SMART HEALTHCARE SYSTEM

Graduation Project 2022

HOSPITAL BEDS PER 1,000 PERSON IN 2019*

2.87

USA

2.46

UK

8

Germany

2.52

Canada

5.91

France

*Our World in data Hospital beds per 1,000 people, 1960 to 2019 (ourworldindata.org))

PROBLEM/OPPORTUNITY

USD 503.6 MILLION

Smart Healthcare Products Market size expected in 2028 (2)

USD 160 MILLION

Smart Healthcare Products Market size in 2020 (2)

17% (1.6 BILLION)

Elderly's population percent expected to be by 2050 (1)

17.28 MILLION

Elderly deaths caused by Cardiovascular disease in 2019 (3)

684,000

Total deaths caused by Falls in 2021 (4)

In World

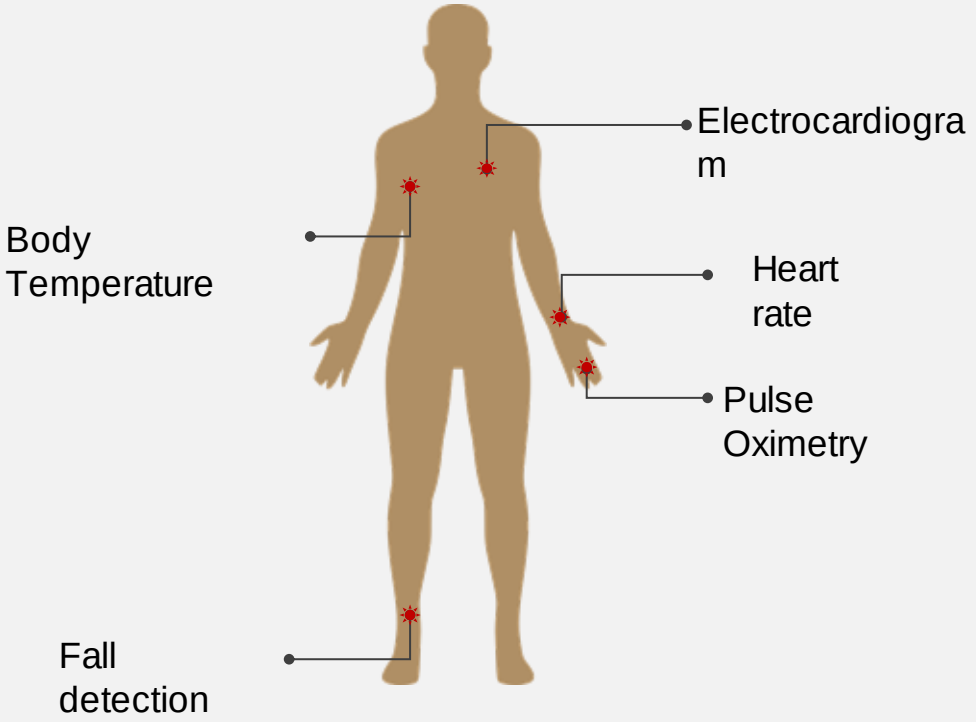
(1) National Institutes of Health — World's older population grows dramatically | National Institutes of Health (NIH)
(2) Verified Market Research — Smart Healthcare Products Market Size, Share, Growth, Trends & Forecast (verifiedmarketresearch.com)
(3) OurWorld in Data — Causes of Death - Our World in Data
(4) Worldhealthrankings — Falls (who.int)

OUR MISSION

Is to develop a smart healthcare system to help old people -65 years or above- with chronic diseases, who lives with a caregiver, do their checkups and detect diseases related to imbalance with automated patient monitoring and critical cases alerting.

SOLUTION DESCRIPTION

A healthcare device for Elderly, which provides and records measurements of some body parameters, and generates an alert at critical conditions.



SOLUTION FEATURES

Real-Time Health Monitoring And Tackling Emergencies

Help doctors provide urgent care to those who are in the most danger.

User friendly, Reliable And Provide Analytics

Developable And Customized

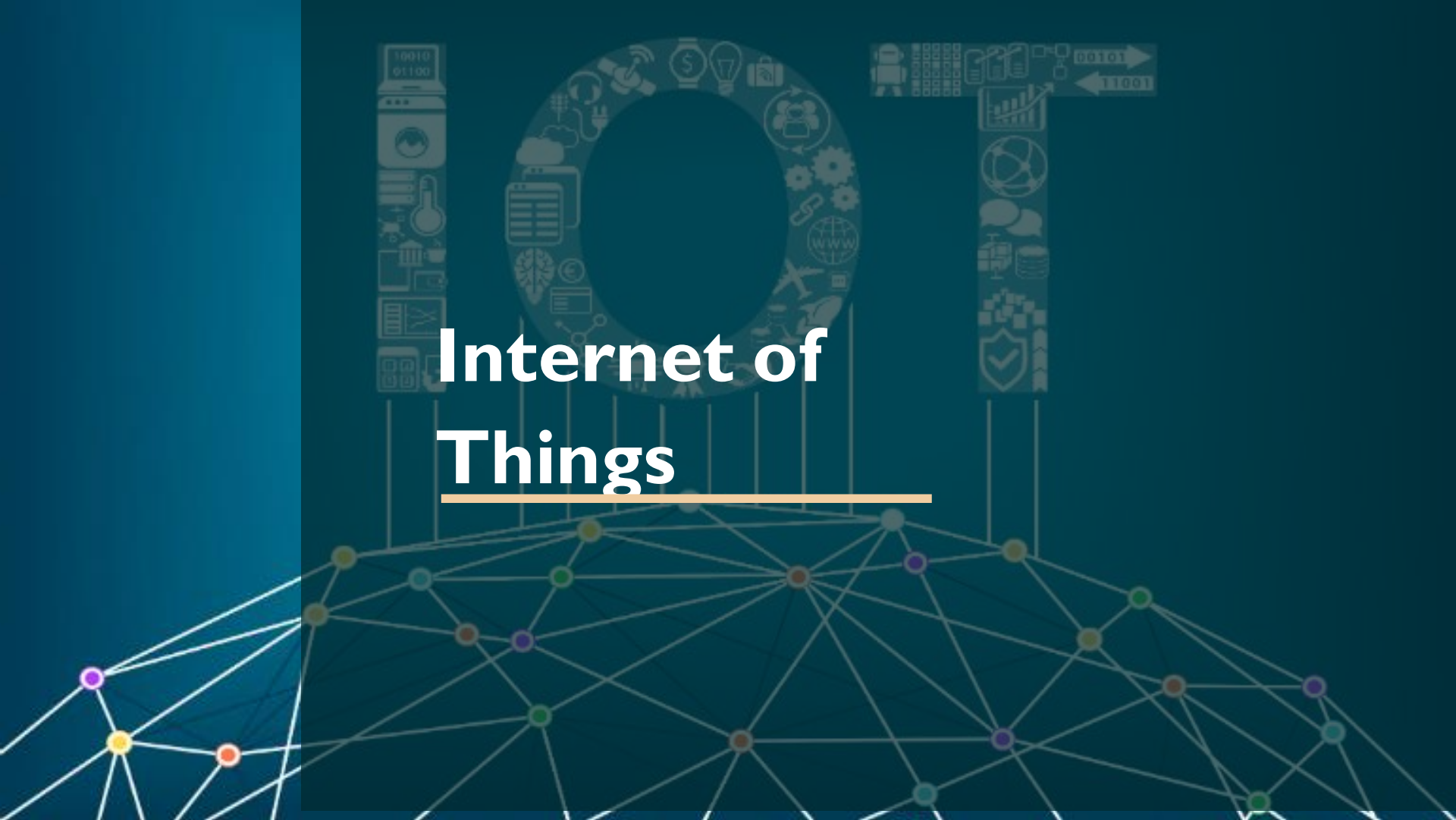
The system can be developed or modified according to patient needs.

Work With All Devices

Secure And No Effort Needed

As it is easier rather than going to hospital regularly.

In A Wearable Format


Internet of
Things

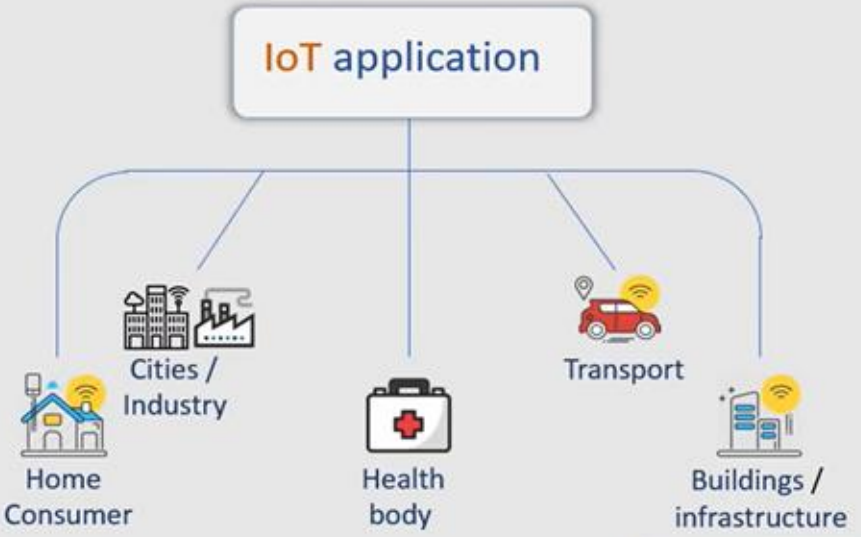
WHAT IS IOT?

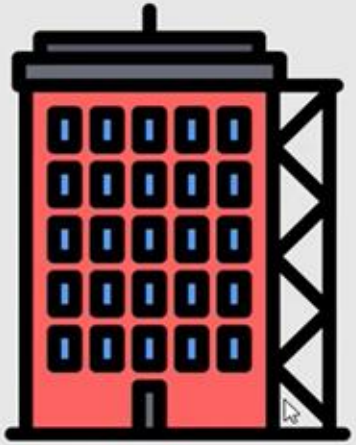
Internet of Things

Internet – Wide range of applications and system of rules built on a largely interconnected networks

Things – Every objects that are capable on connecting with Internet

Things are enclosed within few set of vital existence including human beings, sensors and transmitting devices, and any other object which can connect with other existence any time.





Observing:

- Stability
- Leaning
- Load
- Tension

IoT Characteristics

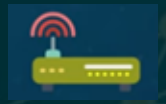
Self Configurable

Unique identify

Dynamic and self adapting

Integrated into Information Network

IoT Architecture

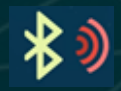


Application Layer or API Management

Processing Engine or Event Processing Layer

IoT Gateway or Aggregation Layer

IoT Devices

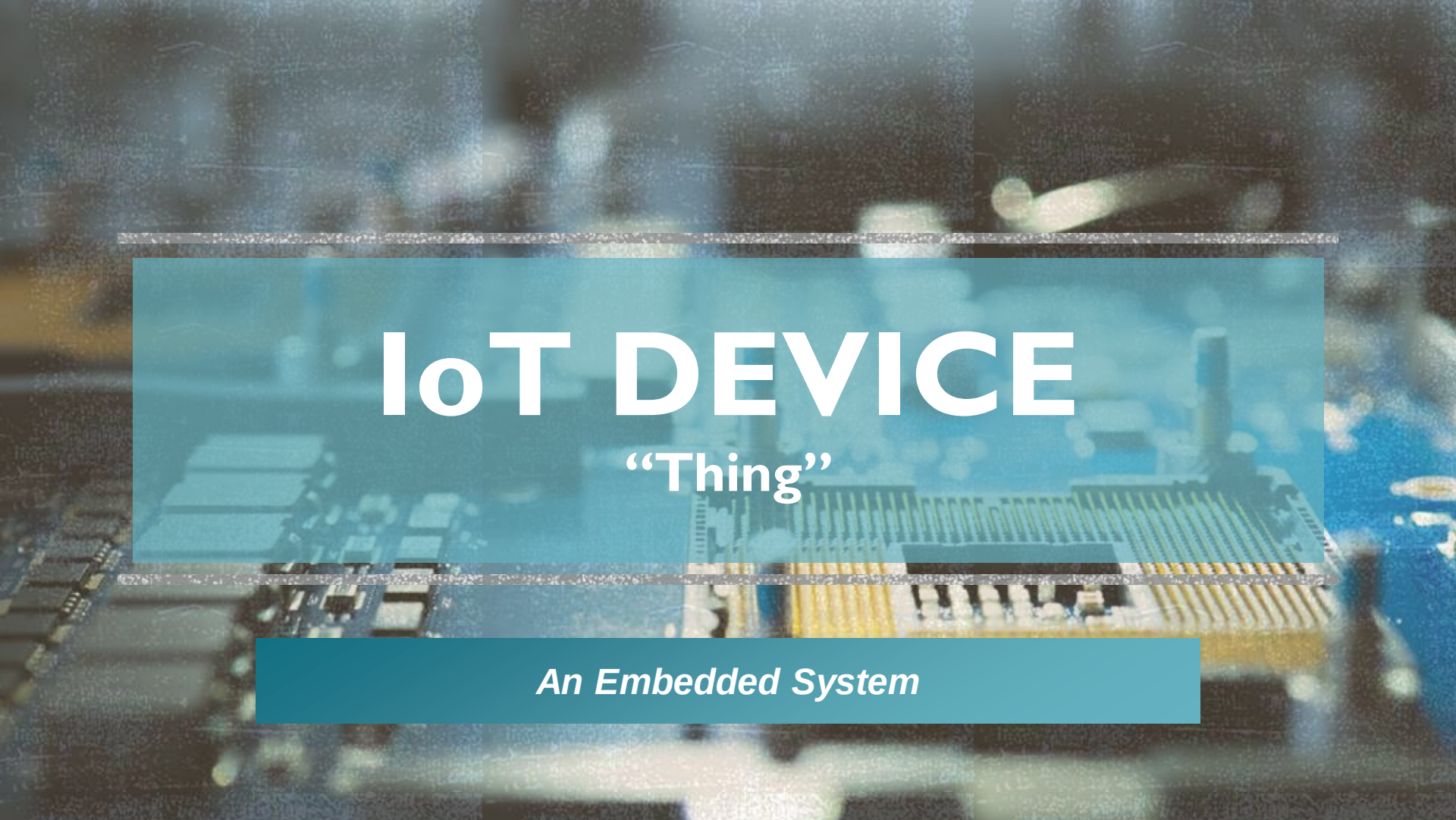


HOW IOT AND BIG DATA IMPACT HEALTHCARE?

