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# Biomedical Systems

Carnegie Mellon University

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- **Introduction to biomedical systems**
- **Biomedical Systems: Robotics**
- **Examples**
- **Virtual Instrumentation**
- **Examples**



# BioMedical Systems

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relating to both 1) biology *and* 2) medicine.

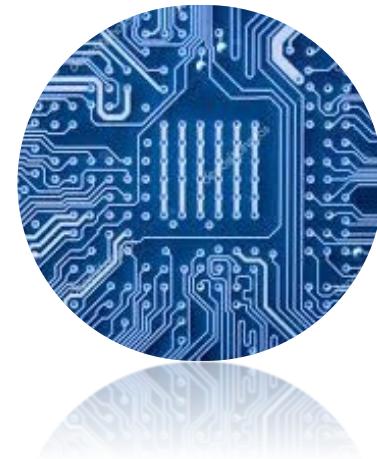
Oxford definitions

used to describe something that uses **biological science** in medical developments

set of things **working together** as parts of a **mechanism** or an **interconnecting network**; a **complex whole**.

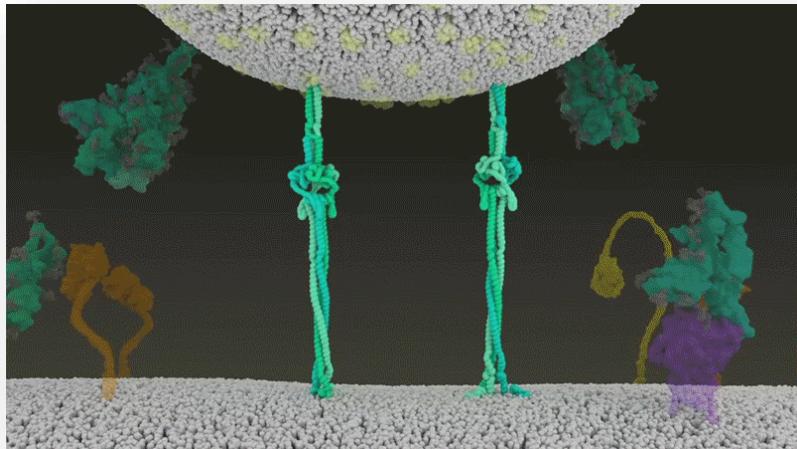
Oxford definitions

Cambridge definition



# Biological and Medical Systems

Systems: Composed by instruments/equipment that work together to develop an action that they could not perform individually.



Biological System  
(How coronavirus infects cells)



Medical System  
(hospital/patient services)



Biomedical  
Systems

Source

Instruments and/or equipment

Resolution for medical purpose

# Medical System



Gloves



Mask



Head cover



Coverall Gown



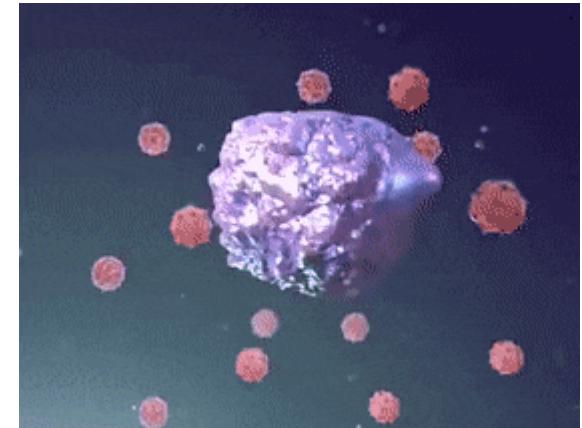
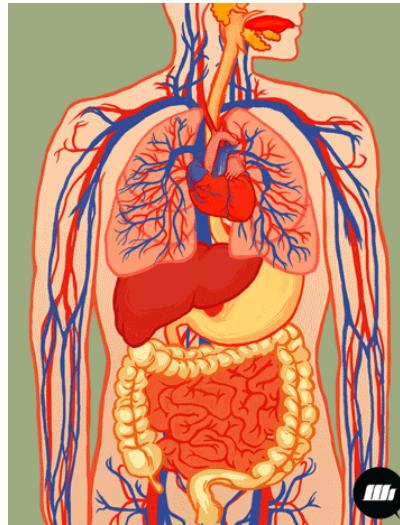
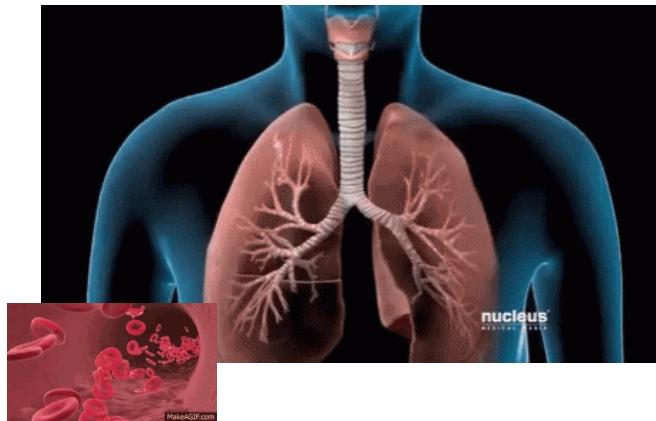
Shoe cover



Personal Protective Equipment (PPE)

