An appendix to smart solutions in fighting COVID-19

RADOVAN STOJANOVIĆ

UNIVERSITY OF MONTENEGRO AND MECONET

Presented at HiPEAC 2021, 19/01/2021

Outline

- About me
- Introduction
- SMART solutions
- Conclusion

About me

- Professor at University of Montenegro
- More than 25 years working in areas of electronics, measurements, computing and systems on PCB and systems on chip, embedded systems and IoT.
- Experiences in more than 30 projects from different international and national schemes.
- Establisher of MECO - Mediterranean Confrence of Embedded Computing and CPSIoT - Workshop on Cyber Physical Systems and Internet of Things as well as Summer School on CPS and IoT.
- Establishers of several high-tech laboratories, startups and associations.
- More than 250 publications
- Moto “The excellence is a habit”

Introduction

- All people and institutions worldwide fighting COVID-19.
- The efforts are evident in every area of life and work: medicine, economy, politics, education, IT, social networks, research, organizational, social and managerial, terrain etc. In fact, the battle is taken 24/7/365 in every place of the globe.
- SMART4ALL project contributed in fighting COVID in different ways from its fields of experise.
- Here, we demonstrate a smart and low cost solutions to detect and monitor COVID-19 symptoms based on wearables health care device in standalone and cloud versions using cyber physical and IoT technologies.

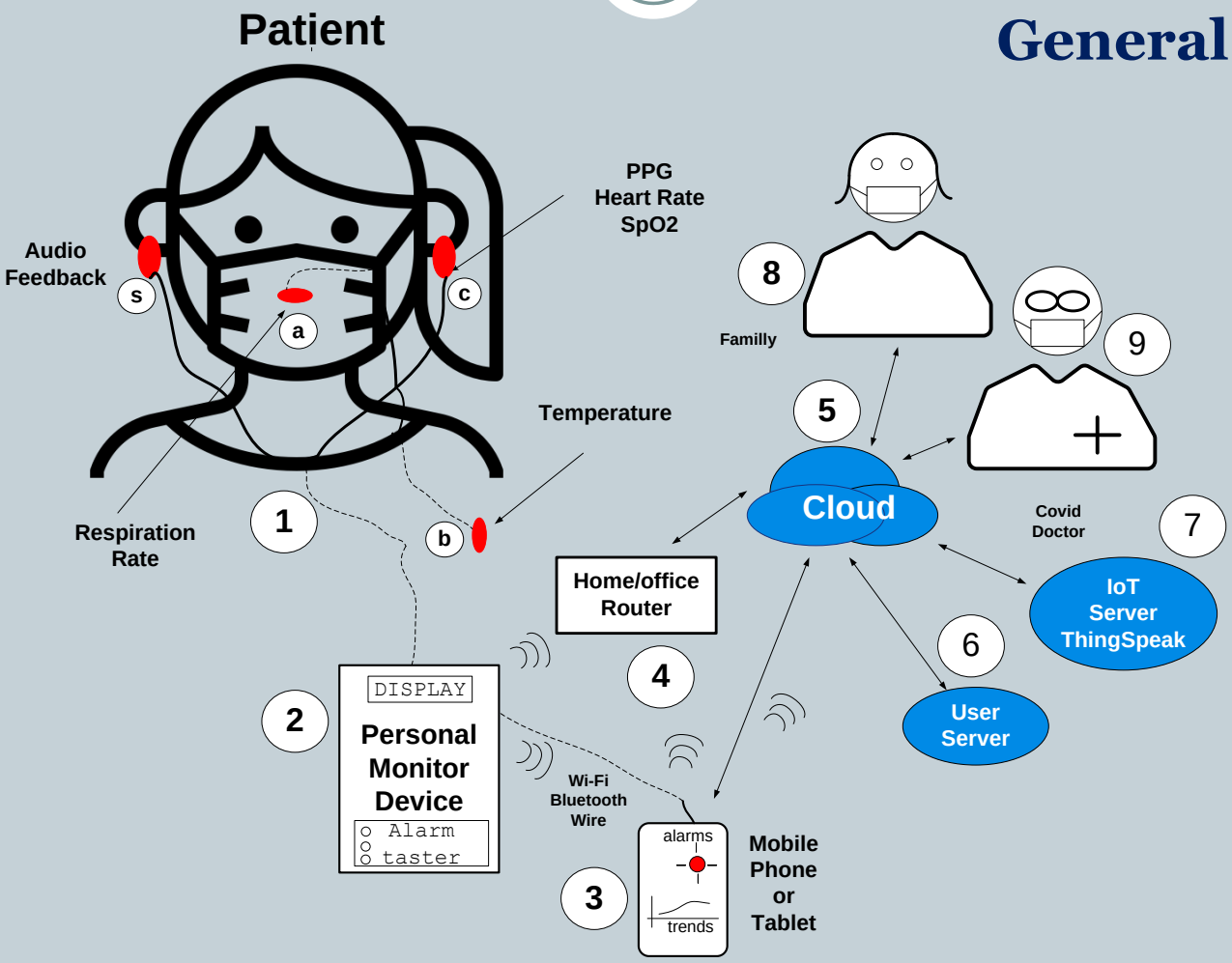
- Covid-19, Vital Signs
  - Body temperature, M
  - Pulse rate, M
  - Respiration rate (rate of breathing), M
  - Blood pressure, M
  - Oxygen Saturation, M
  - Cough, M, NM
  - Gastro issues, NM
  - Diarrhea, NM
  - Muscle and body pain, NM

