Hand-Held PoC Biosensor Device for Detection of Cancer and Cardiac Diseases and It's Smartphone Application

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Abstract

- Risk assessment platform for diagnostics and monitoring
- Detection of multiple biomarkers for **cancer** and **cardiovascular diseases** (CVD) in human blood samples.
  - ⅓ of natural deaths are due to CVD and ⅙ is due to cancer. [1]
- To increase it's portability → ESP32 → programmed with Arduino IDE.
- App interface to create an daily easily usable environment.
- Used MIT App Inventor to create the Android phone application
- Wi-Fi communication

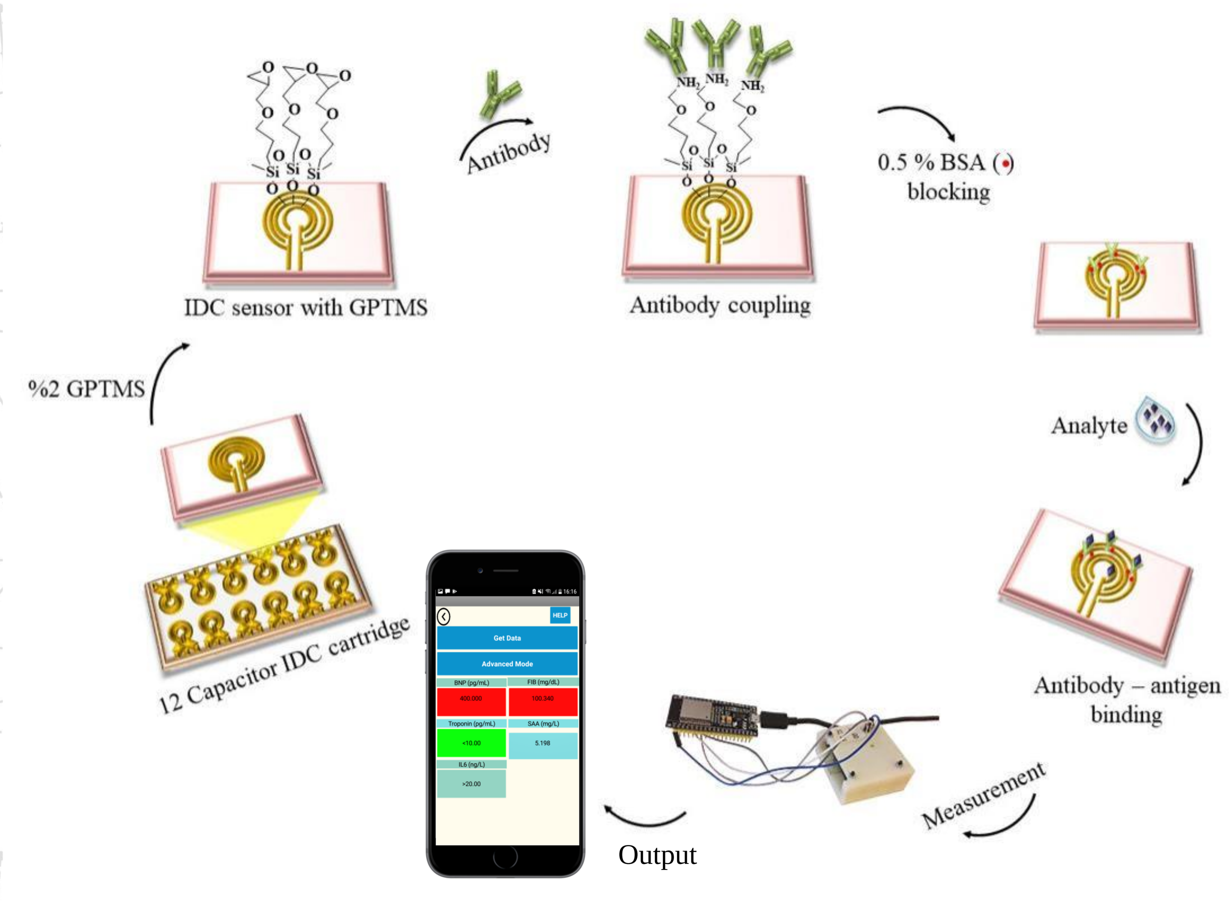

Fig 1. Illustration of working principle of the biosensor and communication with it.[2]