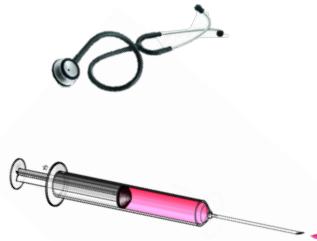
# Biomedical Systems

**Biological source: originated from living organisms**

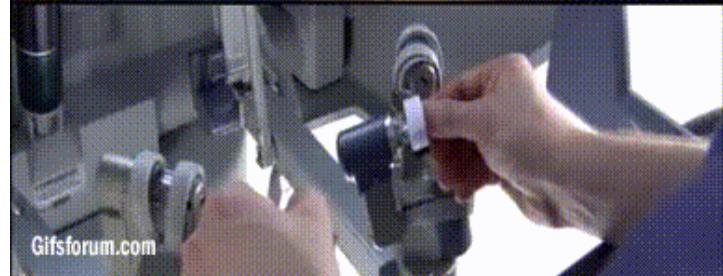
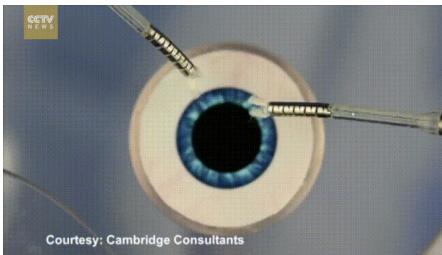