SCORE		3	2	1	0	1	2	3
Respiratory rate (bpm)	16				X			
Temperature (°C)	38.5					X		
Heart rate (bpm)	96					X		
Oxygen Saturations (%)	97				X			
Systolic Blood Pressure (mmHg)	140				X			
Age	30				X			
COVID-19 positive/negative	N				X			
EARLY WARNING SCORE	2							

M= measurable
NM= non measurable

SMART solutions

General scenario

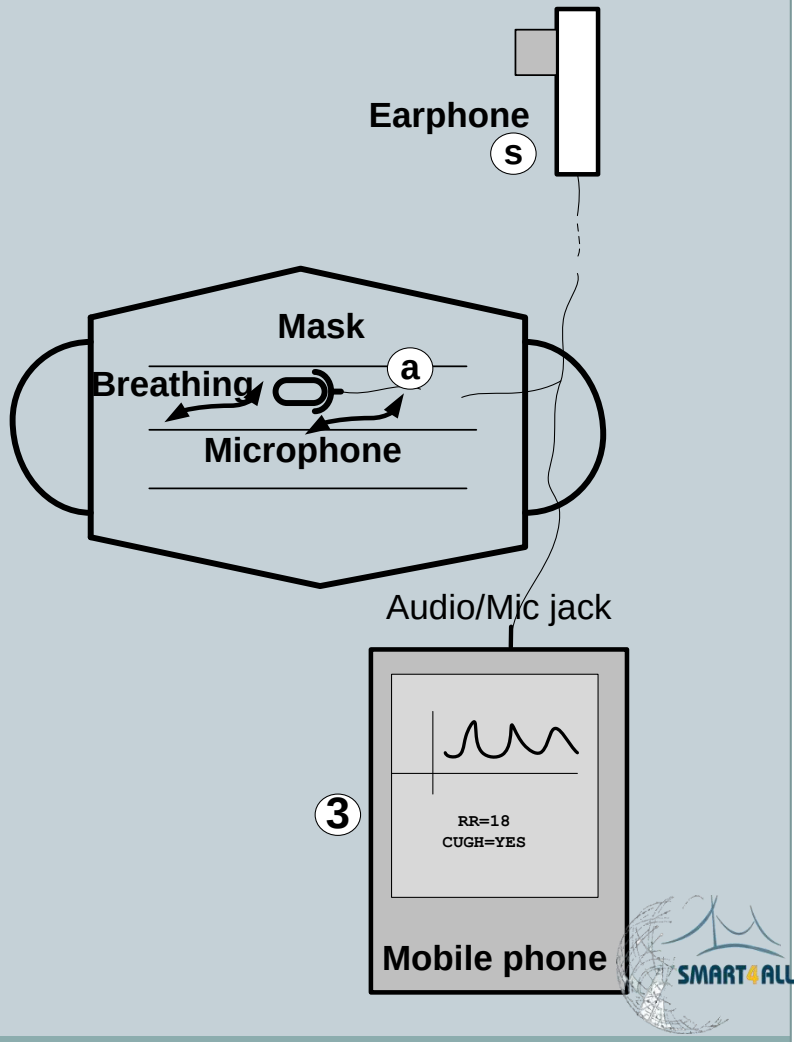


SMART solutions

Configuration #1:

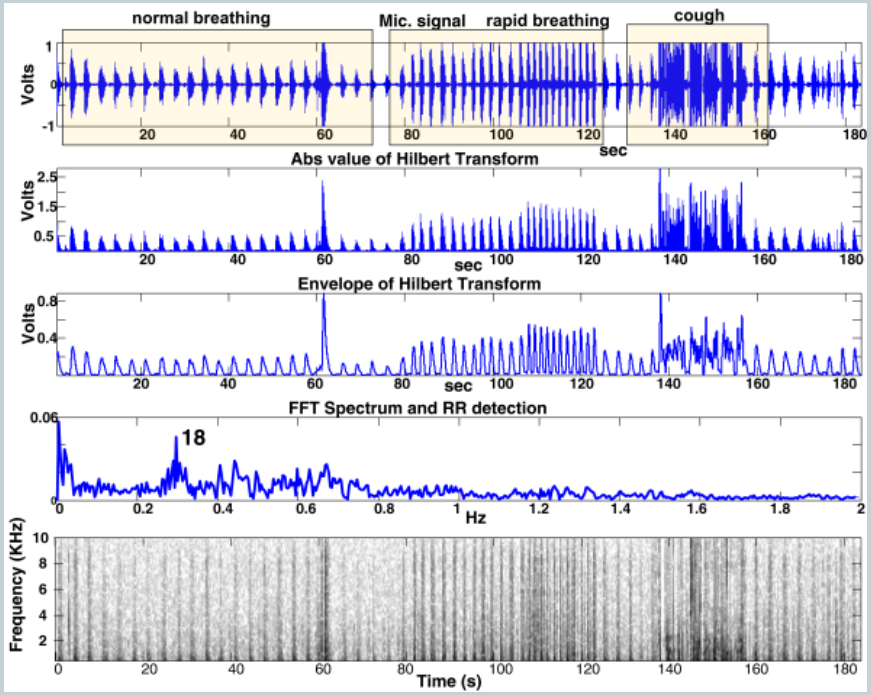
a), s), 1), 3)

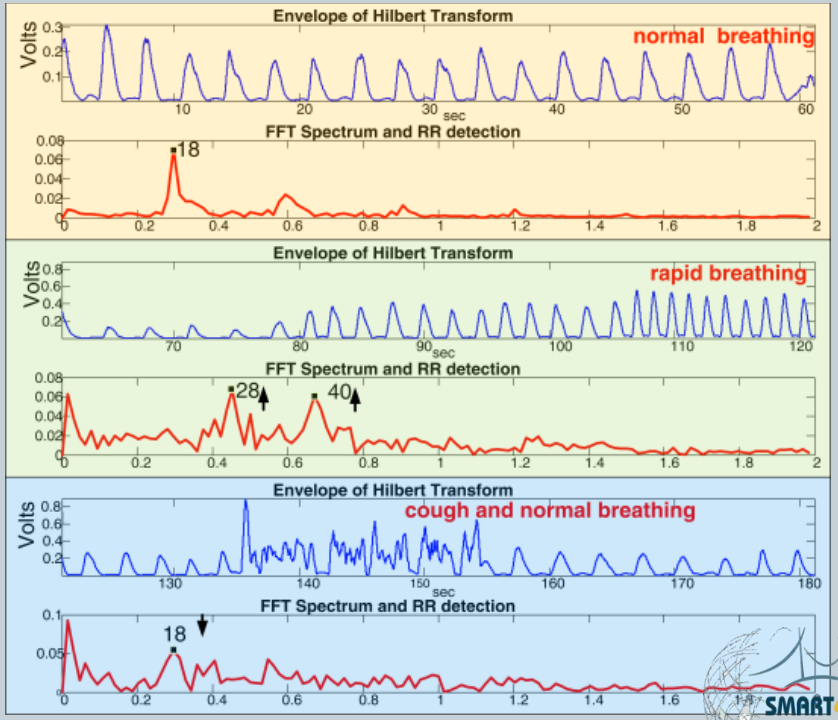
The microphone a) of the headsets is used to detect breathing and cough. The microphone is plugged in mobile phone 3). The signal is processed online or recorded and then processed. The respiration rate, breathing abnormally are monitored. Main challenge is in signal processing and mobile application software. Earphone s) sounds alarm.



SMART solutions

Configuration #1. The mic signal is recorded. The envelope is enhanced by different methods as it is Hilbert transform. The FFT and STFFT are applied to envelope and RR is calculated by detection of dominant peak position within them.