Color Code*	Target Biomarker	Reported by ASM** Hospital	Measured by PoC Device***	Ref. Value	Unit
Green	BNP	94	90-99	70-133	pg/mL
Red	BNP	746	> 500	70-133	pg/mL
Green	SAA	< 4	3.15-3.48	0-7	mg/L
Red	SAA	9.7	9-10	0-7	mg/L
Green	IL-6	< 2	< 2.5	0-5.9	ng/L
Red	IL-6	18	15.4-17	0-5.9	ng/L
Green	Fibrinogen	320.8	292-323	200-400	mg/dL
Red	Fibrinogen	511.9	> 500	200-400	mg/dL
Green	Troponin-I	< 10	< 10	0-23	pg/mL
Red	Troponin-I	1300	> 200	0-23	pg/mL
Yellow	TNF-α	6.8	7.3-8.1	0-8.1	ng/L
Red	TNF-α	15.7	16.1-18	0-8.1	ng/L

Fig. 2. Safe range and reference values for the protein samples.[2]

***ASM: Anadolu Medical Center in Affiliation with Johns Hopkins Medicine*

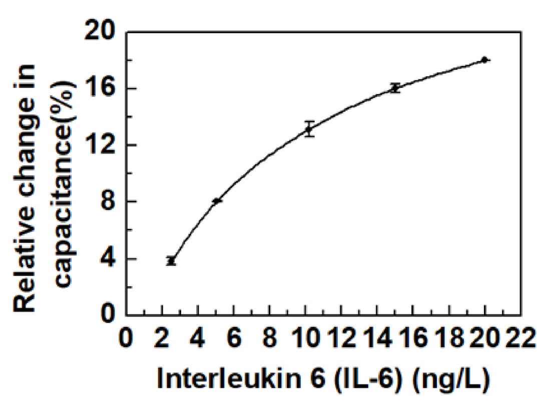

Fig 3. Relative Change in Capacitance vs Protein Concentration of Interleukin[2]

Objectives

The purpose of this project is to understand the functioning of the biosensor made by our supervisors and to integrate it into the phone application to provide convenience for users.

Implementation:

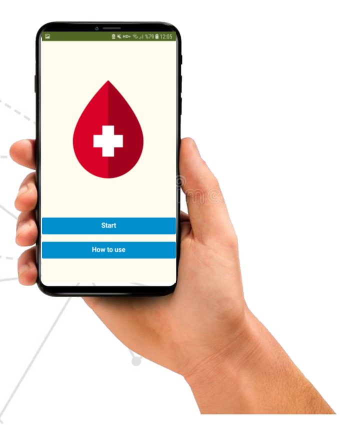

Fig. 4. The monitoring platform

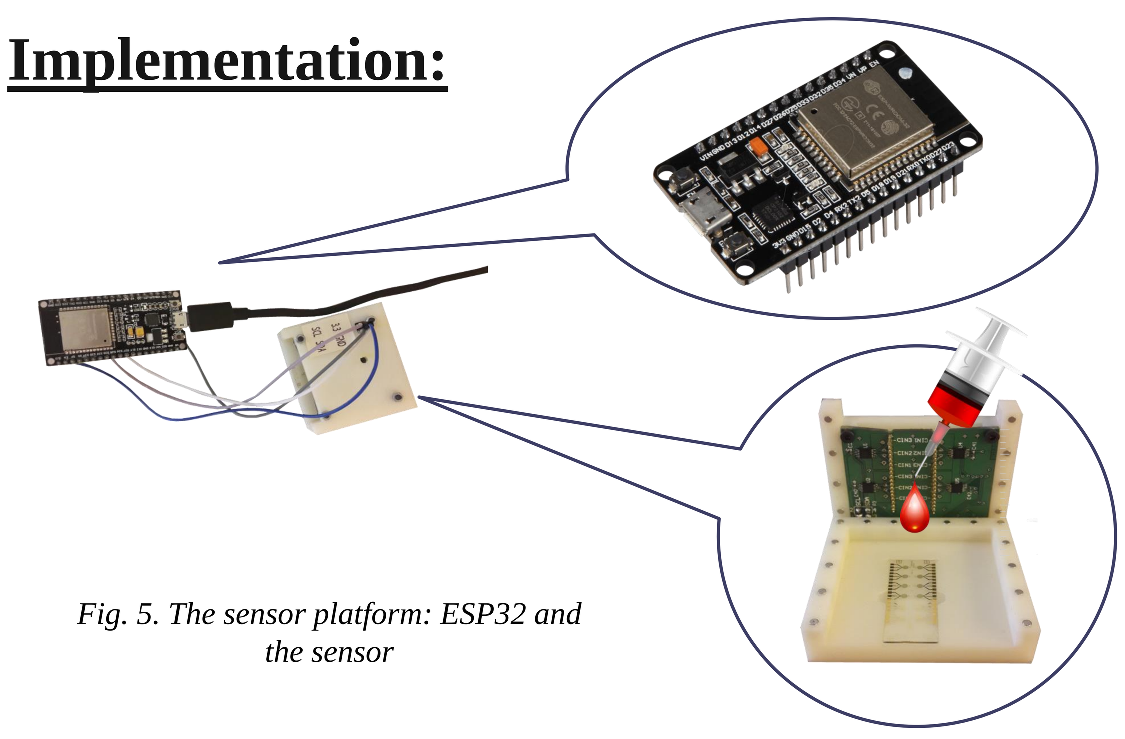

Fig. 5. The sensor platform: ESP32 and the sensor

Methodology

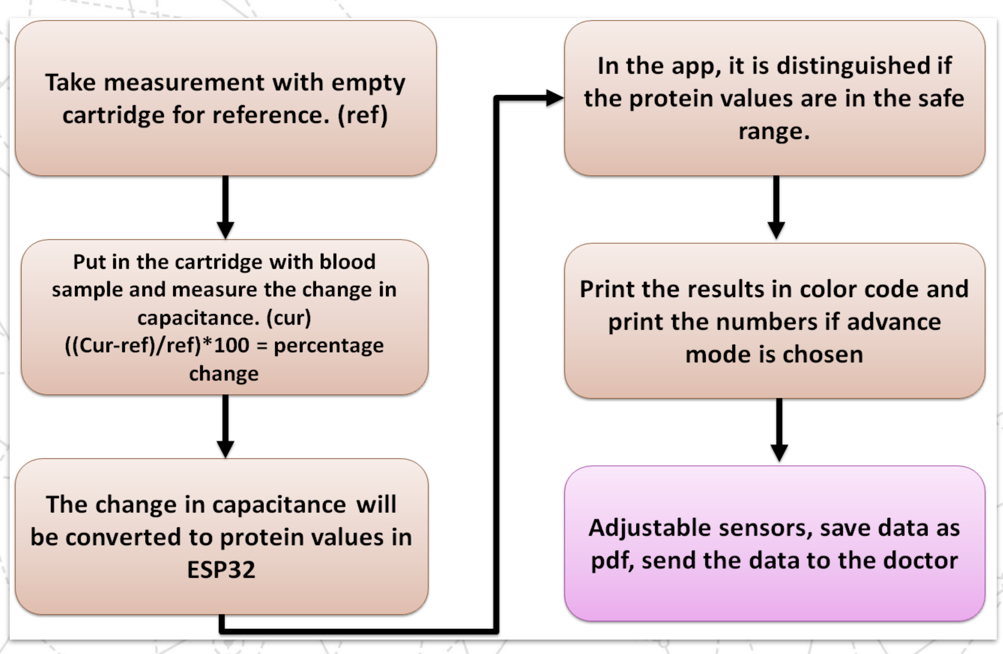

Fig 6. Steps of the software process

- I2C protocol
- Communication between ESP32 and sensors
- Arduino IDE
- Capacitance to protein conversion
- App design