# Biomedical Systems

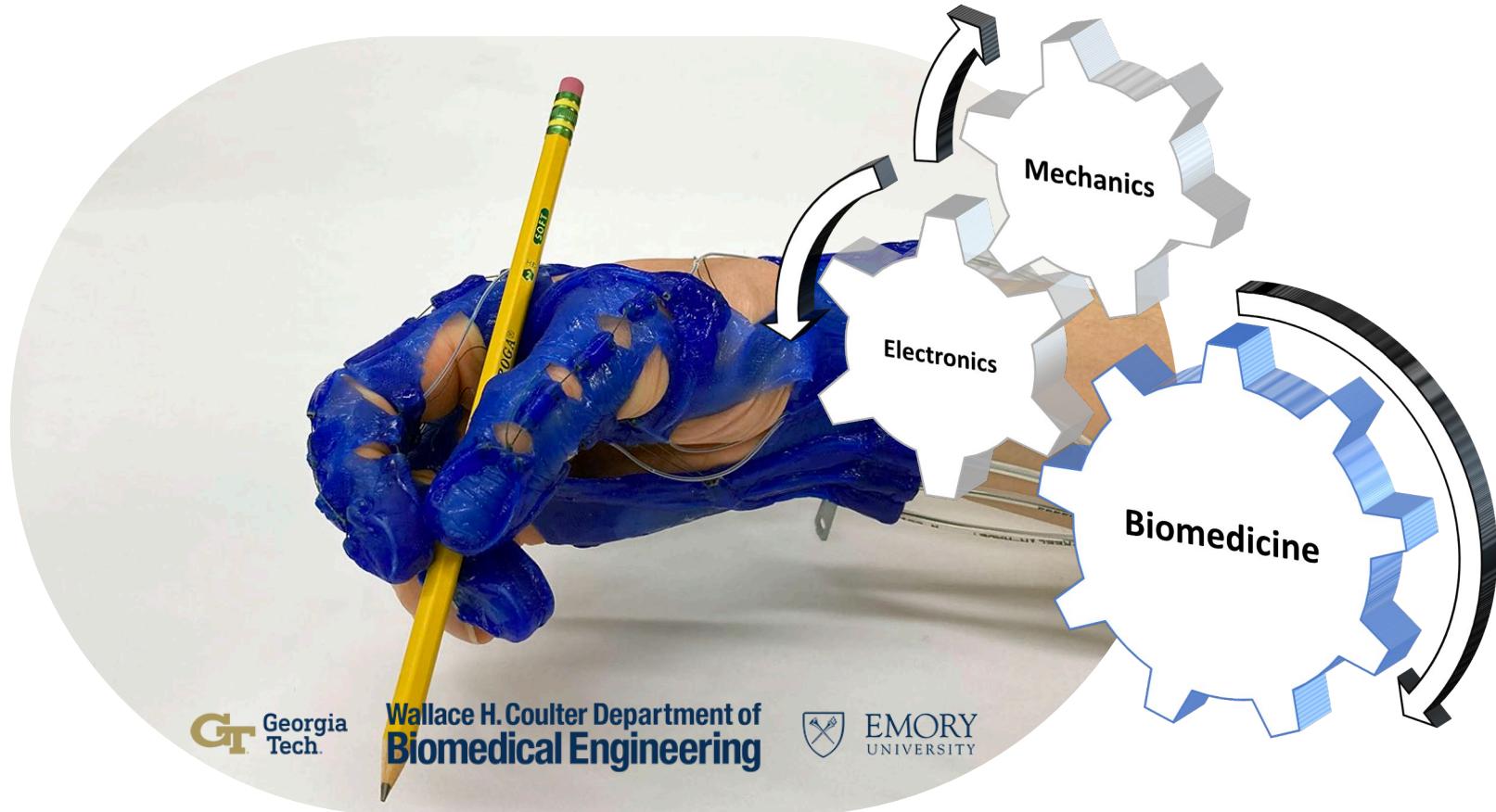


# Biomedical Systems



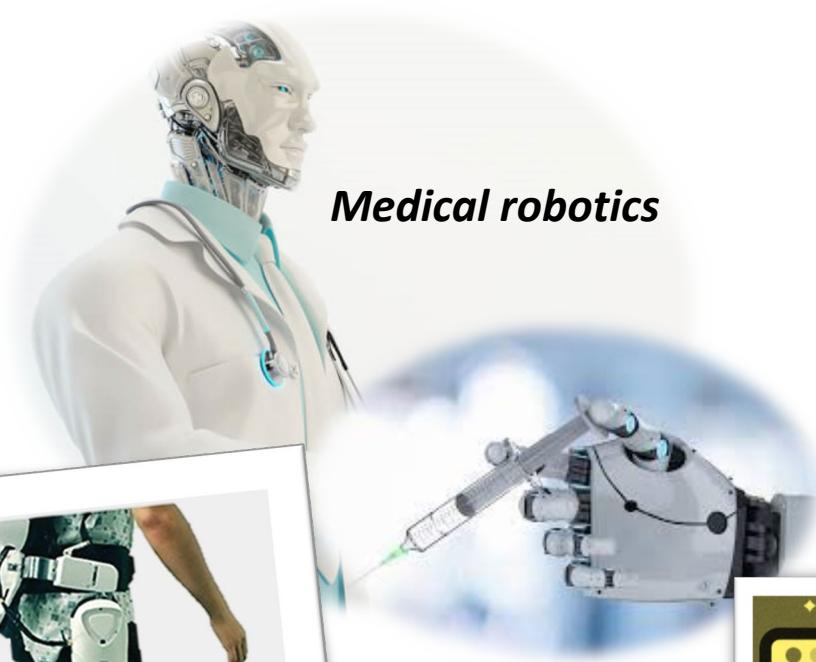


# Biomedical Systems: Robotics

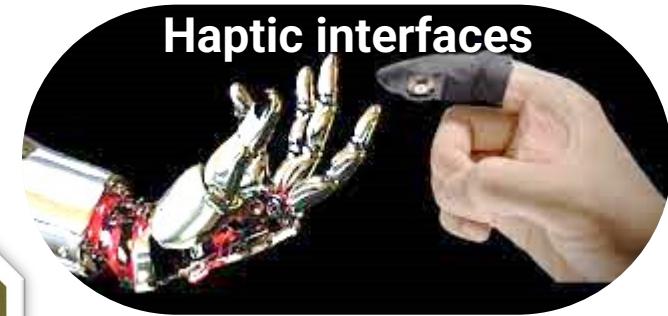
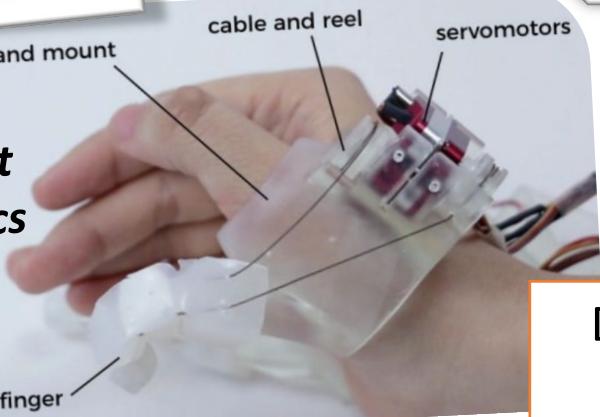


**Design, development, and evaluation of **medical** robotics systems and smart assistive robotic platforms.**

**FOR MEDICAL APPLICATIONS/PURPOSE**



## *Medical robotics*



DIAGNOSE or CURE pathologies or other medical problems.



***“...attempts to use the Stretch RE1 Robot as a surrogate for body parts he can no longer control.”***

- Many application for one system. Robotic Arm, Haptic interfaces, “letter board” to painstakingly spell out words...

<https://www.washingtonpost.com/photography/2021/11/23/my-day-with-henry/>



# Bio-robotic systems structure

## ***MODULES***

**What makes up a system?**

- Mechanical structure
- Electromechanical applications.
- Control electronics
- Hardware PCB
- Mechanical package
- Electric connections
- Software control
- Algorithm software
- User interface

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# Bio-robotic systems structure

## ***MODULES***

What makes up a ROBIO system?

- Hardware PCB
- Software Control

- Software Algorithms
- User interface



### **Virtual Instrumentation**

#### **Virtual functionality**

- Hardware PCB

#### **Virtual programming**

- Software Control
- Software Algorithms
- User interface

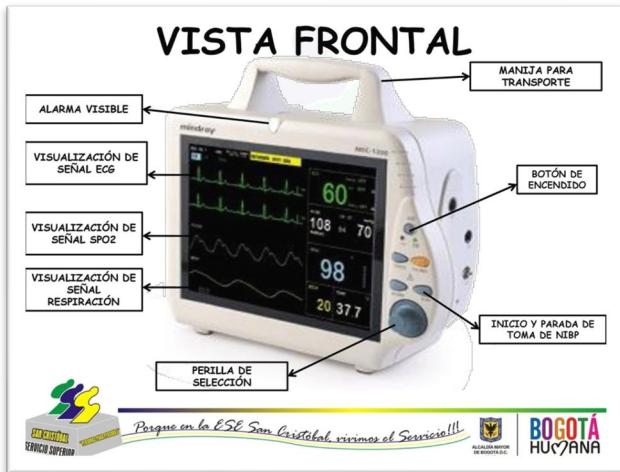
# Virtual Instrumentation

**Virtual functionality**  
- Hardware PCB

**Virtual programming**  
- Software Control  
- Software Algorithms  
- User interface

## System

**DAQ hardware, sensors and actuators, signal conditioning hardware or a Database, and a computer running DAQ software**



-Sensor Temp



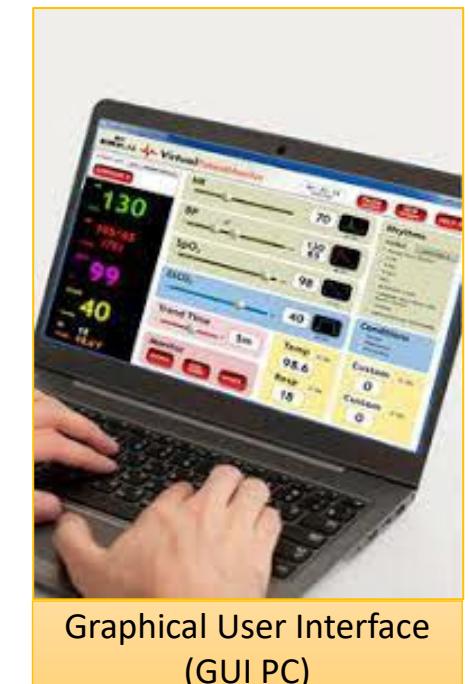
-Sensor SpO2



-ECG



and more...