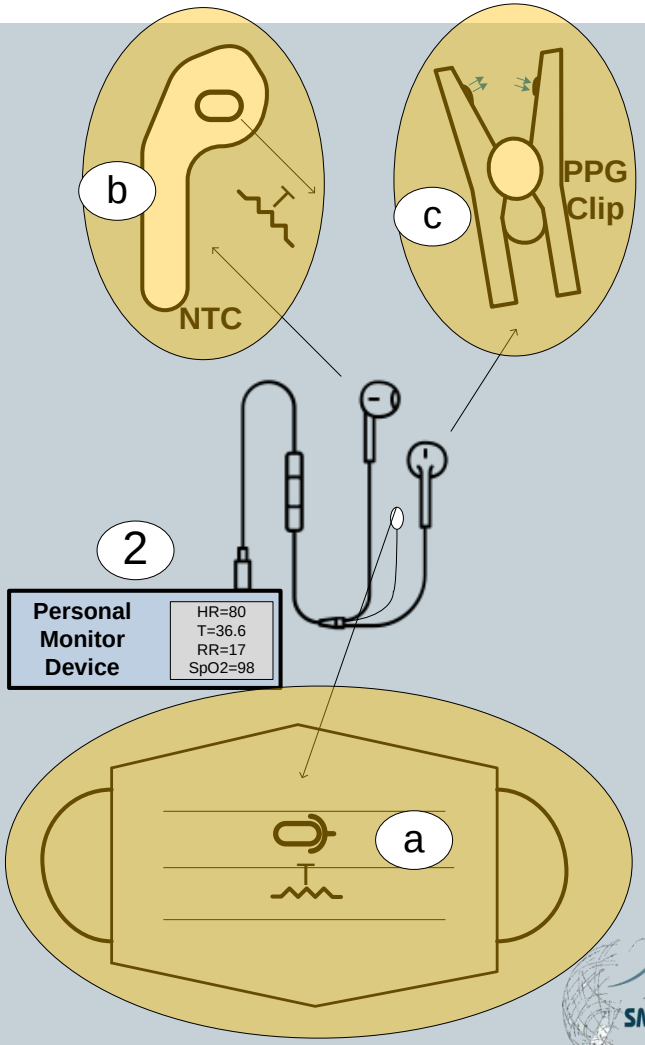




SMART solutions

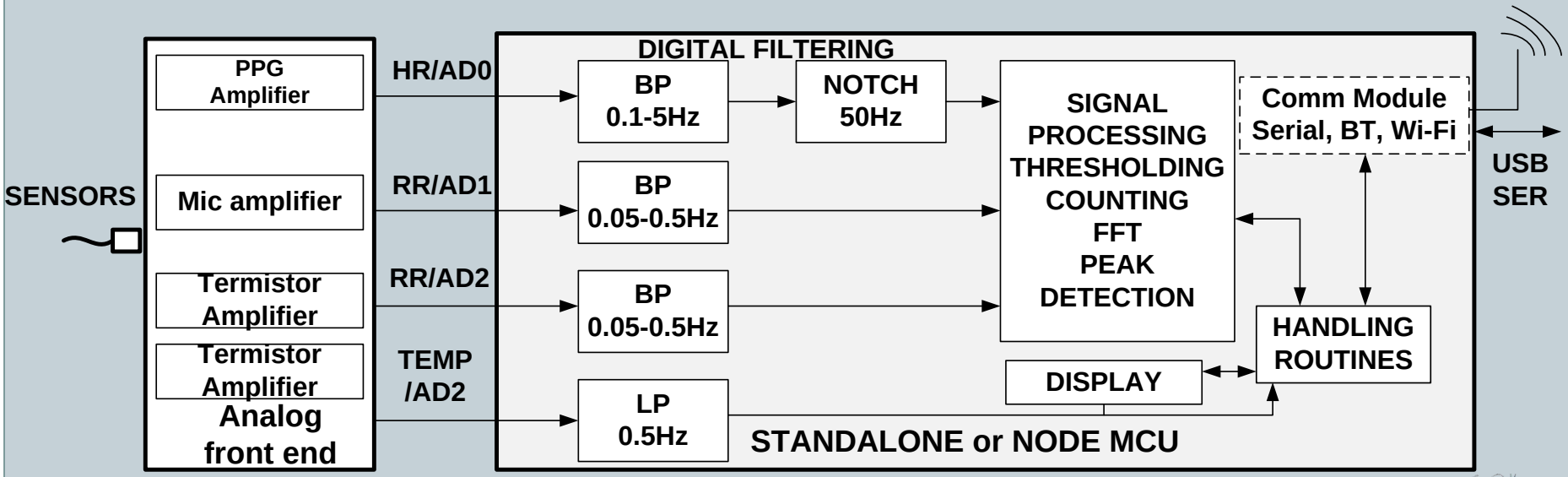
Configuration #2: a),b),1),2)

The headsets are upgraded with additional sensors for temperature b) and heart rate c) as well as SpO2 (oxygen saturation), optionally. To detect heart rate the ear clip variant of PPG sensor is applied, while the temperature is measured by thermistor mounted in earphone. The signals are processed by Ardunino based Personal monitor device (2). The measured and extracted values are displayed by OLED display.