1- Patients everyday life: Connected wearable devices and online diagnosis.

2-Medical research, drug research, and accuracy of clinical trial outcomes.

3- For Hospitals apart from monitoring patients' health IoT devices are used for tracking real time location.


IoT DEVICE
“Thing”
An Embedded System

IoT DEVICE

An Embedded System  *Use a Microcontroller*

DEVICE 1

For General patient check up

- High Processing Capability
- Customized
- High Speed
- Has Ethernet & Wi-Fi peripheral

Needs of Project

Small size

Reliable

Not power consuming

Inexpensive

DEVICE 2

For Fall Detection

- Moderate Processing Capability
- High Speed
- Has Wi-Fi peripheral

Clock

In MHz

- between 1 MHz to 300 MHz

Peripheral interface

- I2C, SPI, and UART

Cost

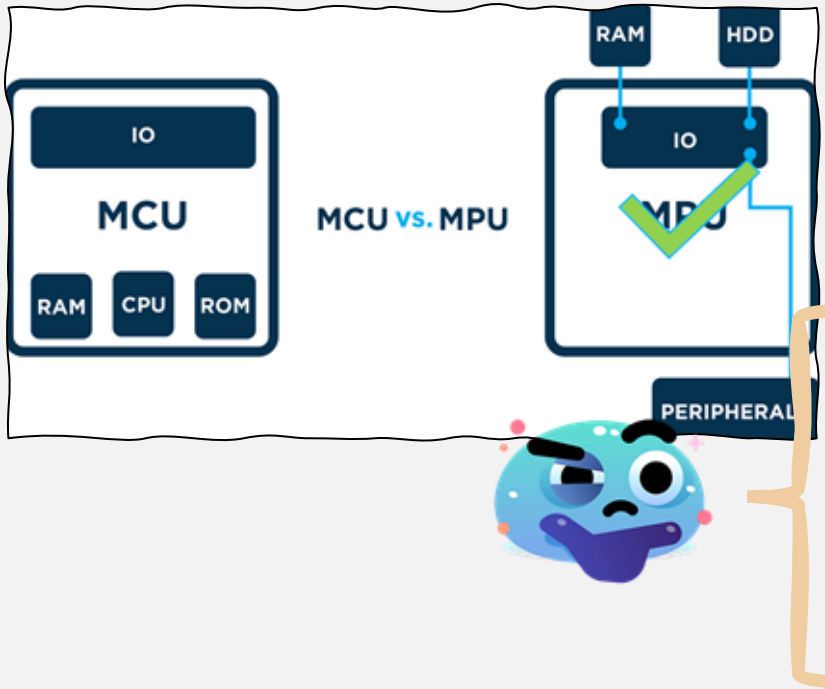
Low

Power consumption

Low

Overall Size

Small



Clock

In GHz

- between 1 GHz to 4GHz

Peripheral interface

- USB, UART, and high-speed Ethernet

Cost

High

Power consumption

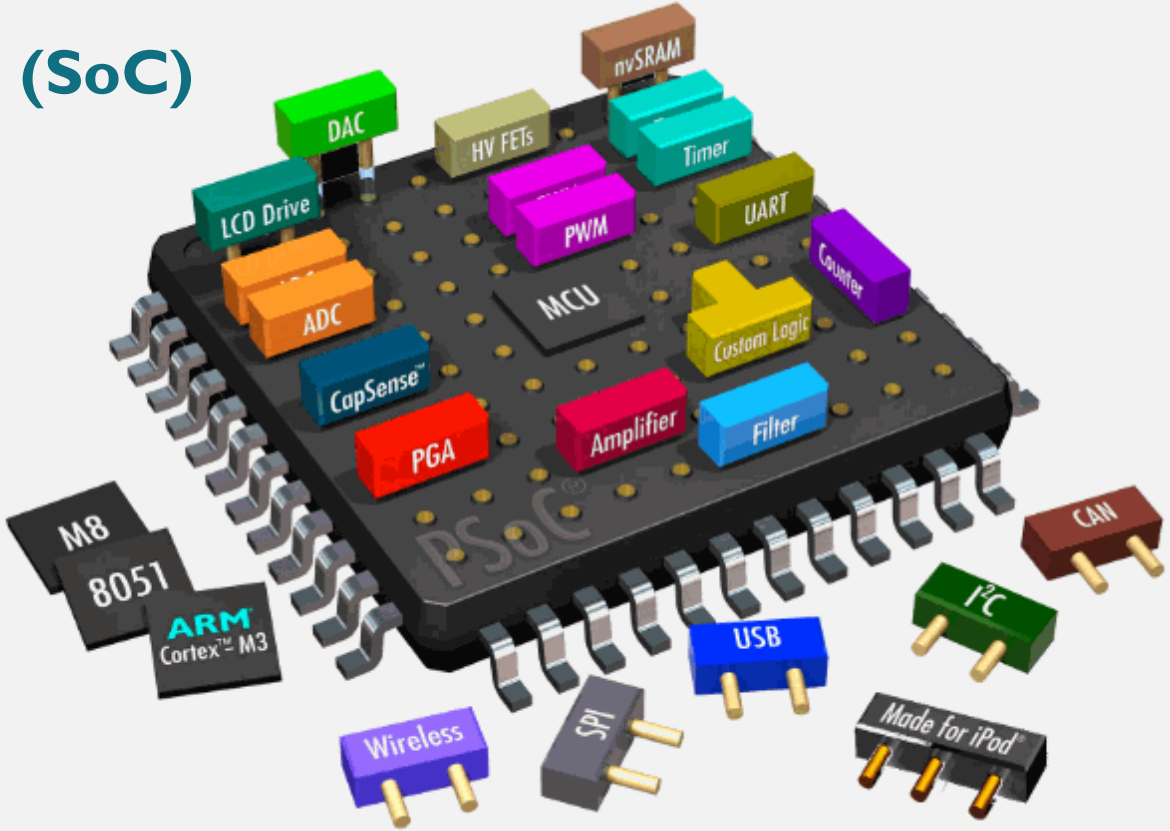
High

Overall Size

Large

SYSTEM ON CHIP (SoC)