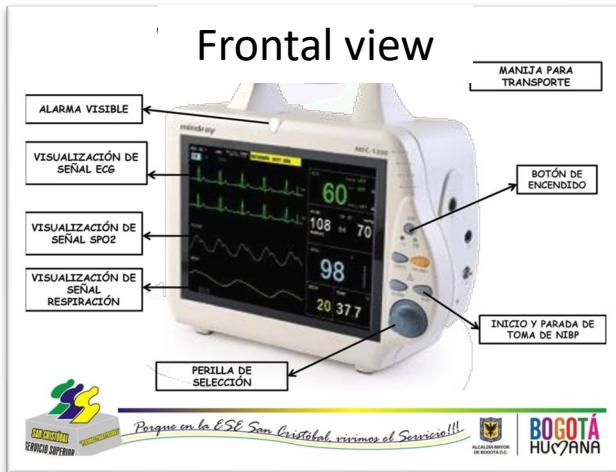
# Virtual Instrumentation

**Virtual functionality**  
- Hardware PCB

**Virtual programming**  
- Software Control  
- Software Algorithms  
- User interface

## System

DAQ hardware, sensors and actuators, signal conditioning hardware or a *Database*, and a computer running DAQ software



- Sensor Temp
- Sensor SpO2
- ECG
- Tumor cell repopulation
- Pandemia, and more...



## Interface for medical purpose



e.g. Results or diagnose



Create an appropriate user interface that best suits the purpose of the application



Python, LabView, C and more

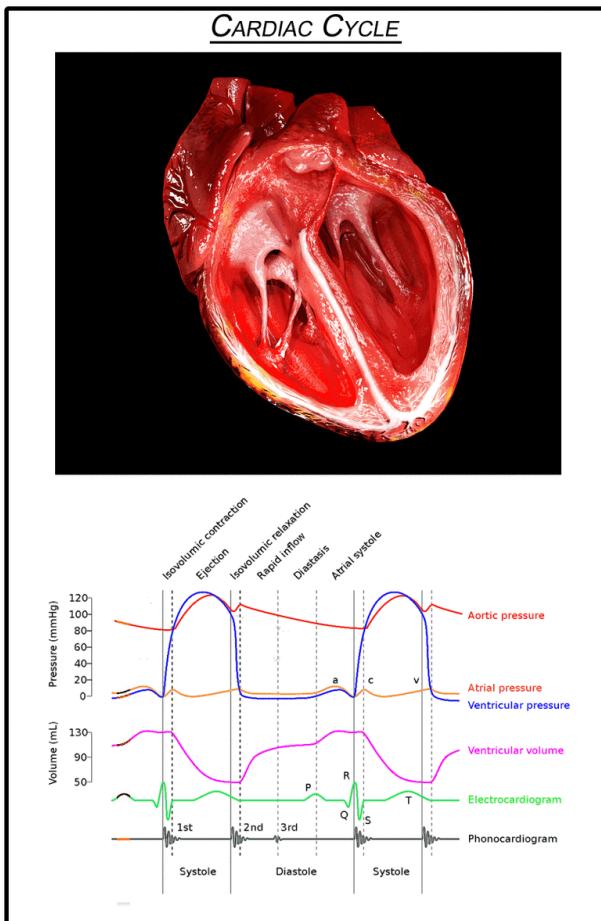
MVP: Minimum Viable Product



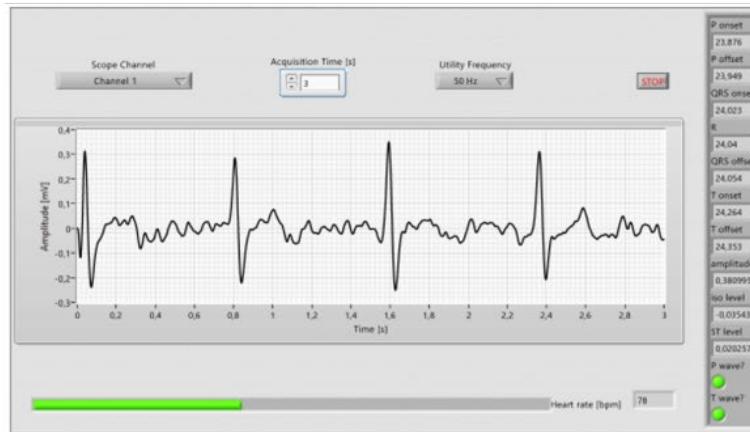
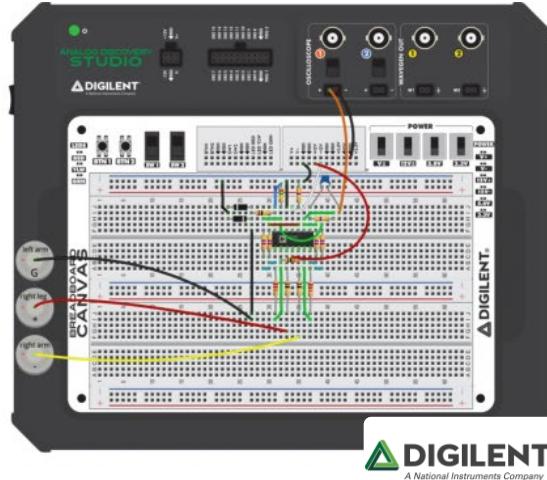
Tools to manipulate and store data, present the results regarding a medical analysis, pathologies, environmental control, mechanical/electrical requirements... PC, Software, networking technologies, internet, etc.