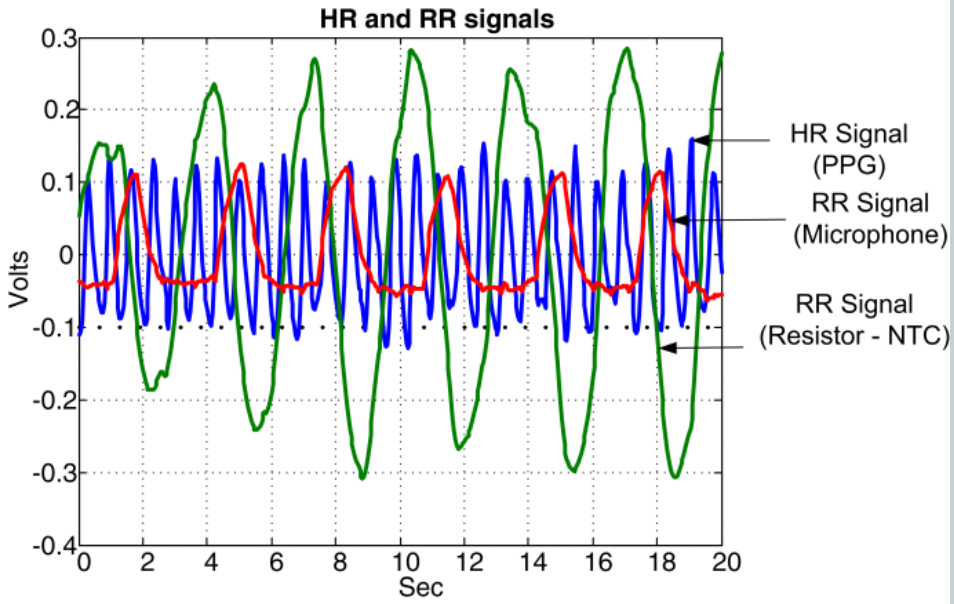
SMART solutions

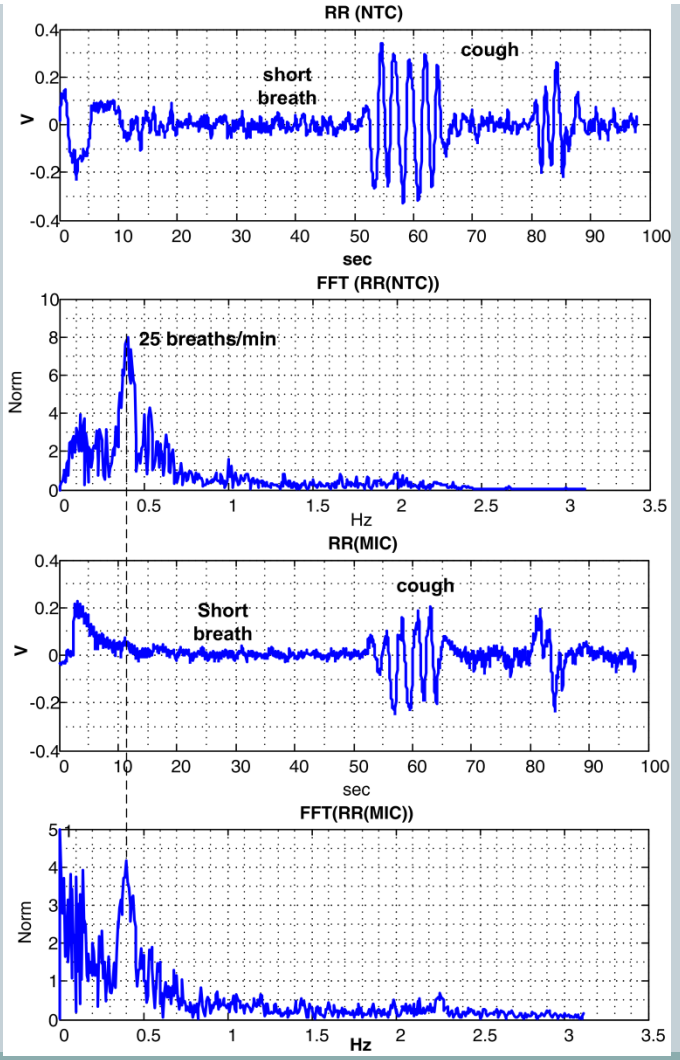
- **Configuration #2**. Personal (Wearable) Monitor Device architecture is based on STANDALONE or NODE MCU (ARDUINO, ESP (8266, 32) or similar). All algorithms for calculation, handling, visualization and communication implemented on a board. Analog preprocessing allows to obtain good signals



SMART solutions

Configuration #2, demonstration. On board signal processing is done in time and frequency domains. The features (RR, HR, cough, breathing abnormally) are extracted from FFT spectrum and displayed in form of number values or alarms.