1. Tiny space
2. lower manufacturing costs & time
3. Power efficient
4. Moderate cost



DEVICE 1

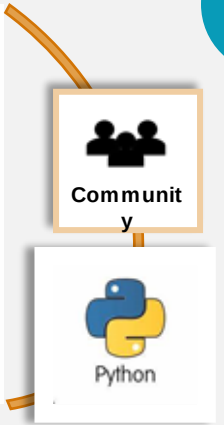
For General patient check up

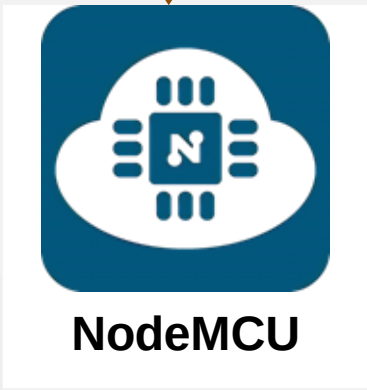
SoC Development Kit

DEVICE 2

For Fall Detection

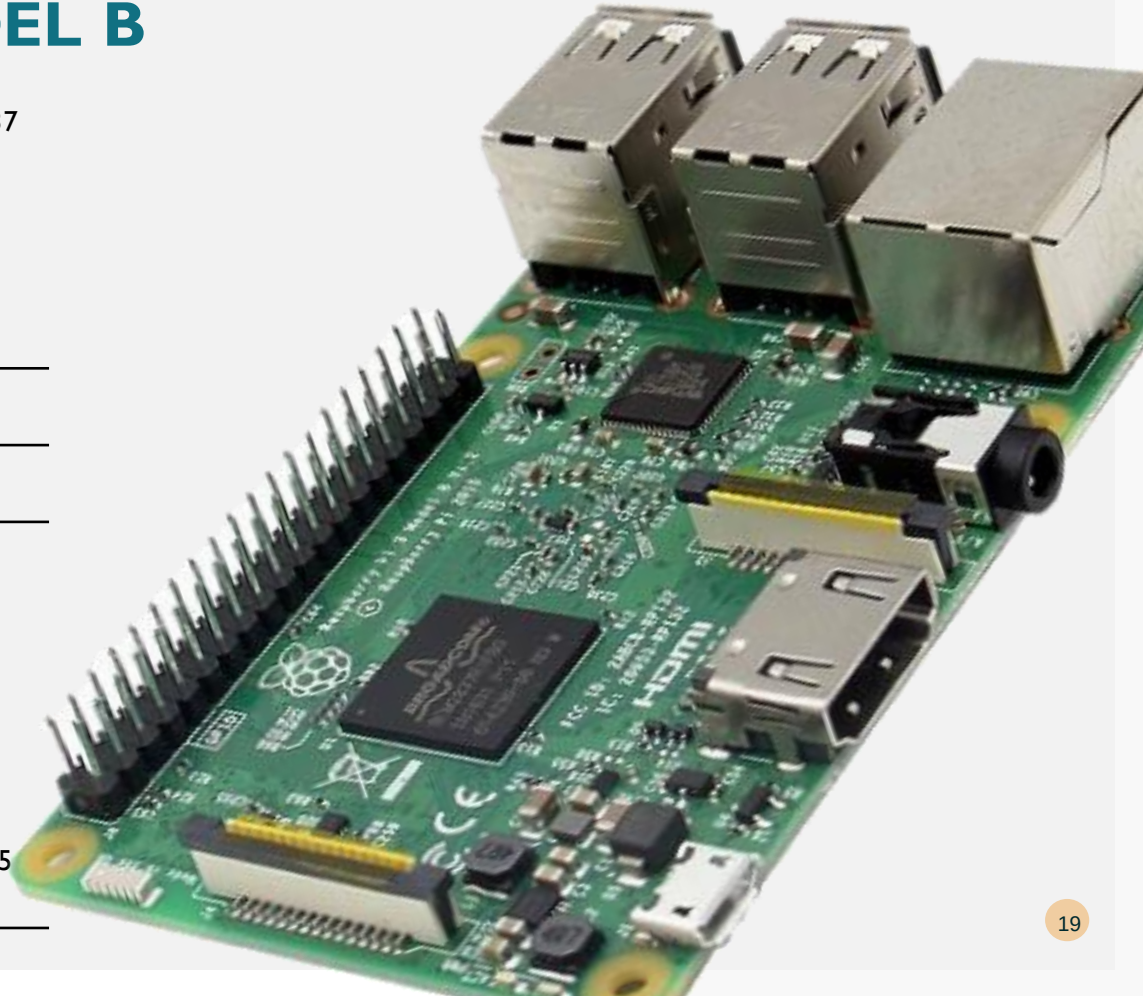
Most popular for IoT Applications

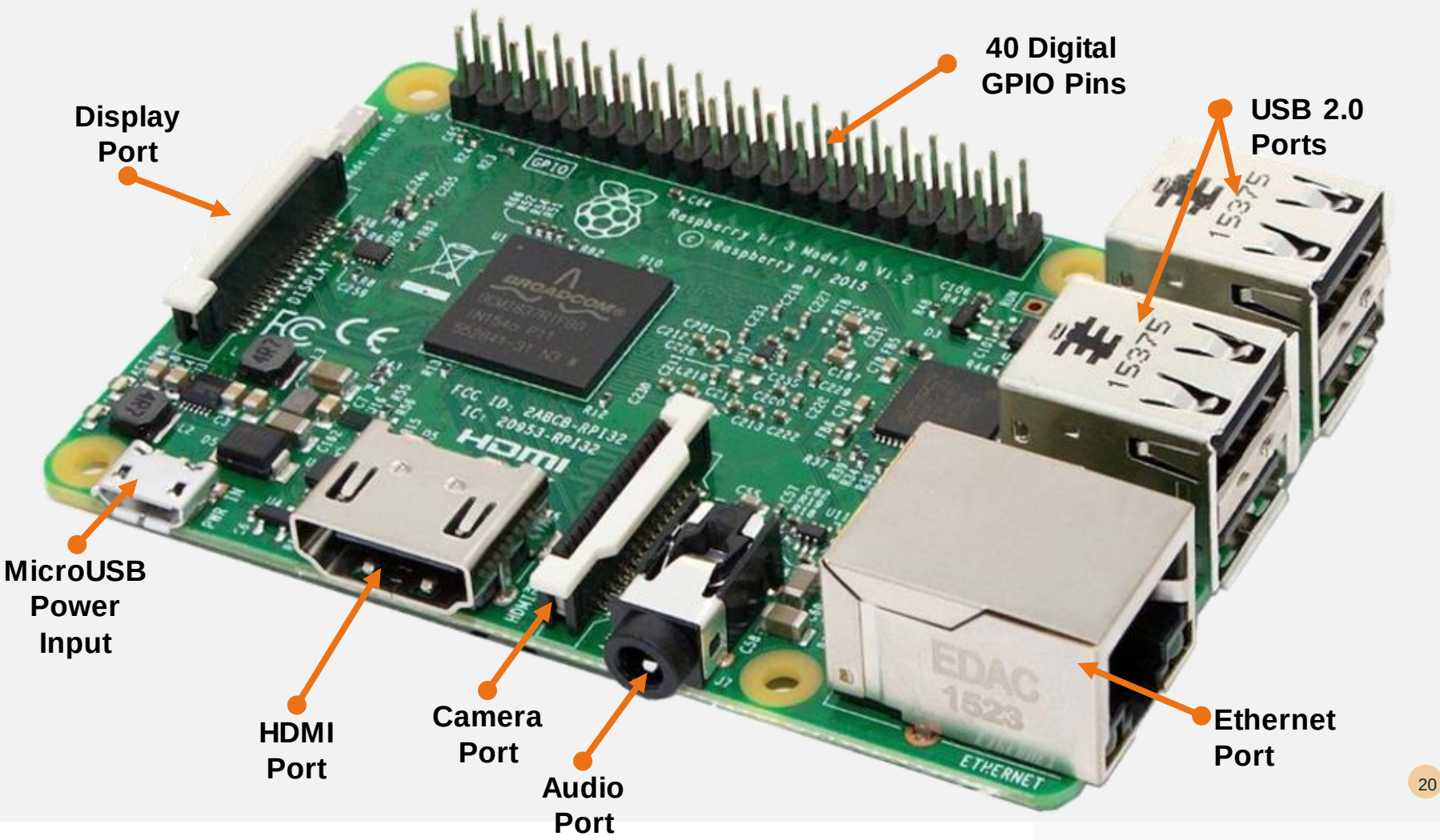


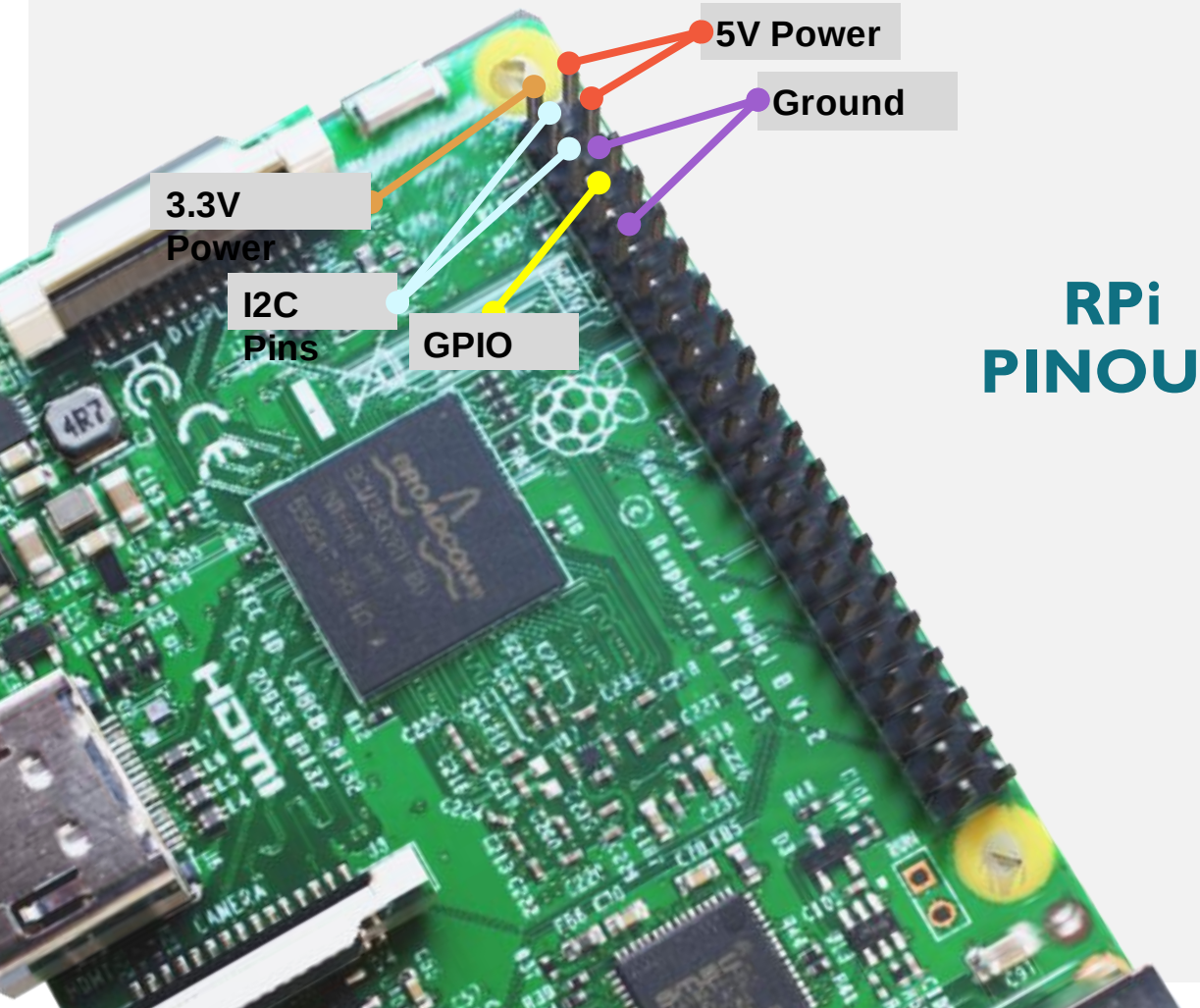


RASPBERRY PI 3 MODEL B

Chip	· SoC: Broadcom BCM2837 · 64bit · ARMv8 · Quad Core Cortex A53 · 1.2 GHz
Storage	microSD Card
Memory	1 GB
Communications	**Wi-Fi** 802.11n WiFi wireless **Bluetooth** Bluetooth 4.1 wireless technology **Ethernet** 10/100BASE-T Ethernet (RJ-45 connector)
peripherals	SPI ,I2C ,UART, PWM




Display Port
40 Digital GPIO Pins
USB 2.0 Ports
MicroUSB Power Input
HDMI Port
Camera Port
Audio Port
Ethernet Port

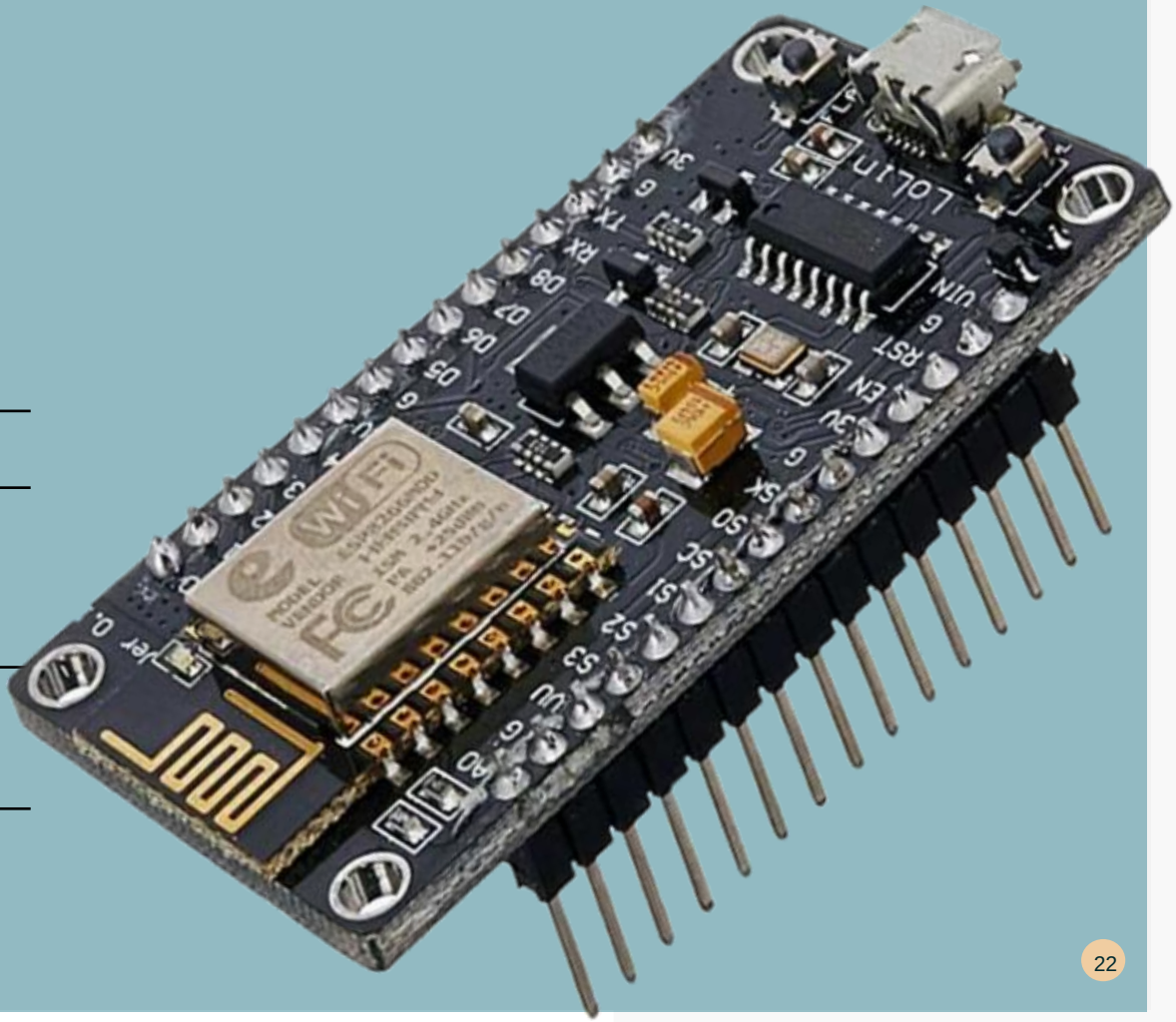


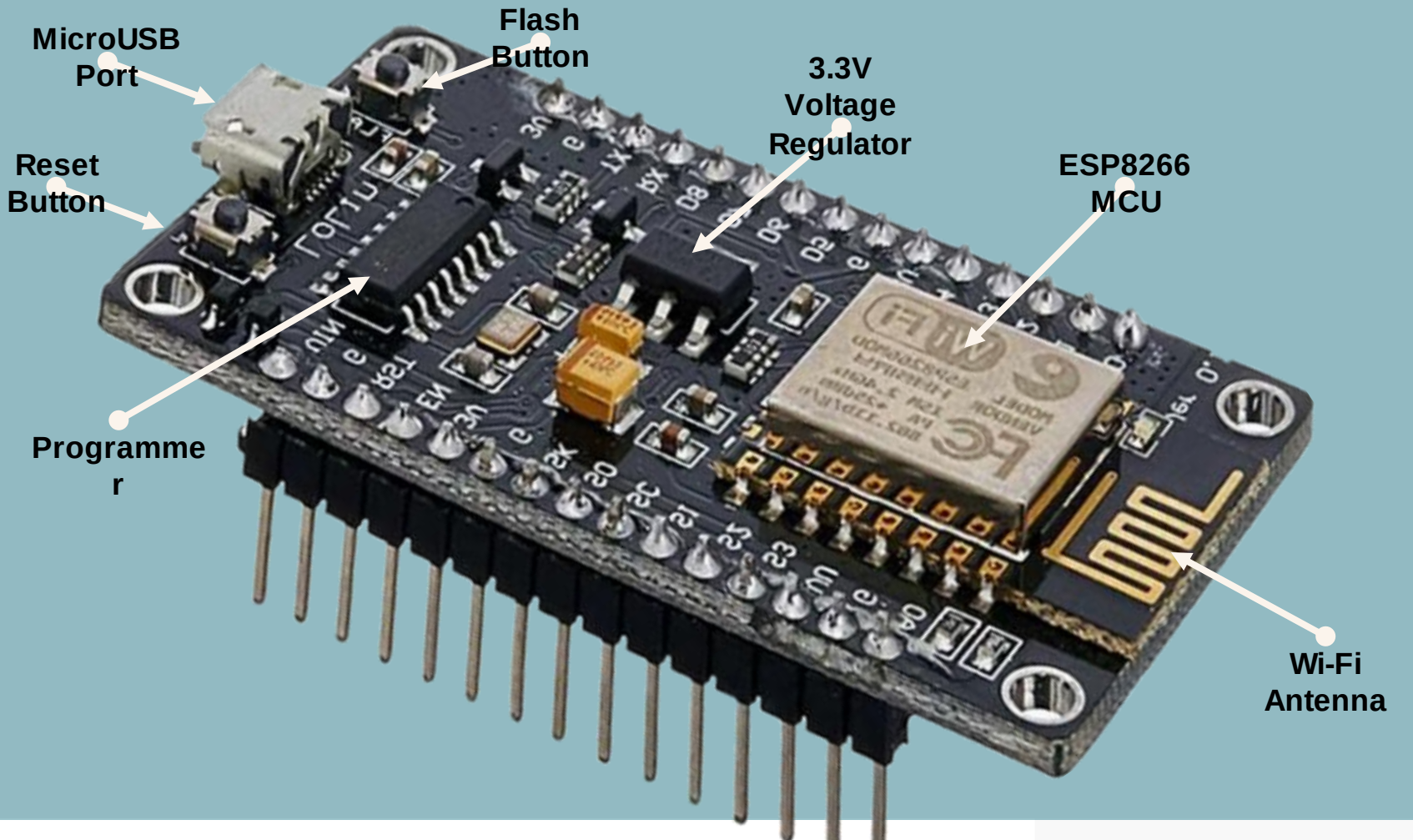
RPi PINOUT

3V3 Power	1	2	5V Power
GPIO2 SDA1 I2C	3	4	5V Power
GPIO3 SCL1 I2C	5	6	Ground
GPIO4	7	8	GPIO14 UART0_TXD
Ground	9	10	GPIO15 UART0_RXD
GPIO17	11	12	GPIO18 PCM_CLK
GPIO27	13	14	Ground
GPIO22	15	16	GPIO23
3V3 Power	17	18	GPIO24
GPIO10 SPI0_MOSI	19	20	Ground
GPIO9 SPI0_MISO	21	22	GPIO25
GPIO11 SPI0_SCLK	23	24	GPIO8 SPI0_CE0_N
Ground	25	26	GPIO7 SPI0_CE1_N
ID_SD I2C ID EEPROM	27	28	ID_SC I2C ID EEPROM
GPIO5	29	30	Ground
GPIO6	31	32	GPIO12
GPIO13	33	34	Ground
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
Ground	39	40	GPIO21