Design a virtual instrument to solve specific tasks for a complete system

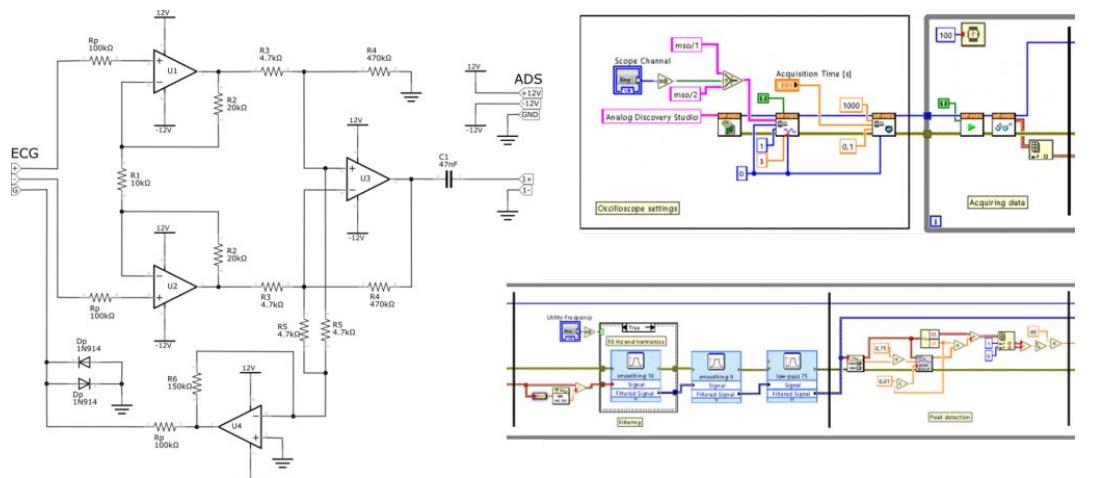
# E.G. Electrocardiogram



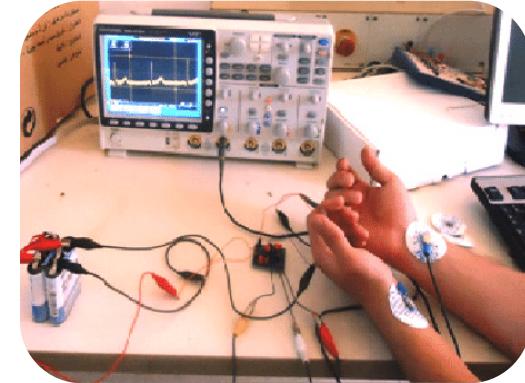
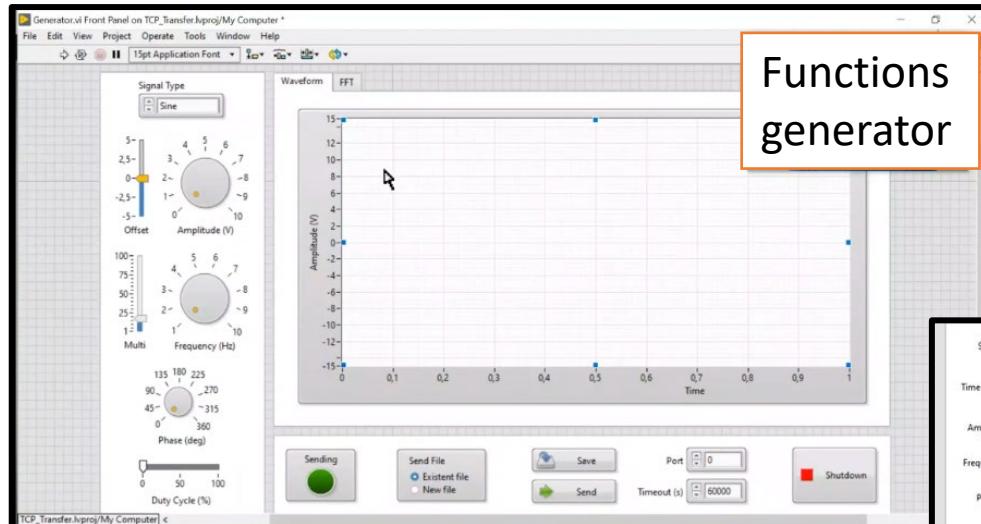
# Virtual Instruments (ECG)



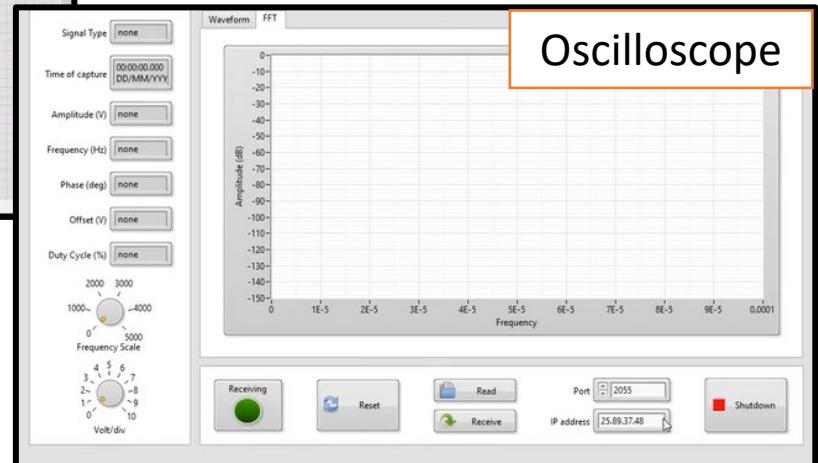
**Build DIY ECG Monitor  
with Digilent Analog  
Discovery Studio and NI  
LabVIEW**