ESP32

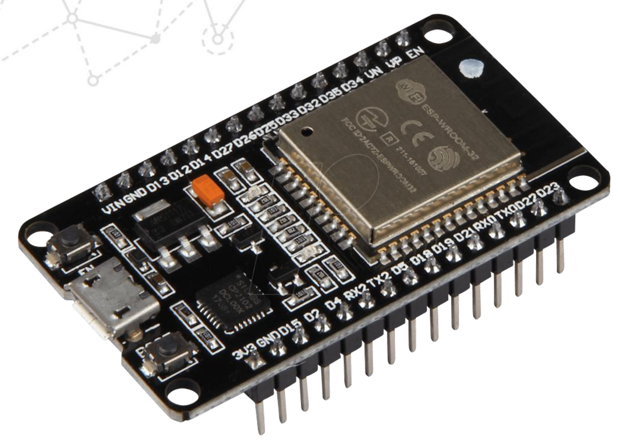

Fig 7. ESP 32 Board

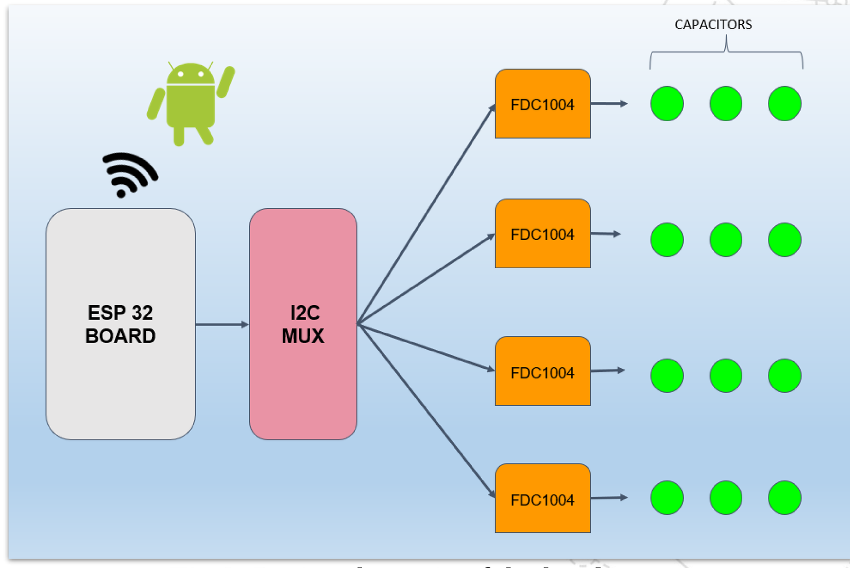

Fig 9. Basic schematic of the hardware

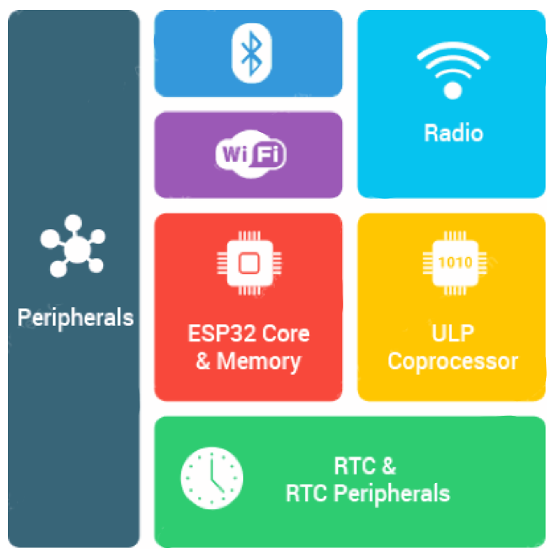

Fig 8. ESP 32 Features[3]

```
void writeByte(uint8_t address, uint8_t subAddress, byte data[], int len)
{
    Wire.beginTransmission(address);  // Initialize the Tx buffer
    Wire.write(subAddress);           // Put slave register address in Tx buffer
    Wire.write(data, len);            // Put data in Tx buffer
    Wire.endTransmission();           // Send the Tx buffer
}

uint16_t readRegister(uint8_t address, uint8_t regis, int num) // addressed slave, the registe
{
  Wire.beginTransmission(address);
  Wire.write(regis);
  Wire.endTransmission();

  Wire.requestFrom(address, num);
  reg =0;

  while( Wire.available() ){
    temp = Wire.read();
    reg = reg+temp;
    if (Wire.available()==1){  //if bytes are still coming shift the alreadt existing value.
      reg = reg<<8;}
  }

  return reg;    //böyle bir şey yaparsam func'ın void olmaması lazım. uint'li bir şeyler
}
```