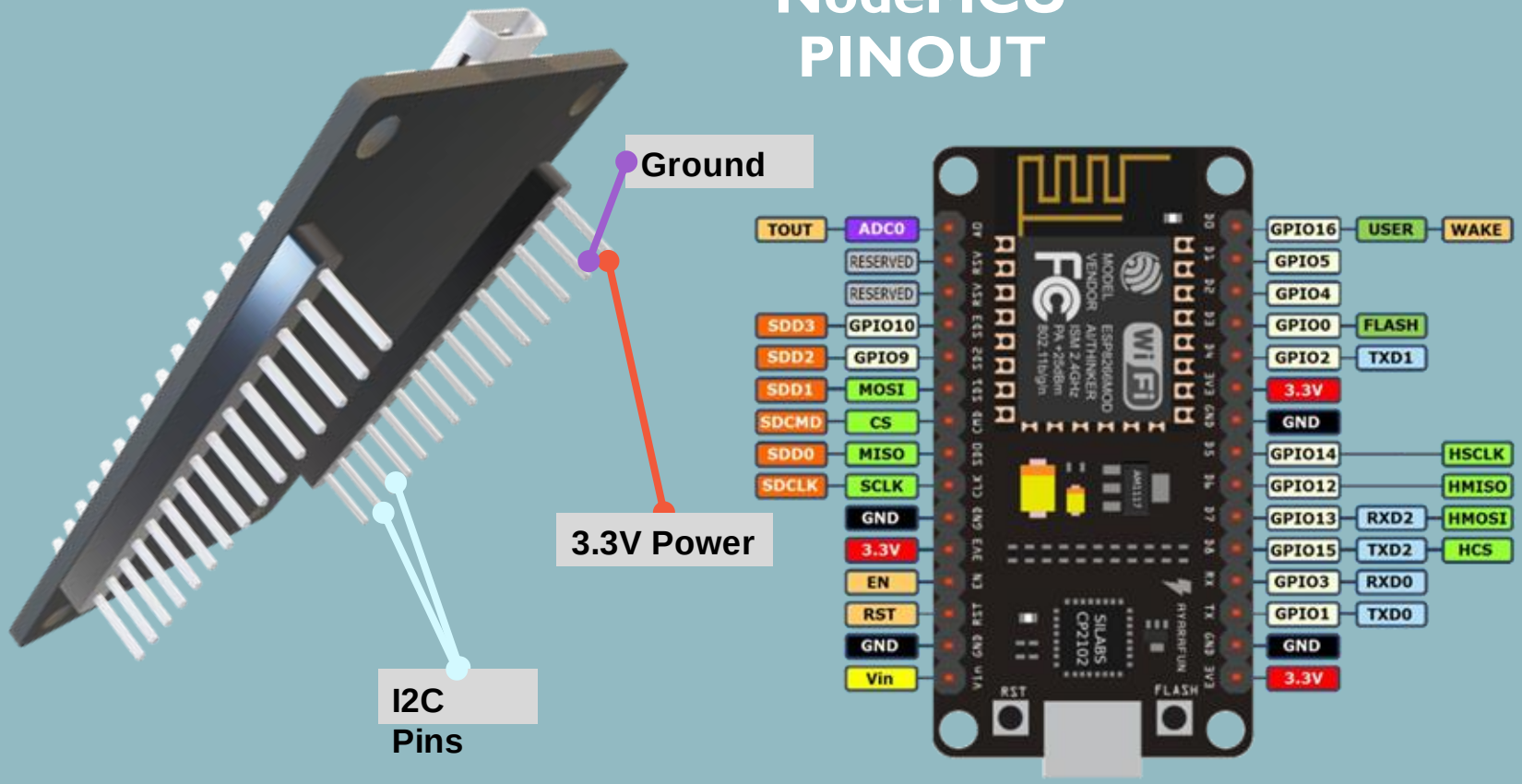
NodeMCU

Chip	· SoC: ESP8266 MCU · Tensilica Xtensa LX106 32-bit RISC microprocessor
Memory	4 MB
Communication	**Wi-Fi** 2.4 GHz Wi-Fi 802.11 b/g/n WiFi wireless Integrated TCP/IP protocol
peripherals	UART, SPI, I2C, IR remote, PWM, SDIO 2.0 Integrated 10-bit ADC




MicroUSB Port
Flash Button
3.3V Voltage Regulator
ESP8266 MCU
Reset Button
Programmer
Wi-Fi Antenna

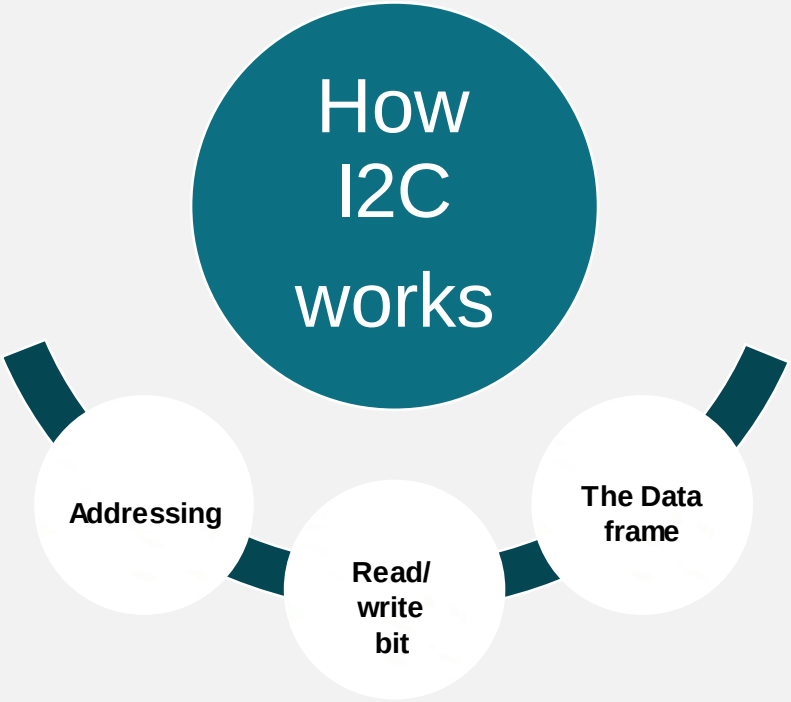
NodeMCU PINOUT

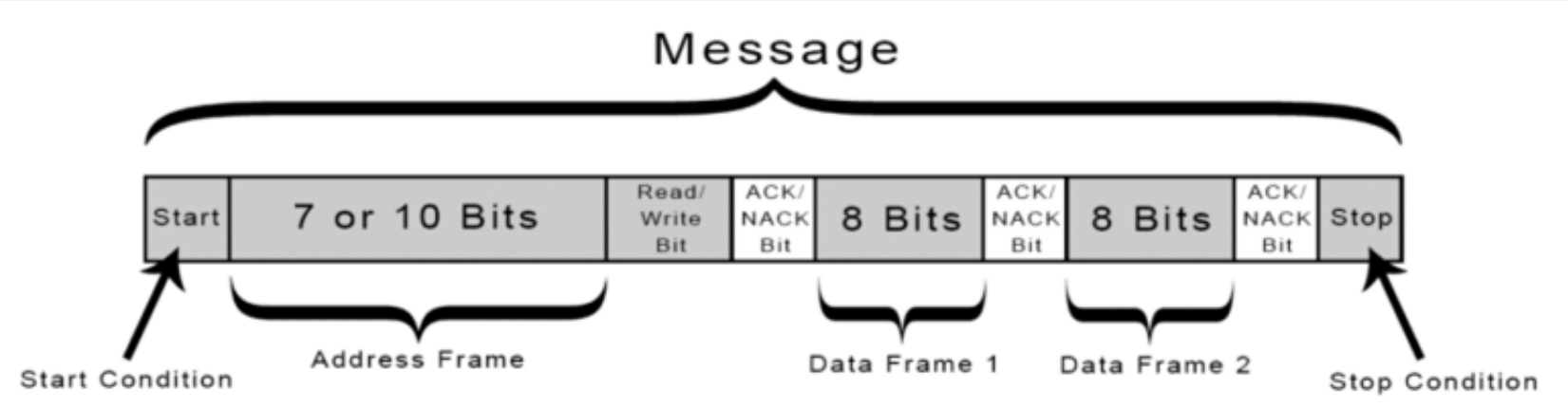


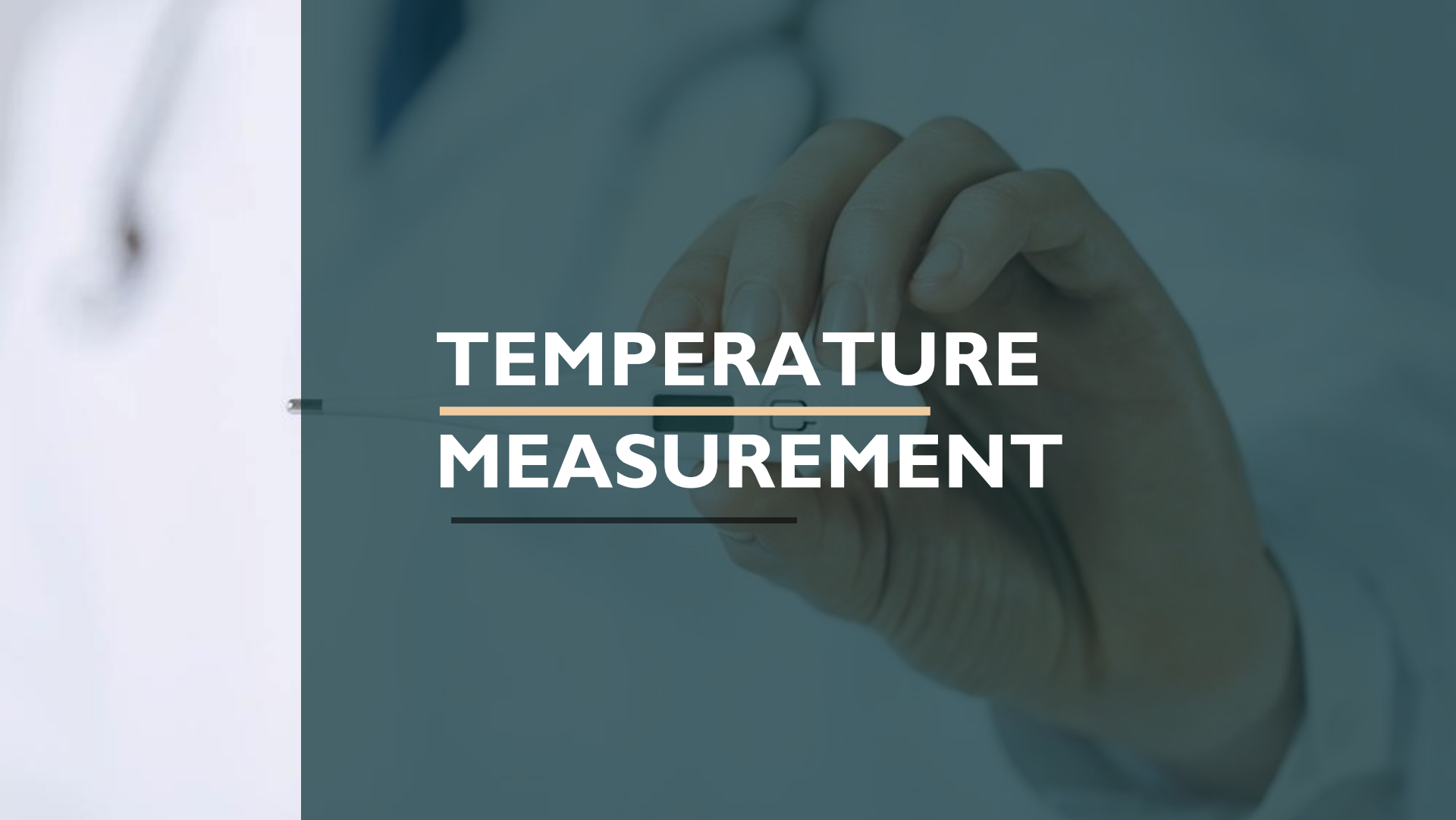
I2C PROTOCOL

INTER-INTEGRATED CIRCUIT (I2C)

I2C is a serial communication protocol, so data is transferred bit by bit along a single wire -the Serial Date (SDA) line .I2C is synchronous, so the output of bits is synchronized to the sampling of bits by a clock signal - Serial Clock (SCL) - shared between the master and the slave. The clock signal is always controlled by the master.


How I2C works
Addressing
Read/ write bit
The Data frame


Message
Start
7 or 10 Bits
Read/ Write Bit
ACK/ NACK Bit
8 Bits
ACK/ NACK Bit
8 Bits
ACK/ NACK Bit
Stop
Start Condition
Address Frame
Data Frame 1
Data Frame 2
Stop Condition



TEMPERATURE MEASUREMENT

NORMAL BODY TEMPERATURE

A normal body temperature for younger adult is (36.4-37.6℃) but for the older adult, it is between (35.8-36.9℃). At higher levels (38℃ or more) and lower levels (35℃ or less), asking for a medical help is a must.

HARDWARE IMPLEMENTATION OF TEMPERATURE SENSOR

Digital chip DS18B20

Power supply : 3.0→5.5VDC Resolution ratio : 9→12 bits

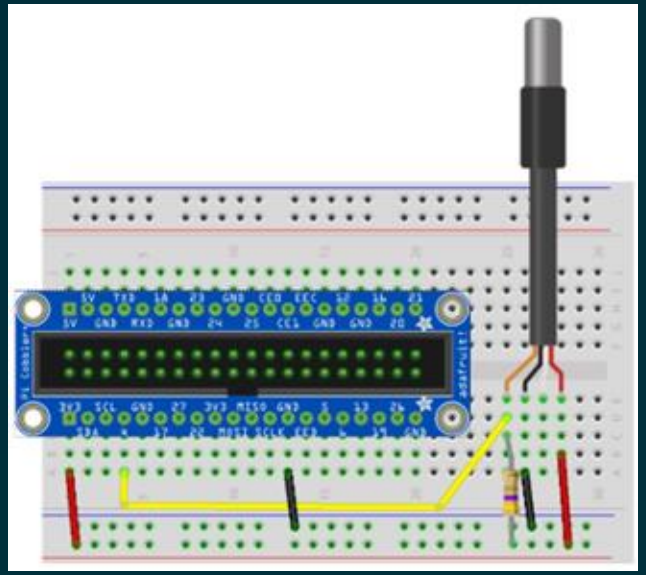
Temperature range : -50→+125℃

Material : Stainless steel

Features

- Temperature sensing quickly, Accurate
- Impact resistance, strong waterproof, long service life
- unique single bus interface

WORKING PRINCIPLE



DS18B20 can directly read the measured. the information written into the DS18B20 only needs one port line (single-wire interface) to read and write, and the temperature conversion power comes from the data bus.

OXYGEN SATURATION AND HEART RATE MEASUREMENT

NORMAL OXYGEN SATURATION

- A normal oxygen saturation (SpO2) is (97-100%) but older adult typically has lower level than younger adult (95%). At 92% or less, asking for a medical help is a must.
- A resting heart rate between 60 and 100 beats per minute (BPM) as normal.