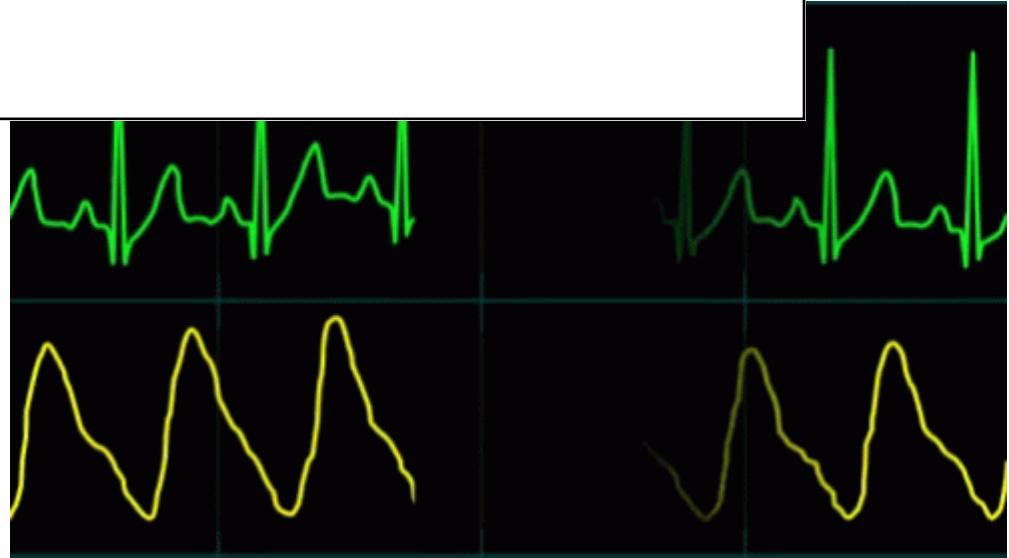


# Virtual Instrument (Oscilloscope )



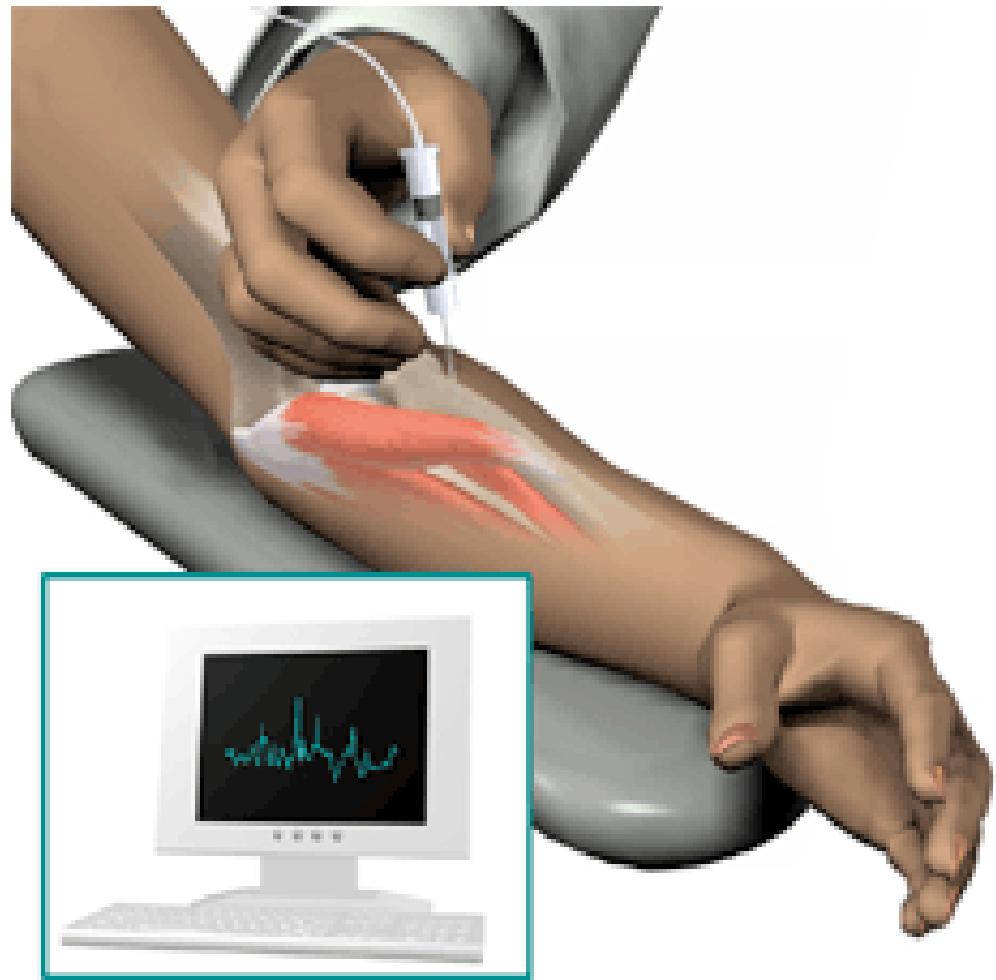
Zizoua et al. 2012. Un Réseau de Capteurs Sans fil  
Dédié au Monitoring de l'Activité Cardiaque.





*Paula López & Omar Romera Project.*

E.G.  
Electrocardiogram

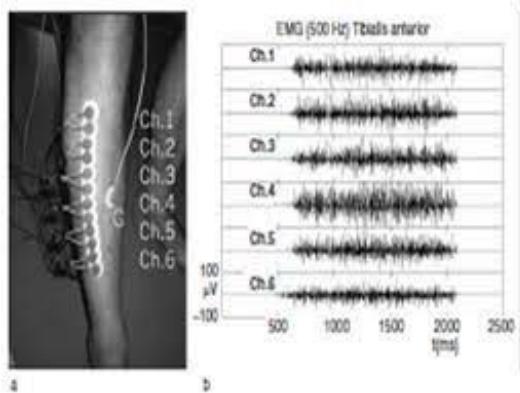


Electromyography  
Test

# Electromyogram (EMG)



**EMG-IMU Wristband for Hand Gesture Recognition**

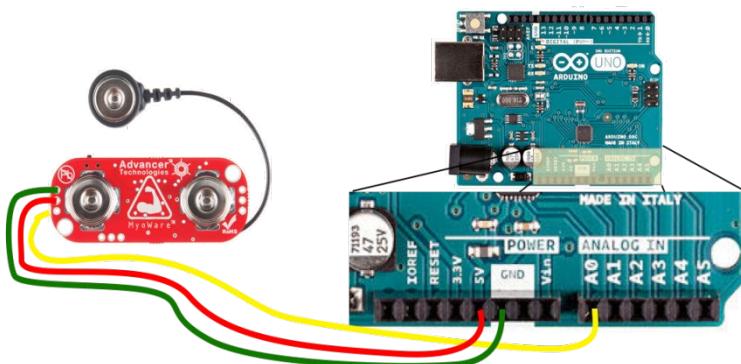


**Electromyography “Muscle Mouse”**

<http://www.wearablesystems.org/emg-imu-hand-gesture-recognition>

<http://hackalizer.com/electromyography-muscle-mouse/>

# Electromyogram (EMG): MyoWare™ Muscle Sensor



Output signal:

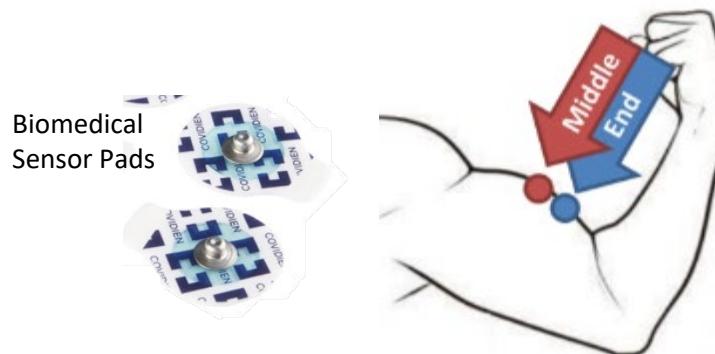
RAW EMG Signal



Rectified EMG Signal



Rectified & Integrated EMG Signal



PROJECTS:

<https://learn.adafruit.com/getting-started-with-myoware-muscle-sensor/placing-electrodes>

<https://www.instructables.com/id/Muscle-Music-With-Arduino/>

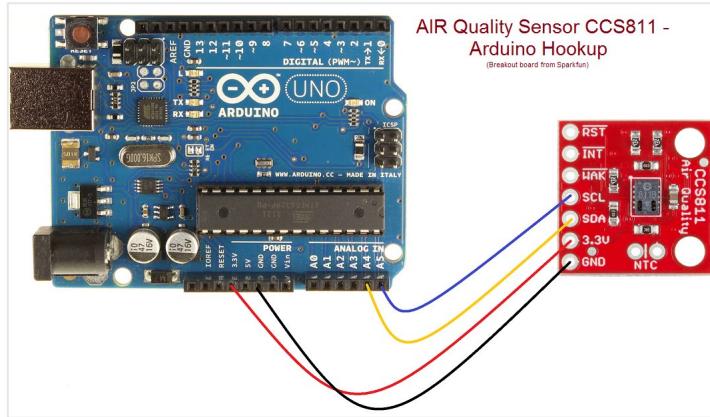


- Electromyogram (EMG)

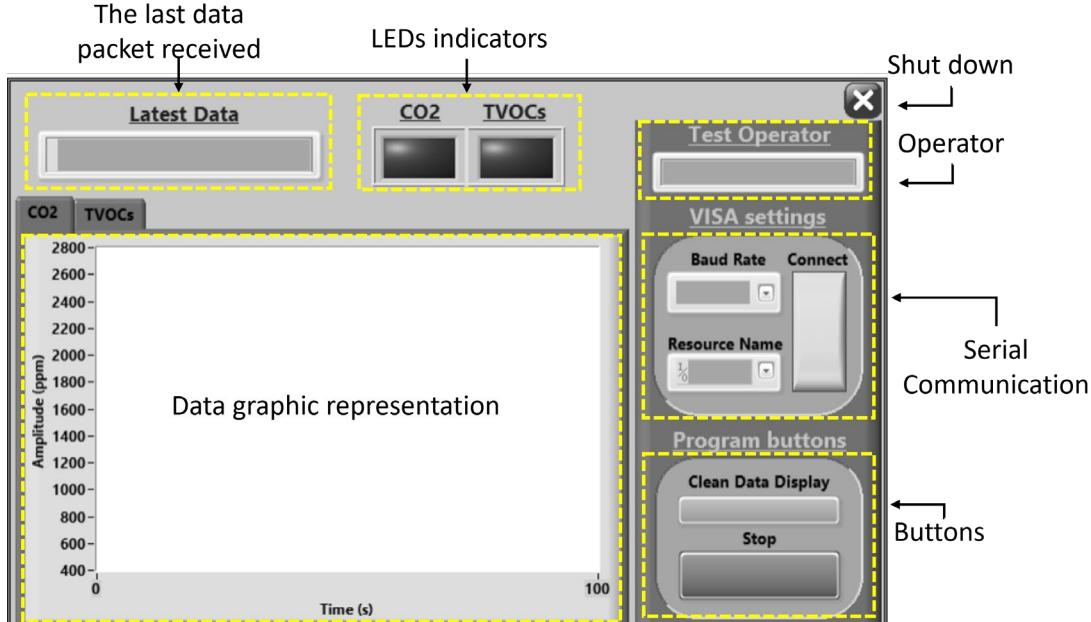


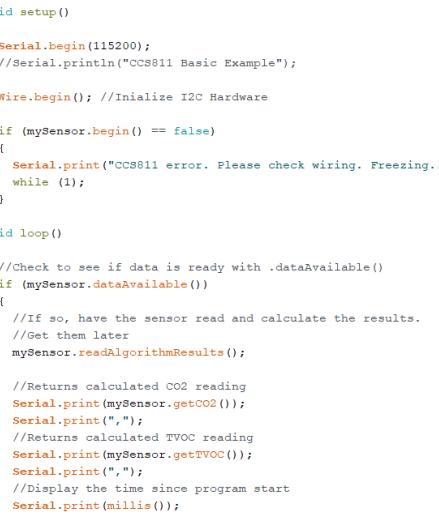
CO<sub>2</sub> and TVOC concentration  
in hospital environments.

