20requirements.
33. https://webstore.iec.ch/publication/3400

34. https://www.esperimentanda.com/come-realizzare-un-pulsossimetro-con-arduino-per-livello-di-ossigeno-in-dispnea-polmonite-da-coronavirus-covid19/
35. https://randomnerdtutorials.com/esp32-ds18b20-temperature-arduino-ide/
36. https://how2electronics.com/micropython-esp32-with-dht11-humidity-temperature-sensor/
37. https://en.wikipedia.org/wiki/Coronavirus_disease_2019
38. https://en.wikipedia.org/wiki/ESP32
39. https://datasheets.maximintegrated.com/en/ds/MAX30100.pdf
40. https://wiki.eprolabs.com/index.php?title=DS18B20_Temperature_Sensor
41. http://wiki.sunfounder.cc/index.php?title=Humiture_Sensor_Module
42. https://learn.adafruit.com/dht
43. https://en.wikipedia.org/wiki/Resistor
44. https://en.wikipedia.org/wiki/Jump_wire
45. https://en.wikipedia.org/wiki/Breadboard
46. https://sequence-diagram-editor.en.softonic.com/
47. https://fritzing.org/