HARDWARE IMPLEMENTATION OF PULSE OXIMETER

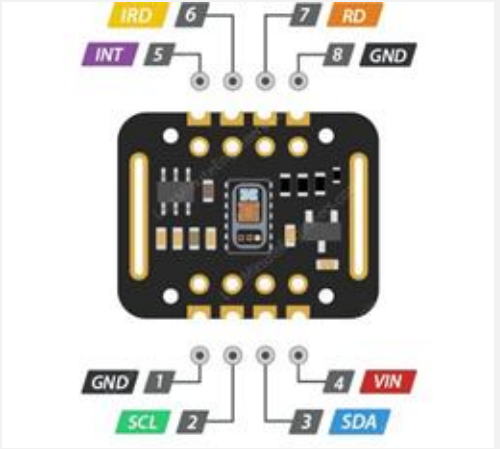
Digital chip MAX30102

Power supply : 3.3→5.5VDC

I2C Addressing : 0×57

Working current : <5mA

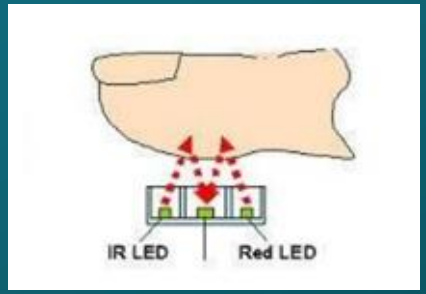
Red/IR LED Driving : current 0→50mA

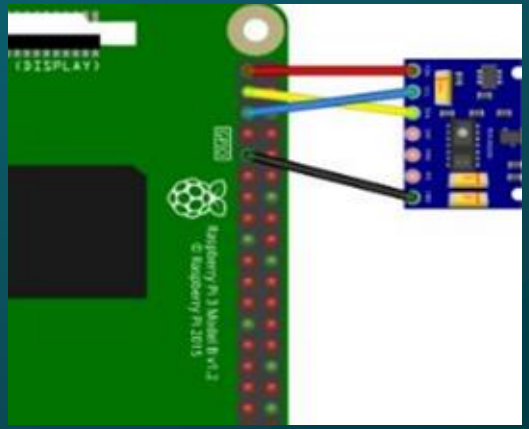


Features

- Tiny 5.6mm x 3.3mm x 1.55mm 14-pin optical module
- Programmable sample rate and LED current for power saving
- Low-power heart rate monitor (<1mW)
- Fast data output capability, High sample rates and High Signal-to-noise ratio (SNR)

MAX30102 WORKING PRINCIPLE

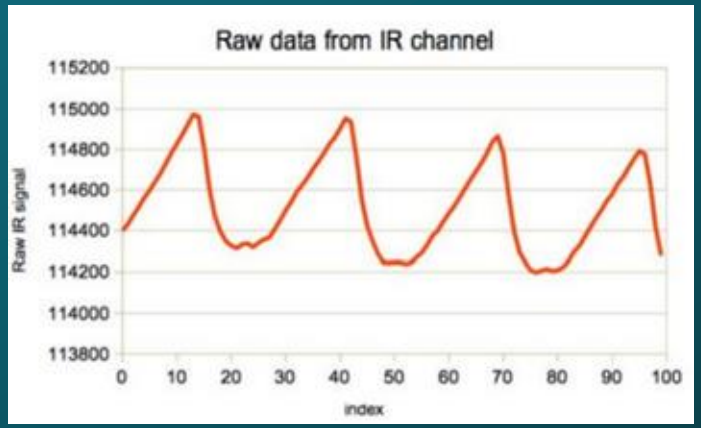


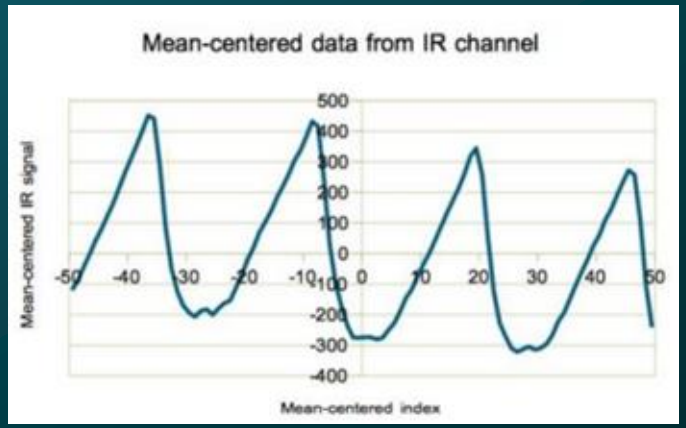


The principles of the sensor operation are very simple: two LEDs, one red (660 nm) and one infrared (880 nm, IR) shine light through human skin. The light is partially absorbed by underlying tissues, including peripheral blood. Sensor's photodetector collects reflected light at both wavelengths and returns two corresponding relative intensities using I2C protocol.

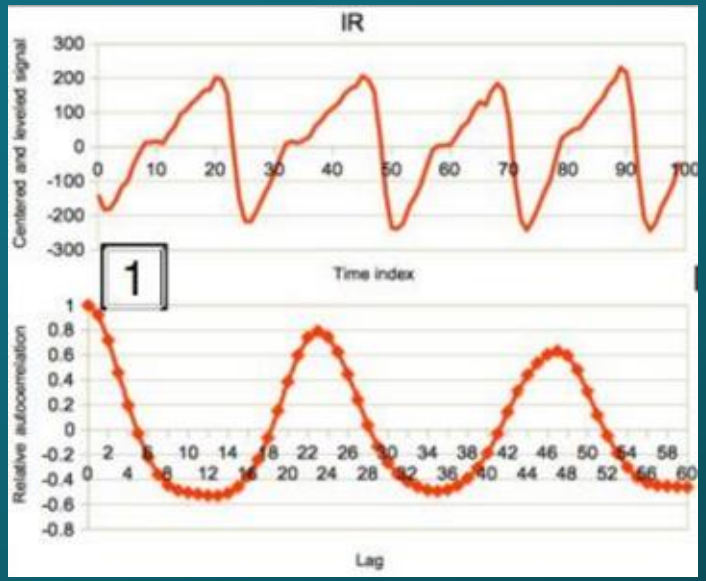
SIGNAL PROCESSING

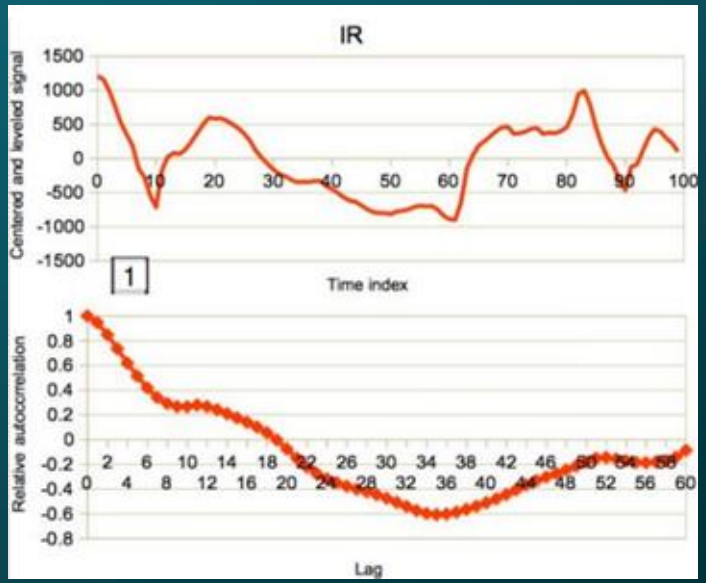
The raw signal is collected at the rate of 25 Hz for full 4 seconds, resulting in 100 digitized time points per end data point Each 100-point sequence must be preprocessed by mean-centering.





AUTOCORRELATION FUNCTION





$$r_m = \frac{1}{n-m} \sum_{t=1}^{n-m} \left(y_t \cdot y_{(t+m)} \right)$$

HEART RATE CALCULATION

In order to determine the average time period between peaks, from which one can calculate signal's frequency (i.e., heart rate) it is sufficient to find the first local maximum of the autocorrelation function. MAX30102 samples analog input at a rate of 25 points per second, therefore at given m the period in seconds is equal to m / 25.

This leads to heart rate expressed in beats per minute (bpm) by:

$$HR = 60*25 / m = 1500 / m.$$

OXYGEN SATURATION CALCULATIONS

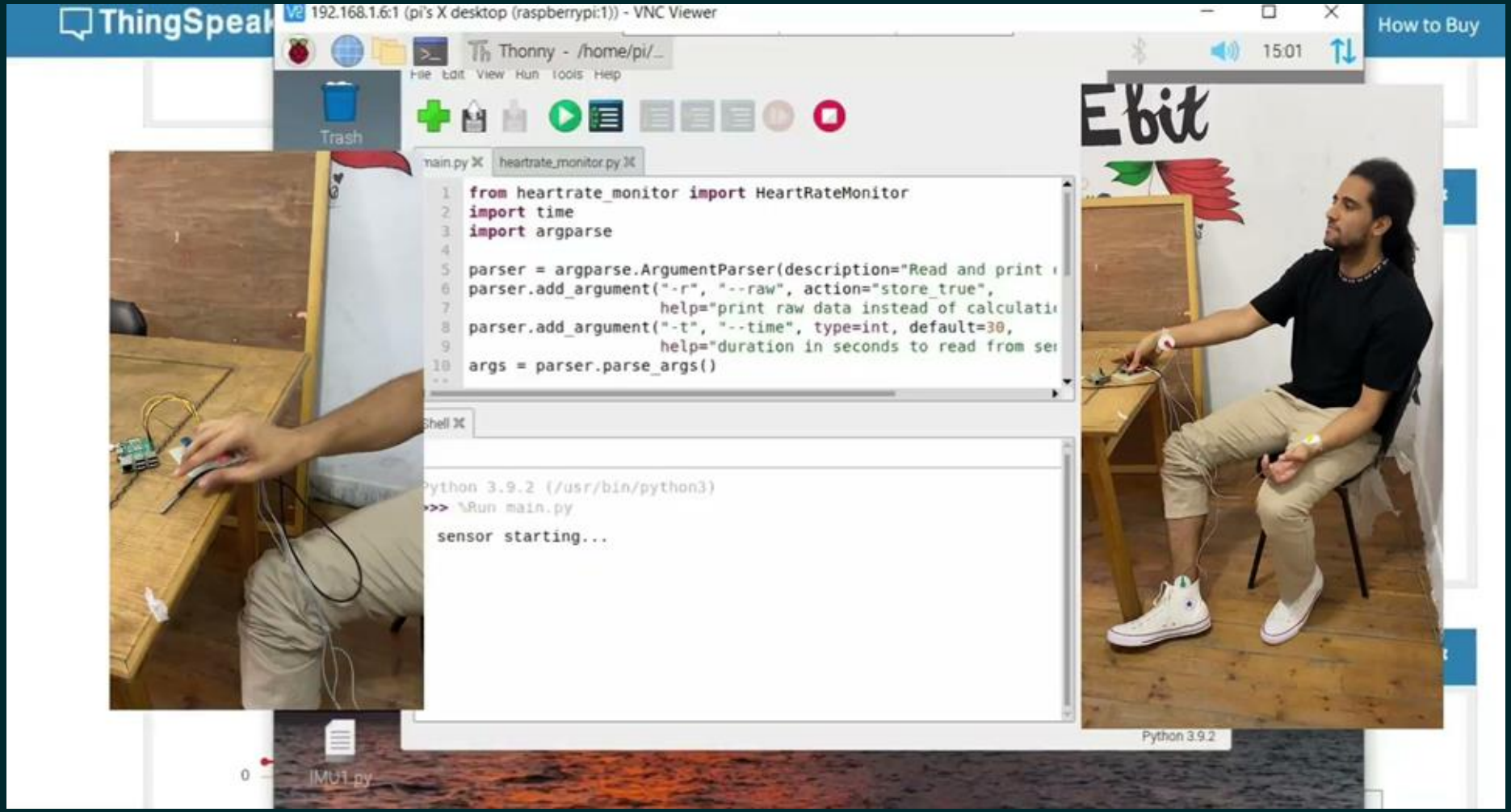
The ratio of red to infrared signals, Z = R/IR, both reflected off the arterial blood the Z ratio is calculated from relative intensities.

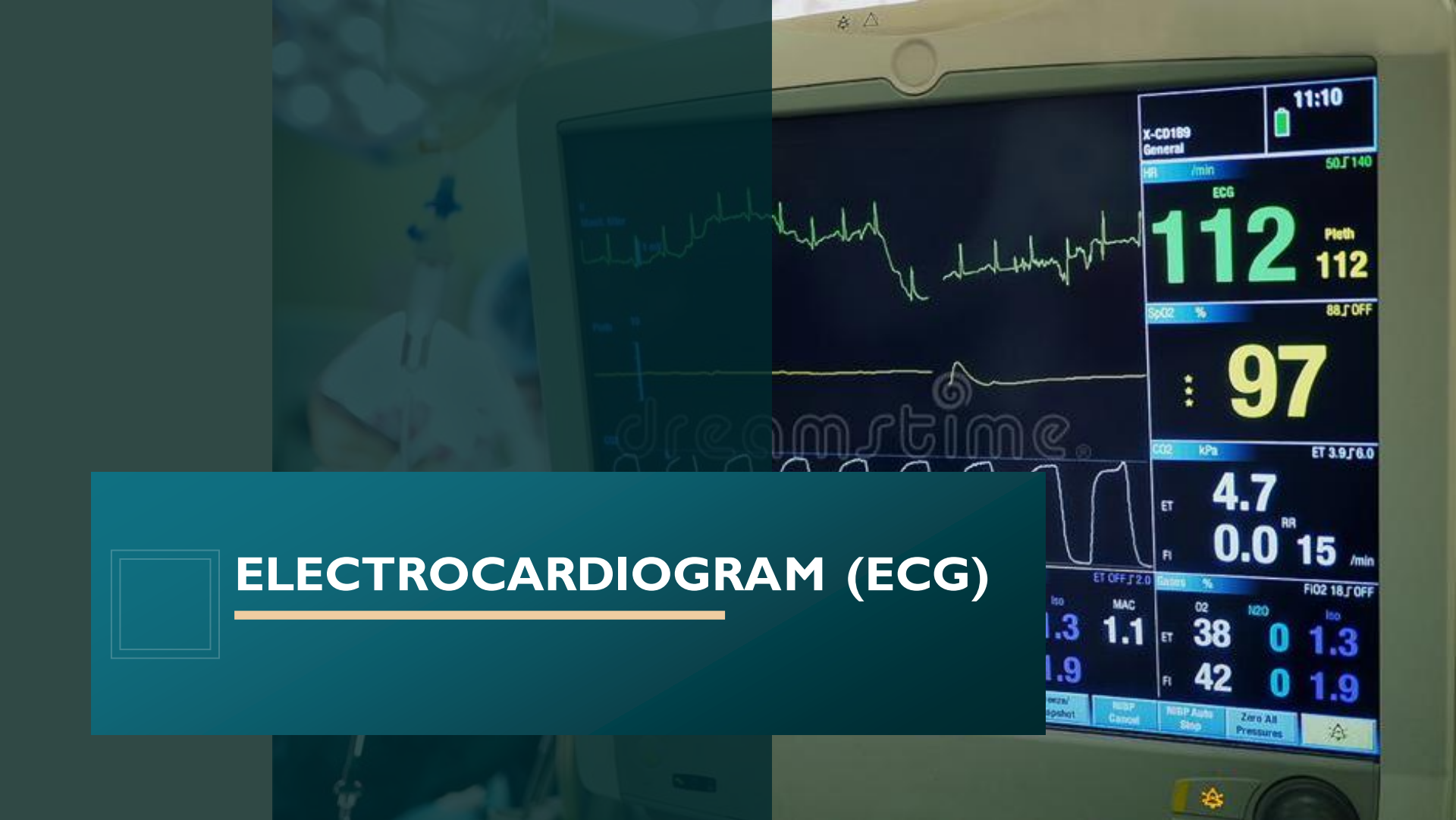
We use root-mean-square (RMS) of the mean-centered of signal y.