# CO<sub>2</sub> and TVOC concentration in hospital environments.



## Arduino (acquire sensor data)





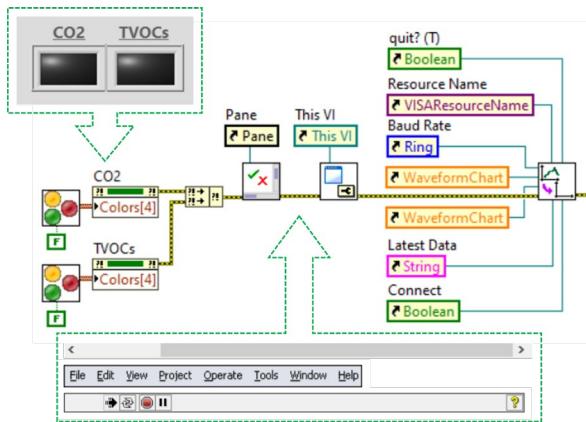
```
LecturaBasicaCCS811 $ void setup() {   Serial.begin(115200); //Serial.println("CCS811 Basic Example");   Wire.begin(); //Initialize I2C Hardware   if (mySensor.begin() == false) {     Serial.print("CCS811 error. Please check wiring. Freezing...");     while (1);   } } void loop() {   //Check to see if data is ready with .dataAvailable()   if (mySensor.dataAvailable()) {     //If so, have the sensor read and calculate the results.     //Get them later     mySensor.readAlgorithmResults();     //Returns calculated CO2 reading     Serial.print(mySensor.getCO2());     Serial.print(",");     //Returns calculated TVOC reading     Serial.print(mySensor.getTVOC());     Serial.print(",");     //Display the time since program start     Serial.print(millis());     //Serial.print("]");     Serial.println();   }   delay(5); //Don't spam the I2C bus }
```

**CO<sub>2</sub>**: Carbon dioxide

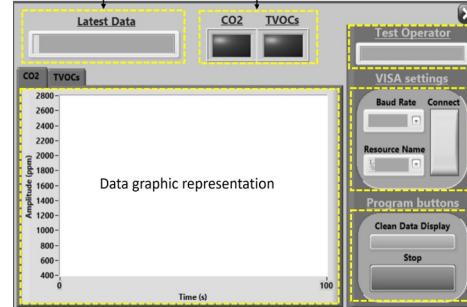
## TVO: Total Volatile Organic Compounds

# CO<sub>2</sub> and TVO<sub>x</sub> concentration in hospital environments.

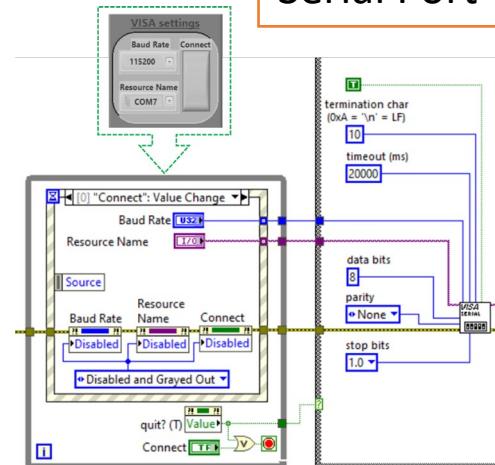
Front Panel



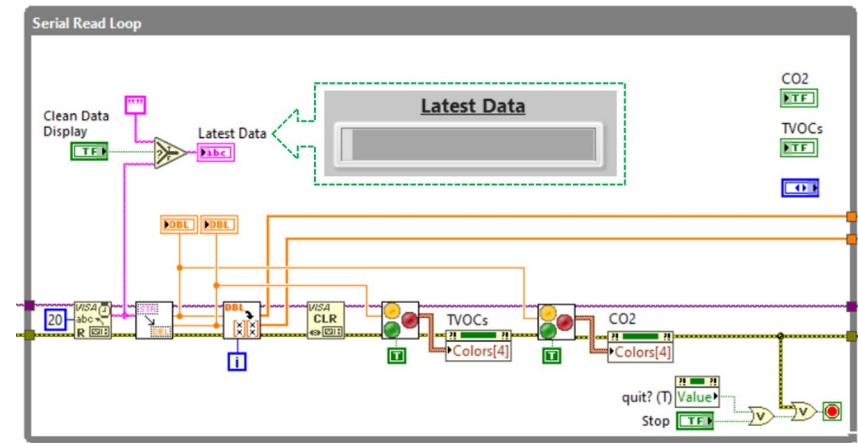
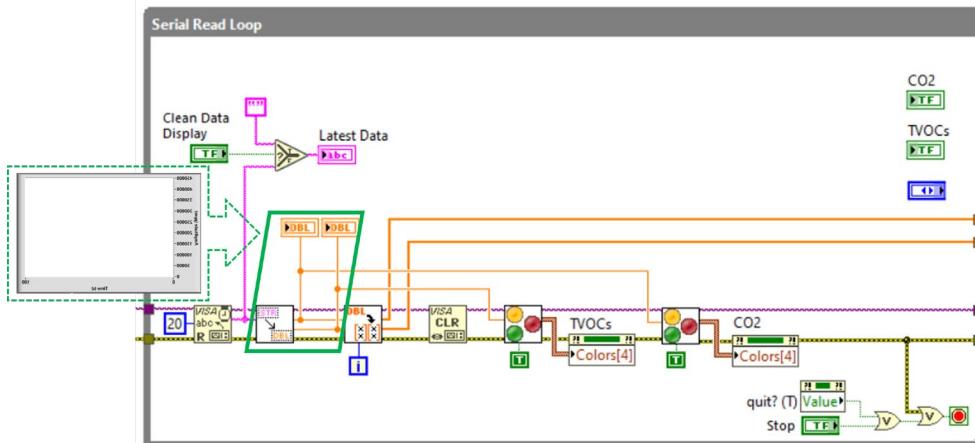
HMI



Serial Port



Processing data



# CO<sub>2</sub> and TVO concentration in hospital environments.