Fig 10. Reading and writing byte functions from the code.

the App

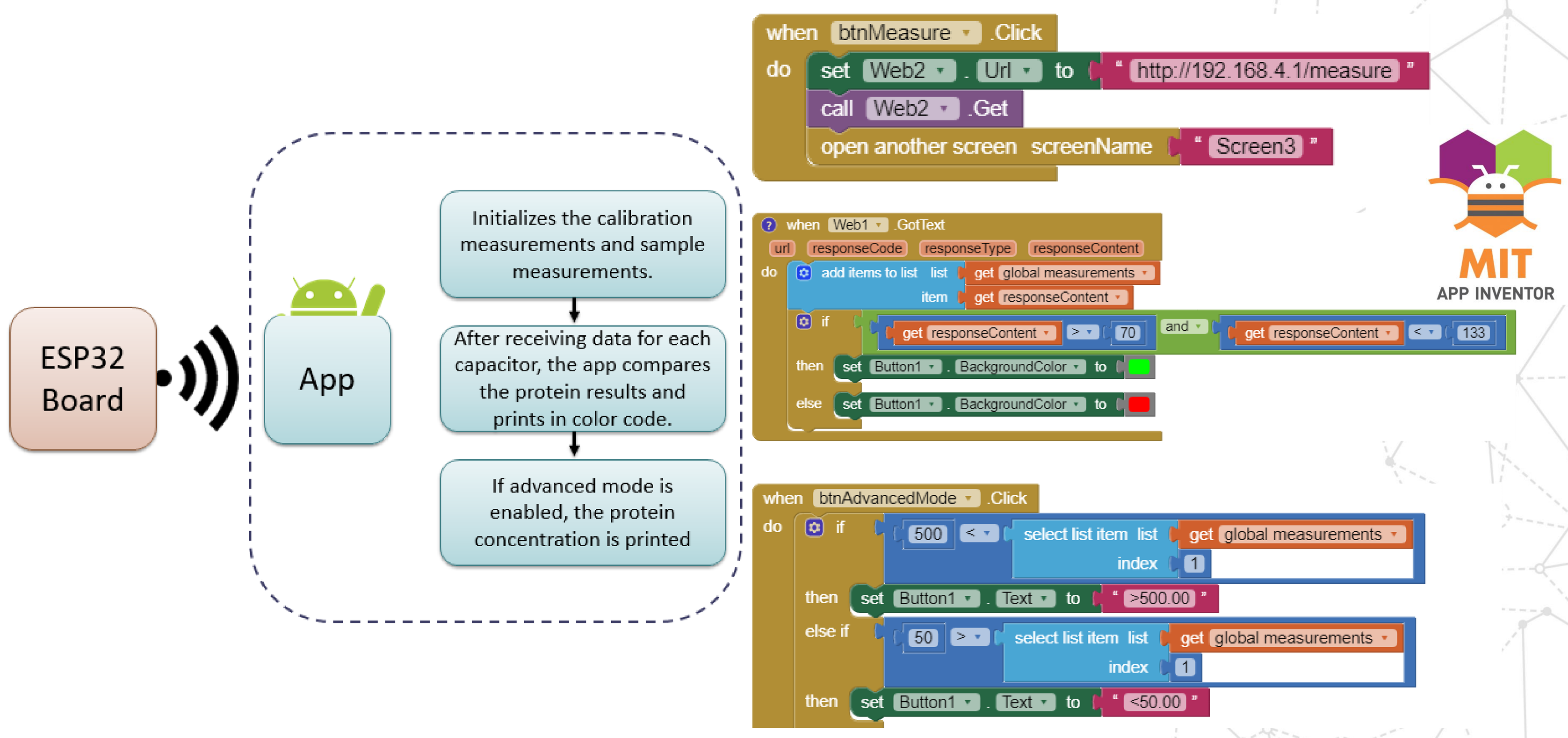

Fig. 11: ESP32 board as an access point for web server and features of the app

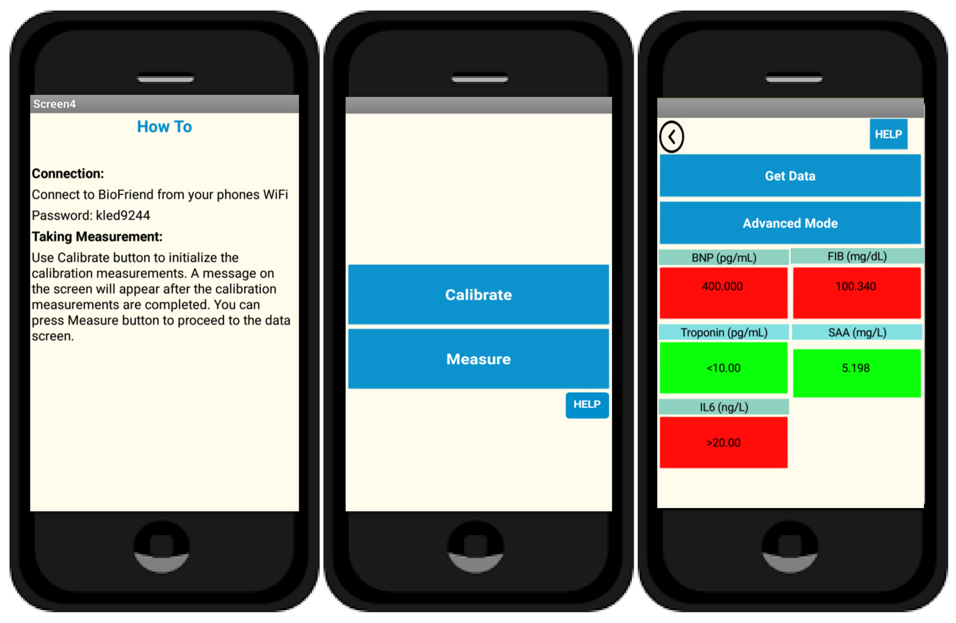

Fig. 12. Examples of interface from the app

- The board sets its own network allowing smartphones to connect to it.
- Measurements are easily triggered through easy to use interface.
- Protein concentrations are displayed color coded after the measurements are complete.

Conclusion

- At the end, the patient is capable of viewing the protein levels both in easy and advanced mode for 5 different proteins. The app and the board is still programmable to use for 7 more proteins if the data is given.
- The app and the sensor complex is intended to be used at home and without the help of the healthcare provider.
- For the future, the app can be improved to be adjustable by the user to choose which proteins s/he would like to test. This way it can be used in even wider areas.

References

1. "Dünyadaki Başlıca Ölüm Nedenleri Neler?" BBC News, BBC, 7 Mar. 2019, www.bbc.com/turkce/haberler-dunya-47460922.

2. Ceylan, Ömer, et al. "A Hand-Held Point-of-Care Biosensor Device for Detection of Multiple Cancer and Cardiac Disease Biomarkers Using Interdigitated Capacitive Arrays." *IEEE Transactions on Biomedical Circuits and Systems*, vol. 12, no. 6, Dec. 2018.

3."Insight Into ESP32 Features & Using It With Arduino IDE (Easy Steps)." Last Minute Engineers, 23 Dec. 2018, lastminuteengineers.com/esp32-arduino-ide-tutorial/.

Geleceği Yazanlar Ekibi. "I2C Protokolü." *Geleceği Yazanlar*, Turkcell, 16 May 2016, gelecegiyazanlar.turkcell.com.tr/konu/arduino/egitim/arduino-401/i2c-protokolu.

Santos, Sara. "ESP32 Access Point (AP) for Web Server." Random Nerd Tutorials, 23 Apr. 2019, randomnerdtutorials.com/esp32-access-point-ap-web-server/.