The nonlinear sensor response requires an empirical calibration between Z and the final SpO2 values

$$SpO2 = (-45.06*Z + 30.354)*Z + 94.845$$

$$Z = \frac{AC_R / DC_R}{AC_{IR} / DC_{IR}} \qquad Z = \frac{RMS(y)_R / \langle Y_R \rangle}{RMS(y)_{IR} / \langle Y_{IR} \rangle}$$


ThingSpeak
How to Buy
192.168.1.6:1 (pi's X desktop (raspberrypi:1)) - VNC Viewer
Thonny - /home/pi/...
File Edit View Run Tools Help
15:01
Trash
main.py
heartrate_monitor.py
from heartrate_monitor import HeartRateMonitor
import time
import argparse
parser = argparse.ArgumentParser(description="Read and print
parser.add_argument("-r", "--raw", action="store_true",
help="print raw data instead of calculati
parser.add_argument("-t", "--time", type=int, default=30,
help="duration in seconds to read from se
args = parser.parse_args()
Shell
Python 3.9.2 (/usr/bin/python3)
>>> %Run main.py
sensor starting...
IMU1.py
Python 3.9.2



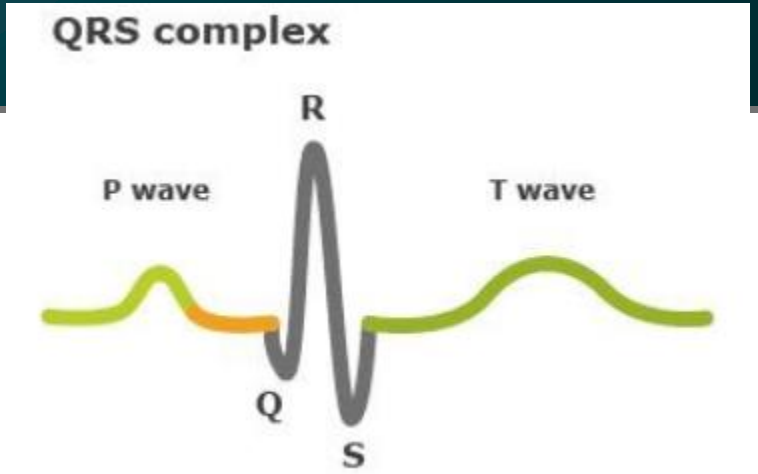
ELECTROCARDIOGRAM (ECG)

ELECTROCARDIOGRAM (ECG)

An electrocardiogram (ECG) is a simple test that can be used to check your heart's rhythm and electrical activity. Sensors attached to the skin are used to detect the electrical signals produced by your heart each time it beats.

WHAT DOES AN ECG SHOW?

If the heart is beating steadily, it will produce the typical ECG pattern: The first peak (P wave) shows how the electrical impulse (excitation) spreads across the two atria of the heart. The atria contract (squeeze), pumping blood into the ventricles, and then immediately relax. The electrical impulse then reaches the ventricles. This can be seen in the Q, R and S waves of the ECG, which is called the QRS complex. The ventricles contract. Then the T wave shows that the electrical impulse has stopped spreading, and the ventricles relax once again.

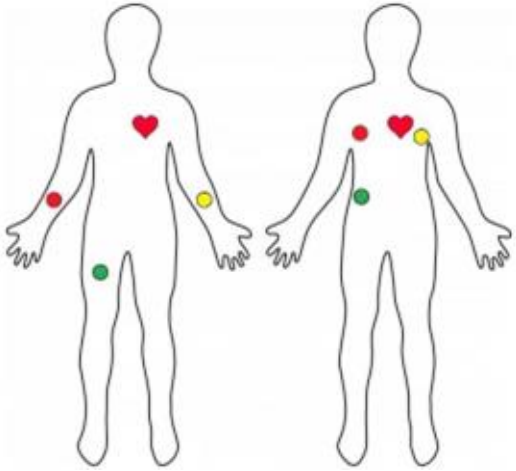


TYPES OF ECG TESTS

Resting ECG: This involves lying still on your back with a bare chest.

Exercise ECG: Here the electrical activity of your heart is measured while you are physically active.

Holter monitor: The electrical activity of the heart is typically recorded over a period of 24 hours. Three or four electrodes are attached to your chest.



PIN DESCRIPTION OF AD8232 ECG MODULE

FEATURES

Fully integrated single-lead ECG front end

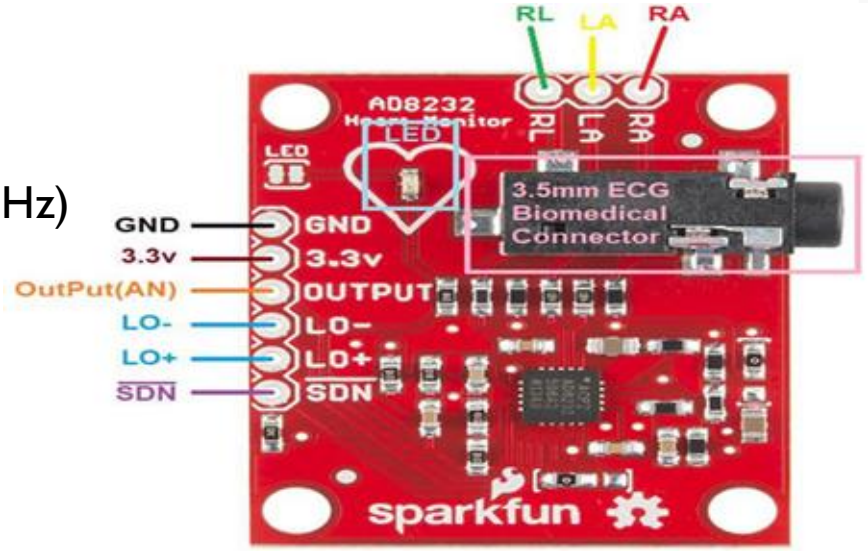
Common-mode rejection ratio: 80 dB (dc to 60 Hz)

Two or three-electrode configurations

Single-supply operation: 2.0 V to 3.5

Fast restore feature improves filter settling

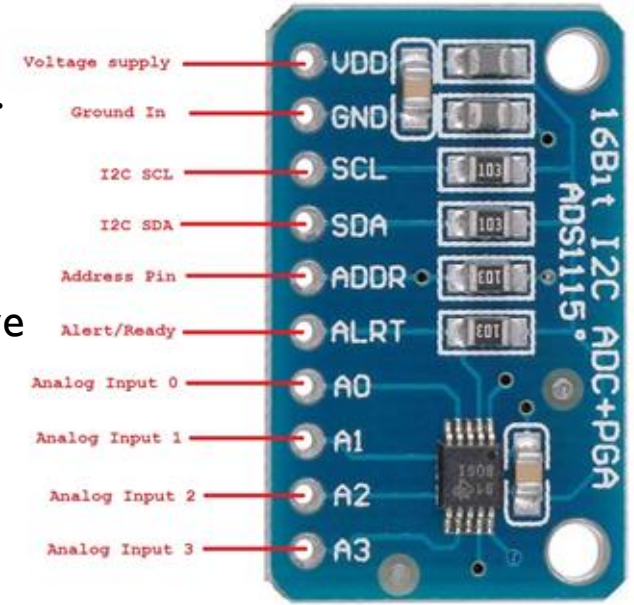
Size: 3.5cm x 3cm

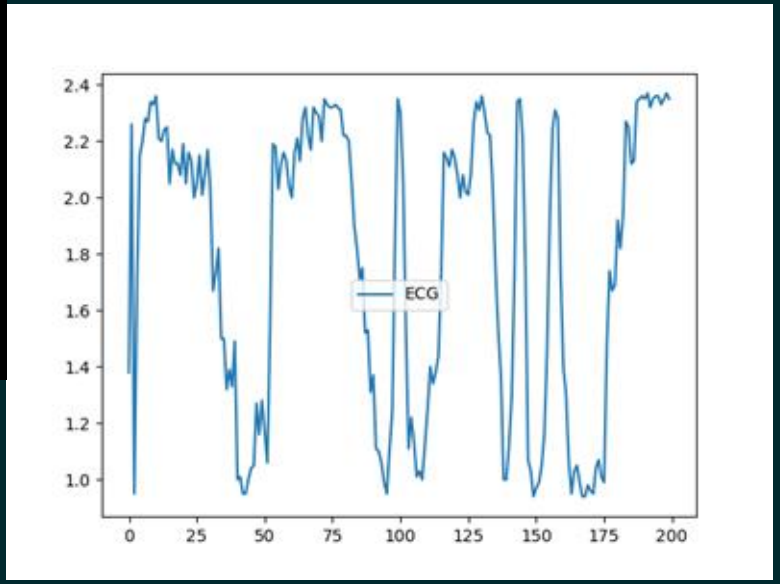


PIN DESCRIPTION OF ADS1115 MODULE

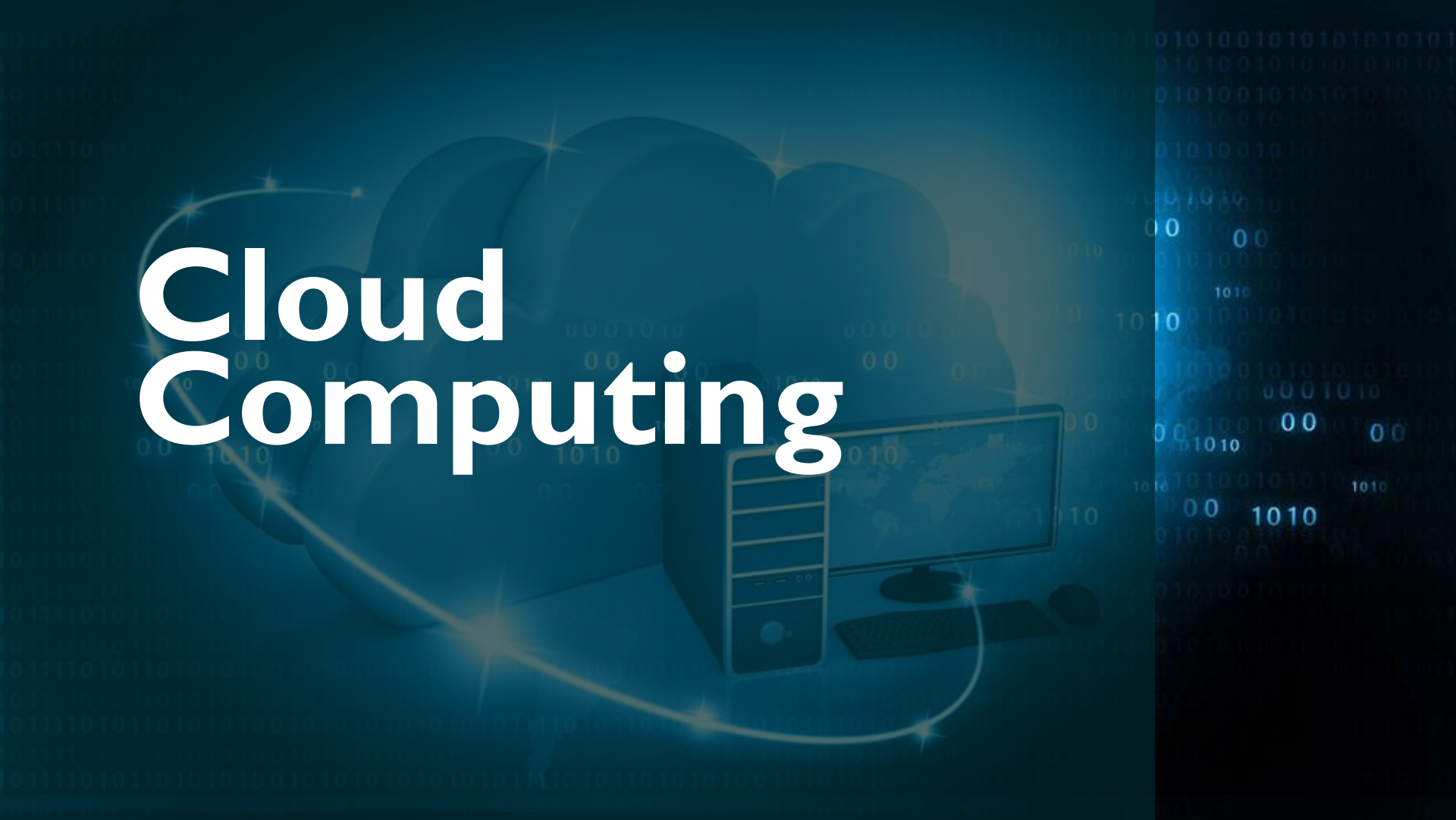
FEATURES

- An ultra-small package with a dimension of 2 x 1.5 x 0.4 mm.
- Two differential inputs.
- The device initializes when the power comes up.
- Digital acquisition output ranges from 0 to 32767 for positive and 32768 to 65535 for negative.
- Minimal consumption power of 150uA.
- The operating temperature ranges from -400C to +1250C.