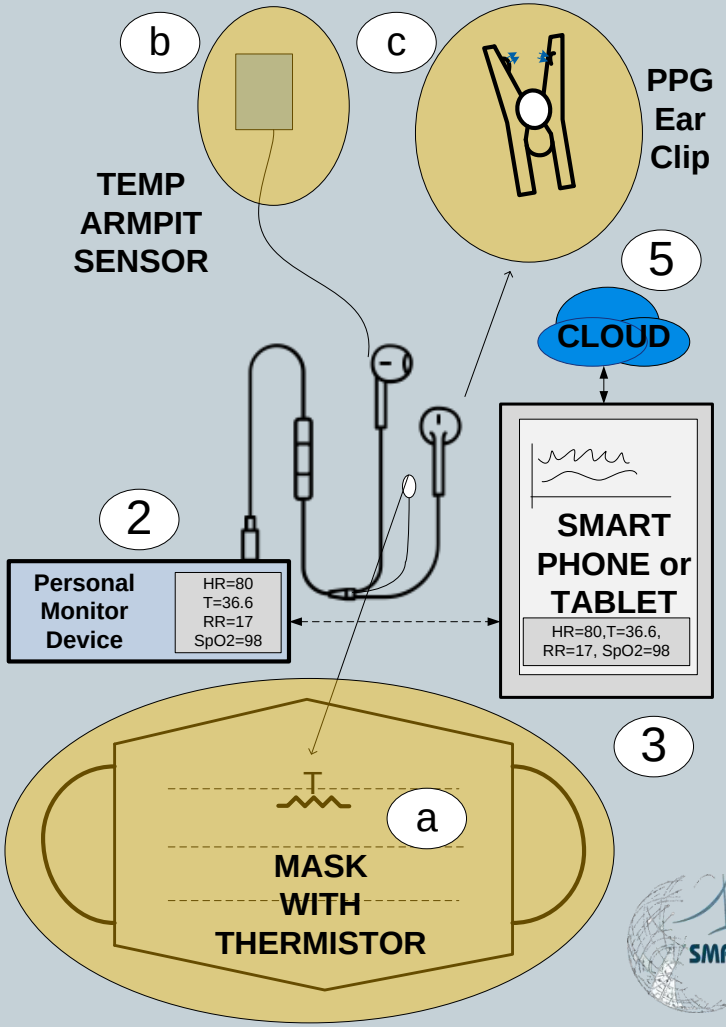


SMART solutions

Configuration #3: SYNTROFOS

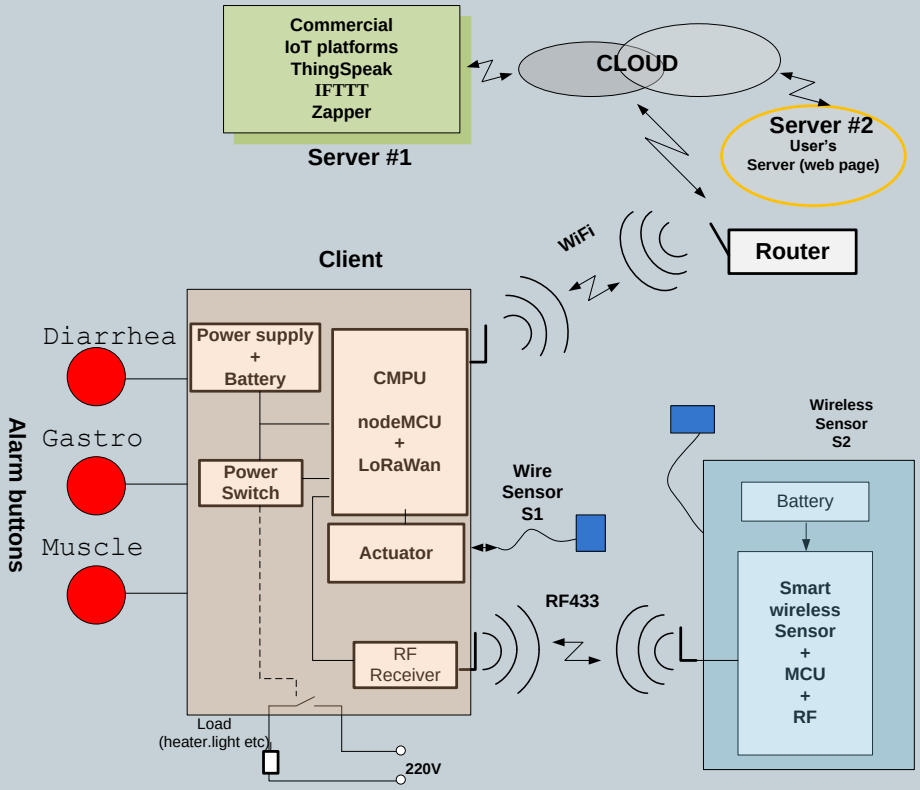
a),b),c) 1),2),3),5)

The configuration #2 is connected by wire or wireless to smart phone or tablet that runs a mobile application which store post process and visualize signals and communicate with CLOUD and further with Remote Doctors or IoT servers. This configuration is ideal for tele-medical applications. If PMD is in node variant (with ESP32 processor) it can directly send to cloud.