2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
ECG
0
25
50
75
100
125
150
175
200

Cloud Computing



Cloud Networking

On-premise

Cloud

Cloud Computing

Instead of installing software on your computer, you access the platform online

Cloud Computing

Provides infrastructure components such as servers, storage, networking, security.

Cloud Computing

Provides computing platforms such as operating systems, programming language execution environments, databases, and web servers.

Cloud Computing

Serverless Computing

IoT Clouds

Blynk

- Controls RPi and NodeMCU via the Internet.
- Controls hardware remotely and displays sensor data.

ThingSpeak

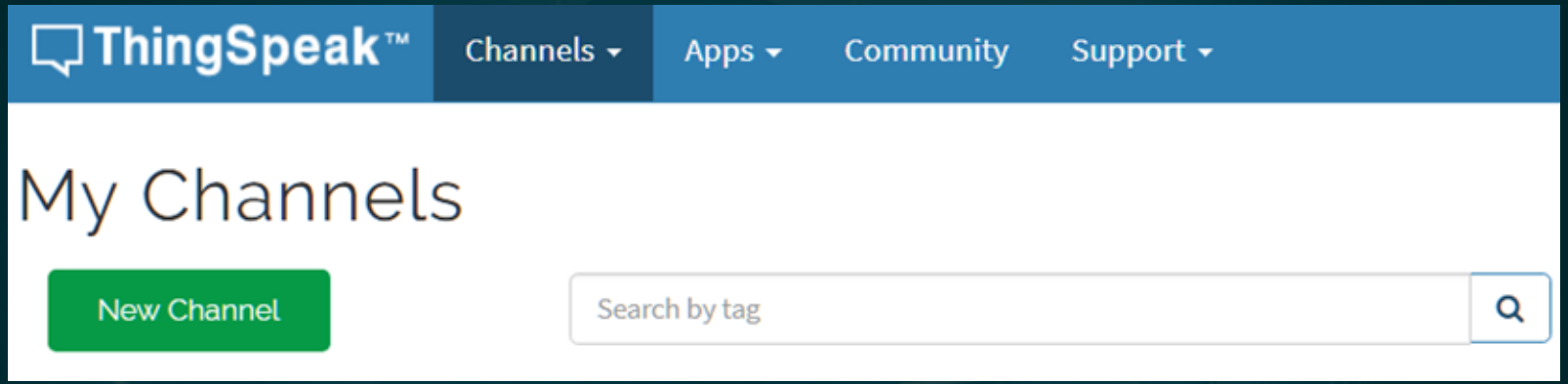
- Collects and stores sensor data to the cloud.
- Provides the app to analyze and visualize data in MATLAB.
- Creates a separate channel to store data.

IFTTT

- Helps in connecting different apps and devices with each other and causes automated actions.

ThingSpeak

- Device
- Analysis
- Cloud



A channel stores the data sent to ThingSpeak:

- 8 fields for storing data of any type.
- 3 location fields.
- 1 status field.

Channel Settings

Percentage complete	50%
Channel ID	1680330
Name	Patient 1
Description	Patient ID: Address

Write API Key

Key	EGGDD5XE4A35W6MB

Field 1	Temperature	☑
Field 2	Heart rate	☑
Field 3	SPO2	☑
Field 4	ECG	☑
Field 5	Fall detection	☑
Field 6		☐

GET Request

```
baseURL = 'http://api.thingspeak.com/update?api_key=EGGDD5XE4A35W6MB'
```

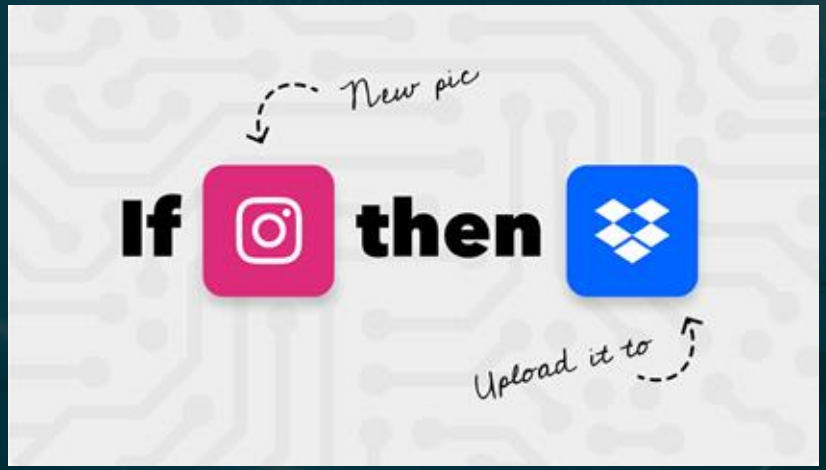
```
finalurl = baseURL +"&field4=%s" %(temperature)
```

```
f = http.request('GET',finalurl)
```

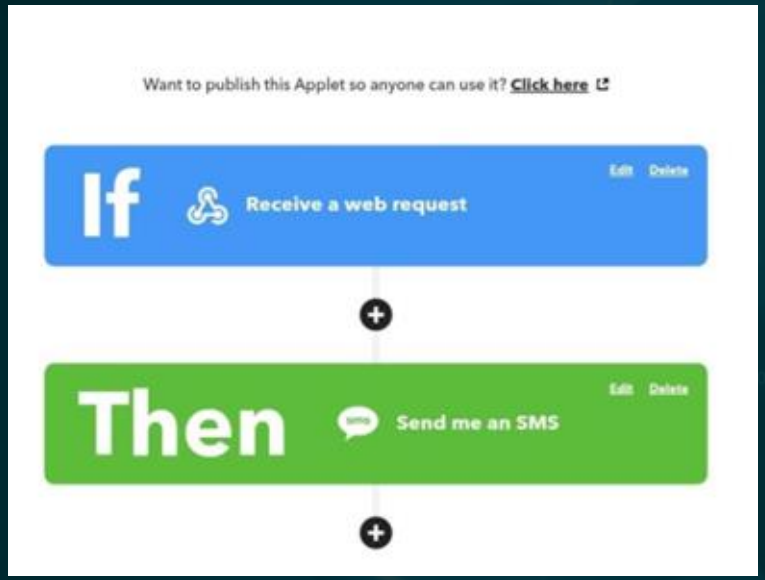
IFTTT

IF This Then That

"This" → Primary Application
"That" → Secondary Application



IFTTT


Want to publish this Applet so anyone can use it? Click here
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eng.fatmamohamed48@gmail.com
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FALL DETECTION SYSTEM

CONCEPT

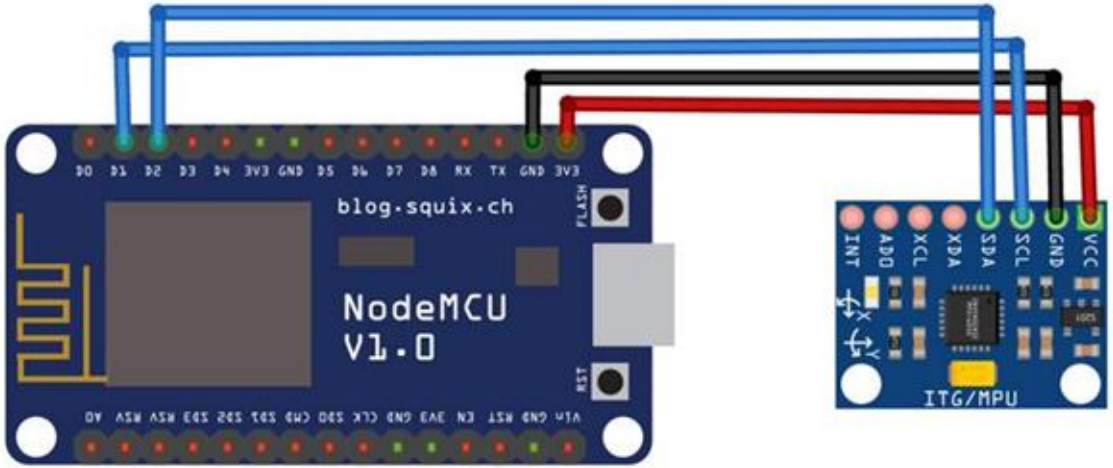
Sensor technology

Fall detection

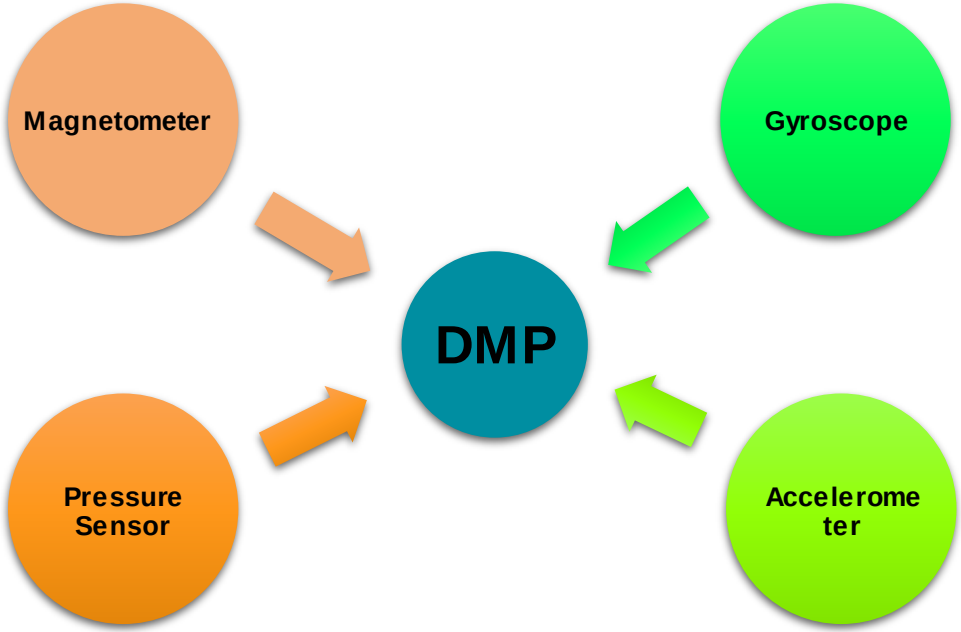
Urgent response

HARDWARE IMPLEMENTATION

Sensor Technology



INERTIAL MEASUREMENT UNIT (IMU)



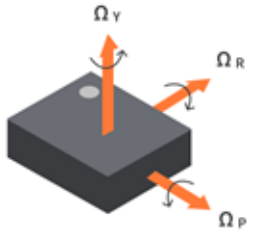
GYROSCOPE & ACCELEROMETER

Gyroscope is used to measure the angular velocity.

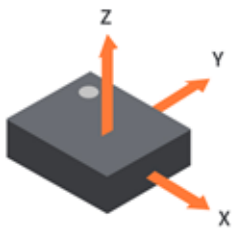
Accelerometer is used to measure linear acceleration.

Both use similar concept where depending on the motion causes a small mass to move relative to fixed plates.

This motion causes a change in capacitance which is used for the required measurements.



Gyroscope sensing
Angular orientation



Accelerometer sensing
axis orientation

PROGRAM CONCEPT

Fall Detection

Trigger 1	Trigger 2	Trigger 3
• **Person Breaks Lower Threshold**	• **Person Breaks Upper Threshold**	• **Large Orientation Change**

TRIGGER 1

This Trigger is the normal case where a person is moving with slow or no acceleration

Trigger 1 should be active almost all of the time

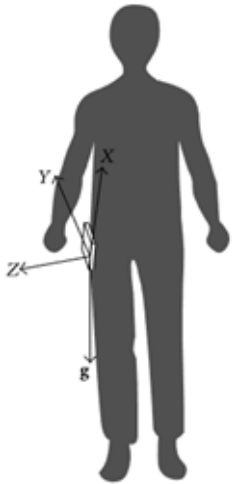
TRIGGER 2

This Trigger activates when the upper threshold is exceeded which mean there is a sudden change in velocity (High Acceleration)

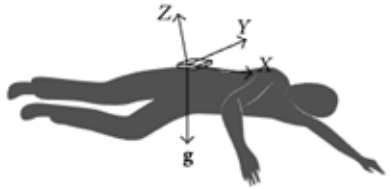
As when a person is falling their velocity increases due to gravity

TRIGGER 3

A change in acceleration is not enough to detect a fall.
When Trigger 2 activates it's required to check if the orientation has changed.
If there is a big change in orientation Trigger 3 activates
If the orientation doesn't change after Trigger 3 is activated , Fall is detected



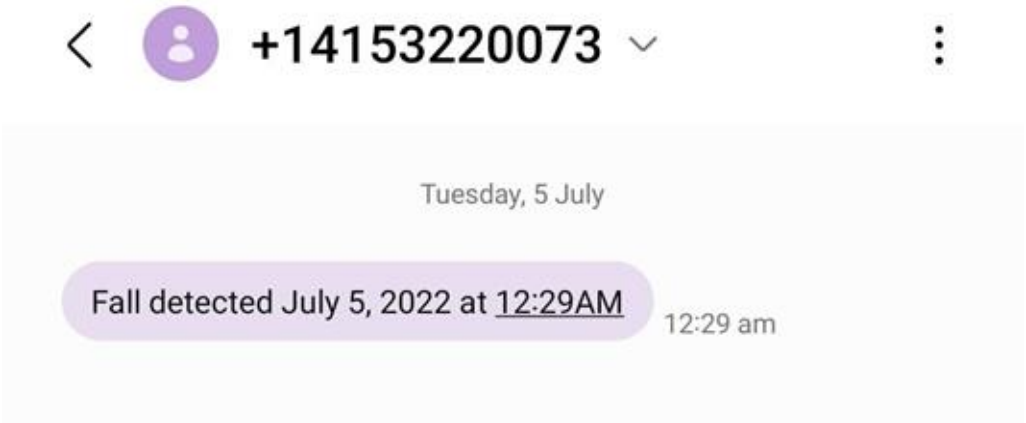
(a)



(b)