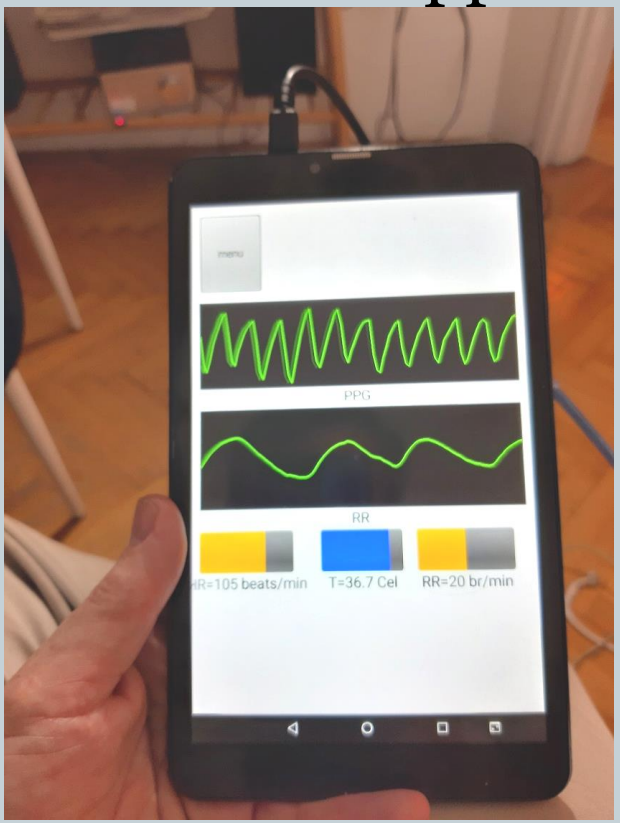
Configuration #4:

IoT based system. The client in form of Node MCU collects vital signs information from wire or wireless sensors mounted to patient. Node MCU process information and perform features extractions and send them to commercial or free IoT platform like ThingSpeak or IFTTT. The remote staff access informations via IoT platforms or being altered about abnormalies.



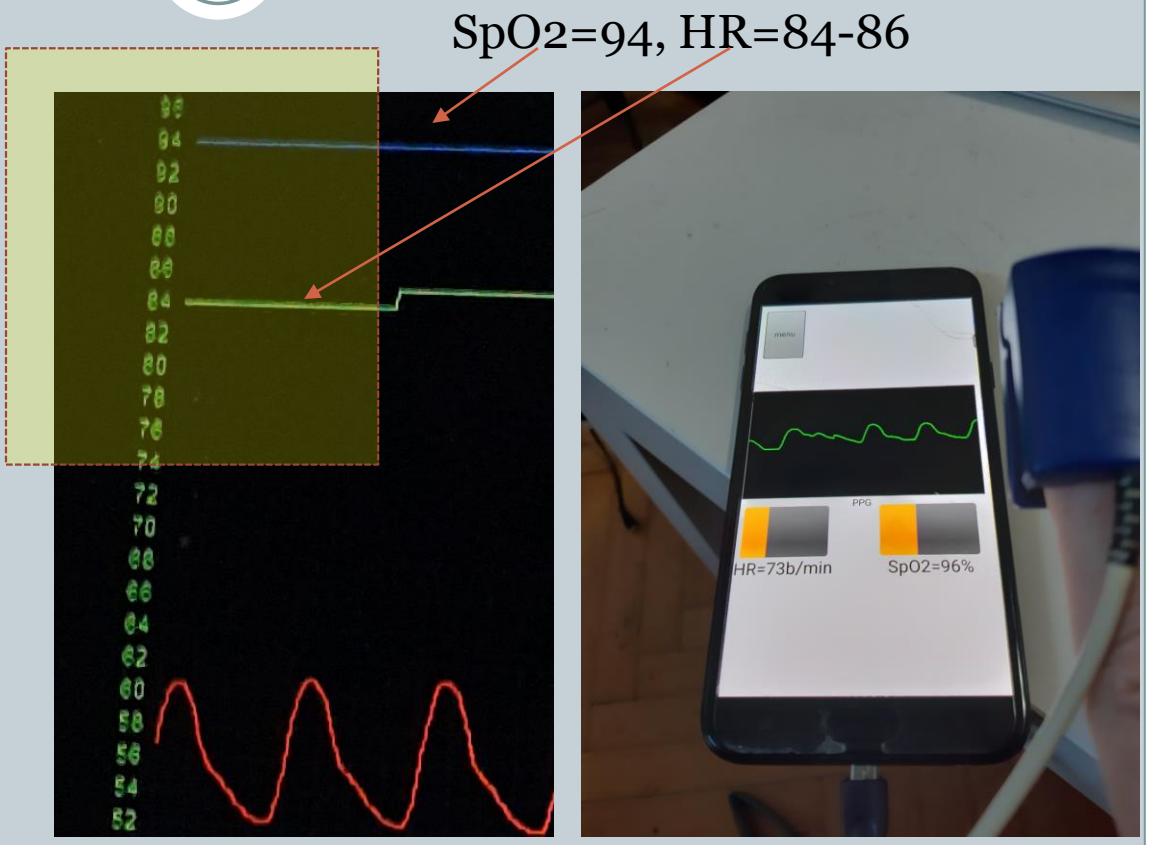
SMART solutions

- Configuration #3, Syntrofos. Disposition of the sensors and illustration of the mobile application.



SMART solutions

- **Configuration #3, Syntrofos, with saturation SpO2 version**, which can be taken from ear or from finger. Saturation is very important in detecting respiration (lung) problems. In fact it is one of main parameters in detection COVID-19 problems.

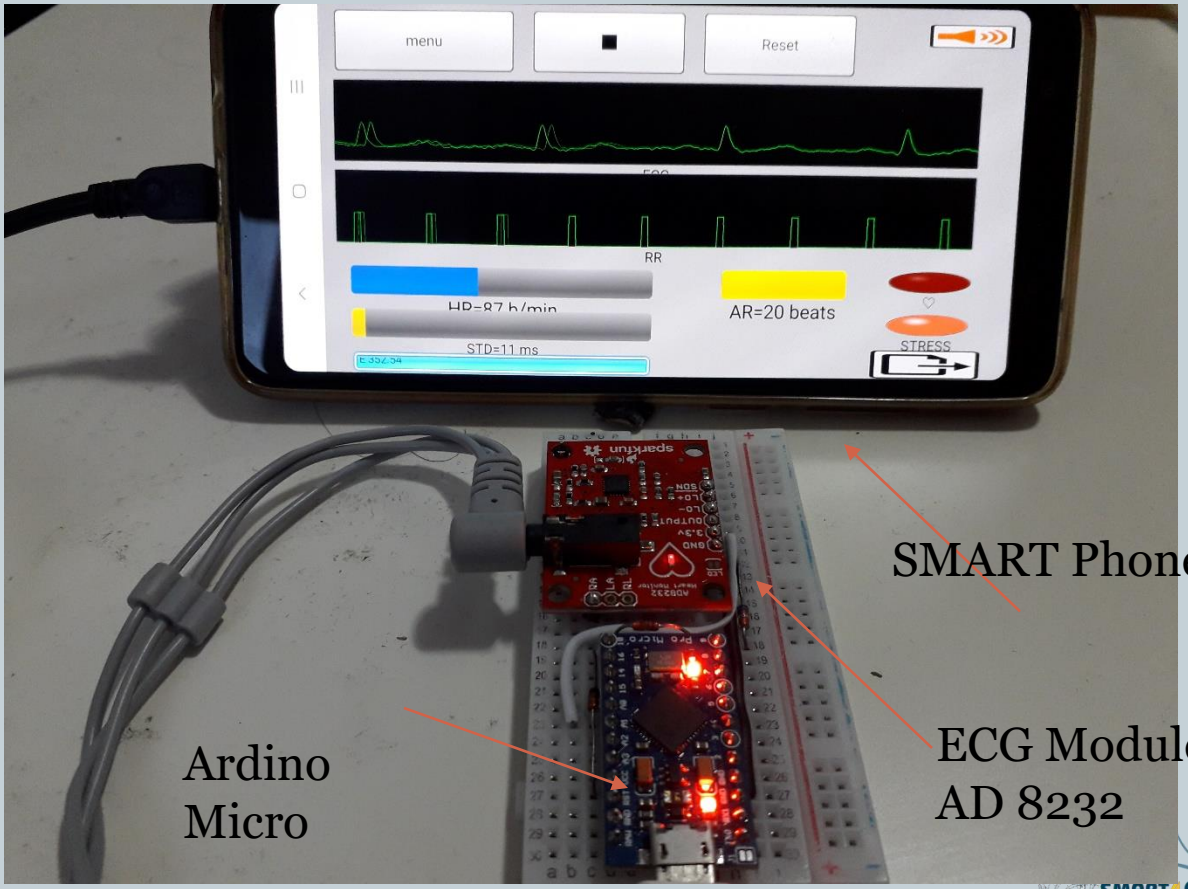


SMART solutions

- Other solutions:
  - Personal ECG Monitor

  Very suitable for monitoring heart work in home and office . Works as monitor, stress detection, arrhythmias detector etc.

  Video.



SMART solutions

- Configuration #3, Syntrofos video.
- Video (Youtube)

Challenges

- Multidisciplinary knowledge (medicine, measurements, electronics, computing and ICT)
- Designing a system that integrate existing solutions in sensors, MCUs, IoT with designed problem made support (gateways, software) .
- Low cost, low power, easy to use and capable to provide enough information for acting.
- Implementing complex algorithms in hardware and providing usefull feature extraction.
- Useful and insinuative visualization.
- Connection to gadgets, cloud and accessibility data 24-7-365.
- Logging and communication features.
- Scalability and modularity.

Conclusions

- We presented a low cost and flexible design of medical systems/devices for purposes of detecting and tracking COVID_19 symptoms using designing knowledge CPS and IoT technologies.
- The sensors are mounted in protection mask .
- The simplest configuration only uses headsets and mobile phone and it is capable of detecting respiration problems.
- The extended versions are capable of detection respiration parameters, heart rate, temperature and oxygen saturation.
- The monitoring signals can be used for self-control or control via remote doctor or medical staff.
- The approach yielded good and stable results and could be considered as one of the feasible solutions in symptoms detection during COVID-19.
- The approach has potential of further improving.

THANK YOU

Q&A

Radovan Stojanovic
stox@ucg.ac.me