SMS MESSAGE

Urgent Response



Mobile Application

Sequence of Operation

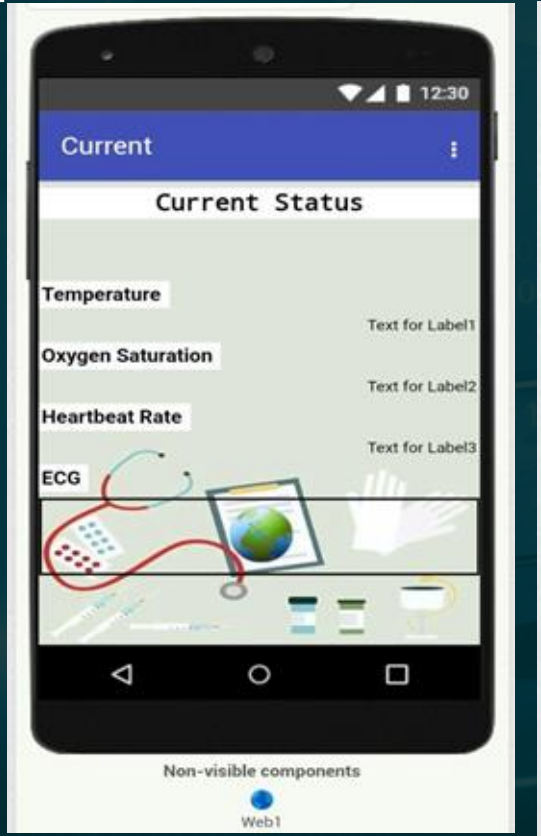
Local Unit
Raspberry Pi

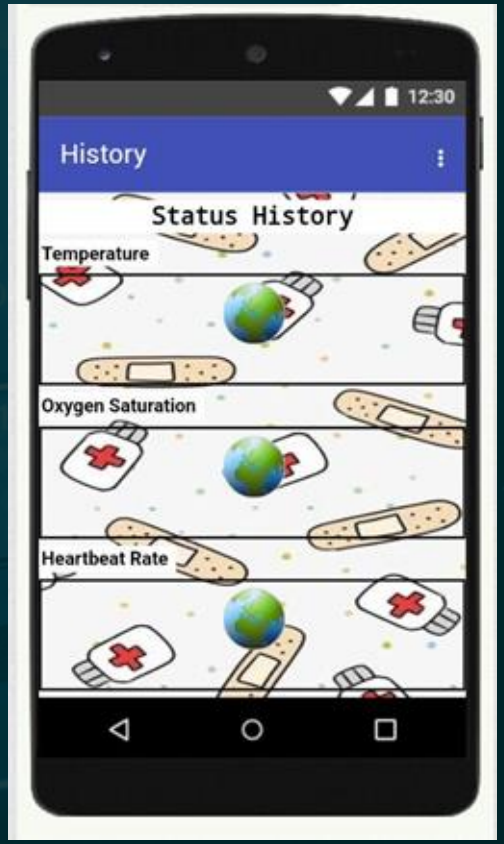
Cloud
ThingSpeak

Application
MIT App Inventor

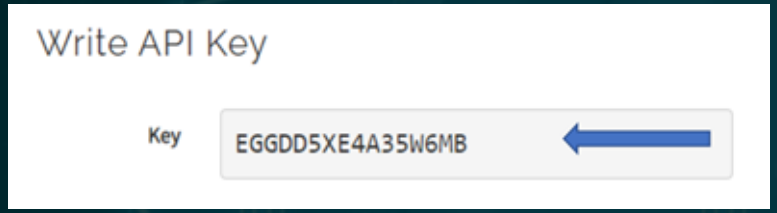
MIT App Screens

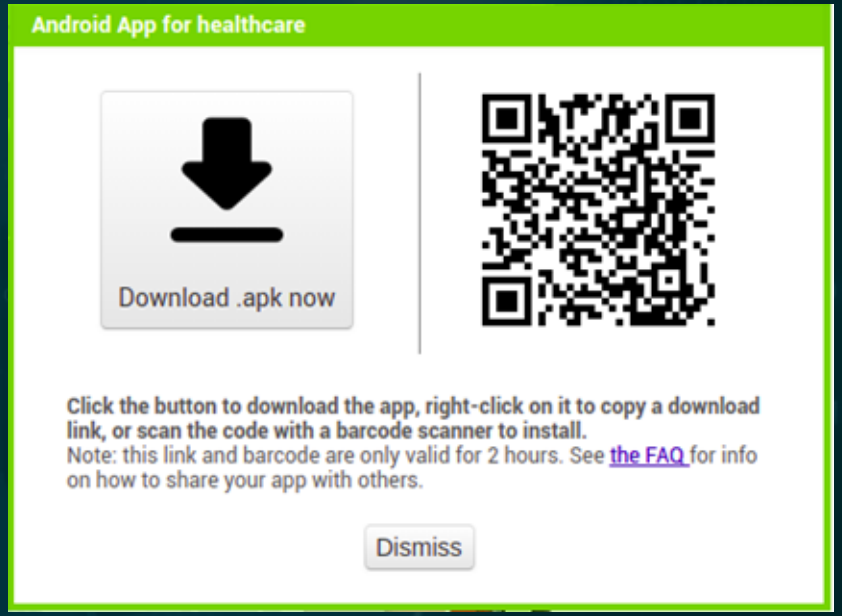
MIT App Screens



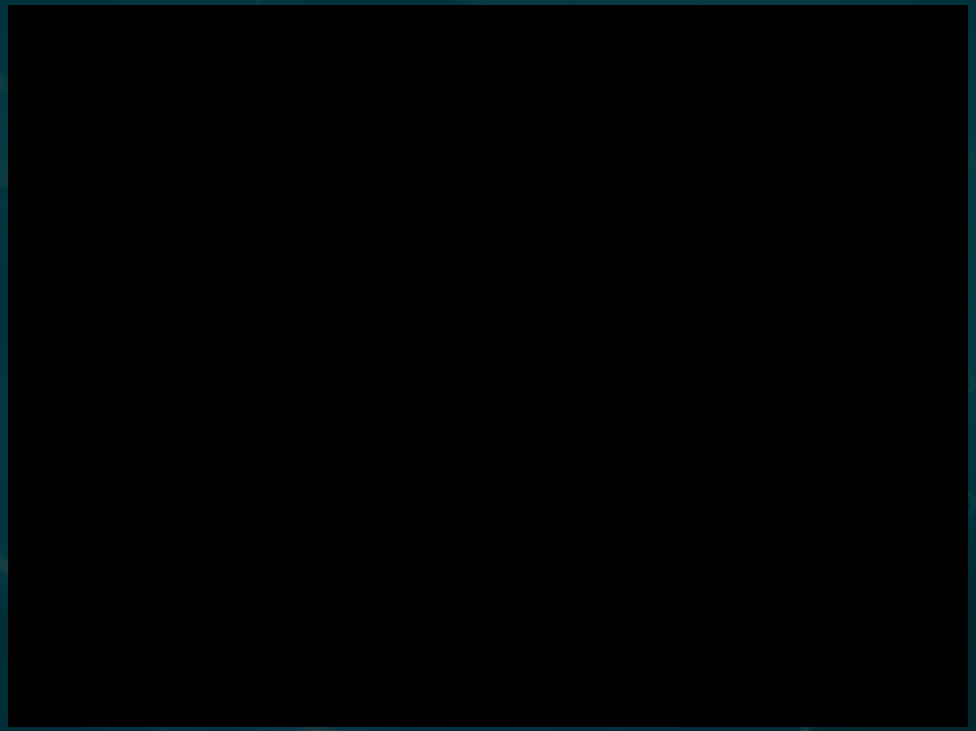


MIT App Download





MIT App




FUTURE WORK

REASONS FOR THINKING OF A FUTURE PLAN

Regarding our device

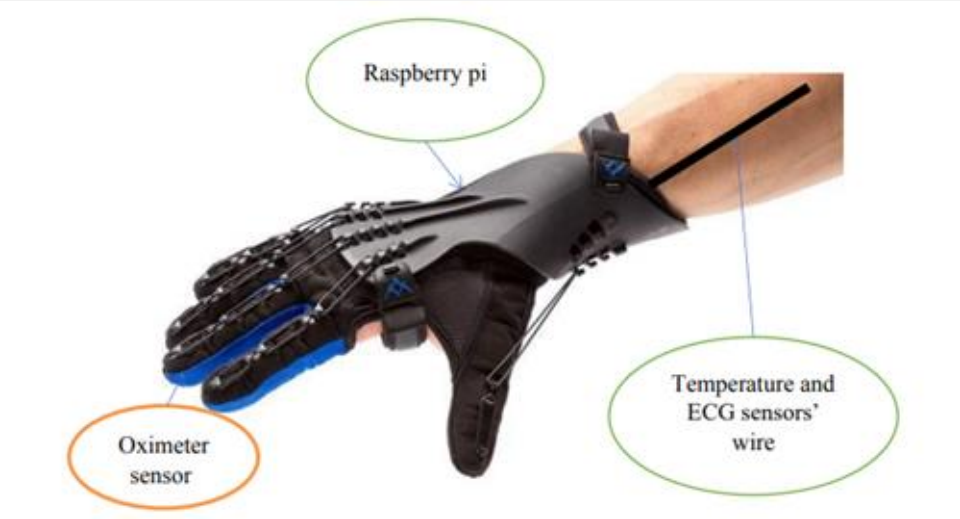
- The device still in its first stages, it needs to be upgraded as it can't be used directly in its current state because it's still not a real product that can be sold in markets.

Regarding patients and doctors

- To facilitate the communication link between the doctor and his patient, and that's will help patient to reach his doctor easily whenever he wants, on the other hand it will help doctor to be aware of his patient's condition so he can intervene at the right time if an urgent thing happens.

FUTURE WORK OF THE DEVICE

According to the reason we mentioned regarding upgrading our device, we came up with this idea which is a ***glove***.



FUTURE WORK OF FALL DETECTION

Placing the module around the patient's leg where it’s placed inside a box where the patient can wrap it around their leg and remove it easily whenever they want, This requires further calibration

AVAILABILITY OF THE DEVICE

When connecting our device to ***ThingSpeak*** cloud, each patient can have their own channel, where each channel has a specific API key, which means that each patient has a unique API key.

Problem

- Our device has only one API key which means the device was made for just single patient and can't be used by any other patients.
- if there are two patients living in the same home, they have to buy two devices because both of them can't use the same device.

Solution

- When a patient uses the device, They inserts their own API key which leads them to their own channel.
- Using mobile application, each patient will have their own username and password which are connected somehow to their own generated API key that leads them to their own channel, so then they can reach their data easily.

ACCESSIBILITY OF PATIENTS WITHIN DOCTORS

With the help of ThingSpeak, we've succeeded to create communication link between patients and doctors, which ease on patients to have a backup for all their readings where they can take a look at them whenever they like to, on the other hand it ease on doctors as well to take a look at all the patient's reading through a specific period of time to detect whether this patient's condition is stable or do they need an urgent visit to the hospital.

FUTURE APP FEATURES

In our future plan we are thinking of upgrading the application where:

- The patient can choose any hospital they would like to pursue their health state with, they can also choose a specific doctor who they would prefer to interact with according to ***rating system***.
- By linking this application with *ThingSpeak*, the doctor can make a priority list of patients they need to visit first according to their medical state by checking the readings saved on their channel.

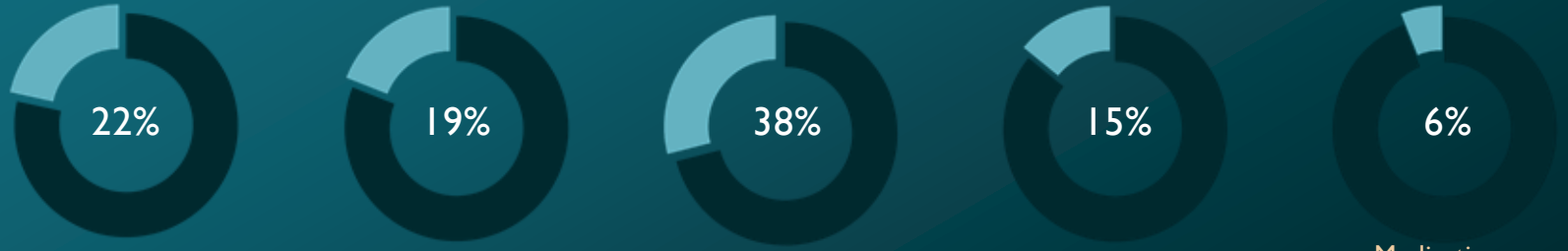
RATING SYSTEM

Adding rating feature for every doctor in each hospital, so when a patient interacts with a doctor, they can give them a rating depending on whether this doctor was good or bad, and this will help other patients who have no idea about any doctors' qualifications or their social skills with patients to choose depending on this rating.


BUSINESS PLAN

MARKET LANDSCAPE

The Internet of Things (IoT) in Healthcare market was valued at US Dollar 46.44 billion in 2020 and is expected to reach US Dollar 89.6 billion by 2026*



Cisco IoT Healthcare

Siemens

Philips Healthcare

IBM Watson

Oracle Healthcare Cloud

Qualcomm IoT Healthcare

*Based on Mordor intelligence https://www.mordorintelligence.com/industry-reports/internet-of-things-in-healthcare-market

	Price	Cloud Synchronization	Fall detection	Pulse Oximetry	Heart rate	ECG	Body Temperature	
	$199 + $50/month	✓	✓	✓	✓	✓	✓	Our Product
	$50 + $50/month		✓					HomeSafe with AutoAlet(2)
	$299 + month subscription				✓		✓	TytoCare Medical Exam Kit(3)
	$759			✓	✓	✓	✓	MD09X Wrist Multi-Parametrs(1)

(1) MD09X Wrist Multi-Parameters and Individual Parameter Patient Monitor - Orthopedic Drills & Medical Devices
(2) HomeSafe with AutoAlert | Philips Lifeline ®
(3) TytoCare Medical Exam Kit

SWOT Analysis

	Strengths	Weaknesses	Opportunities	Threats
Product/ Service Offering	-Synchronized monitoring over cloud -More features than other products	-Intranet -Wired device -Batteries	-International growth in smart healthcare -Space for developing	-Fast developing in tech.
Brand/ Marketing	-Website, social media accounts and YouTube channel explaining usability of device and answering user enquires.	-Huge fund to create brand positioning	-Need of market for Smart Healthcare system -Due to Covid19 it's a need	-Easy of imitation from competitors
Finance	-Lower than average market prices by 15%	-Big investment is need	-There is a direction by governments and companies to invest in healthcare	-Recession and wars
Market				-Environmental and governmental restrictions

OUR TEAM

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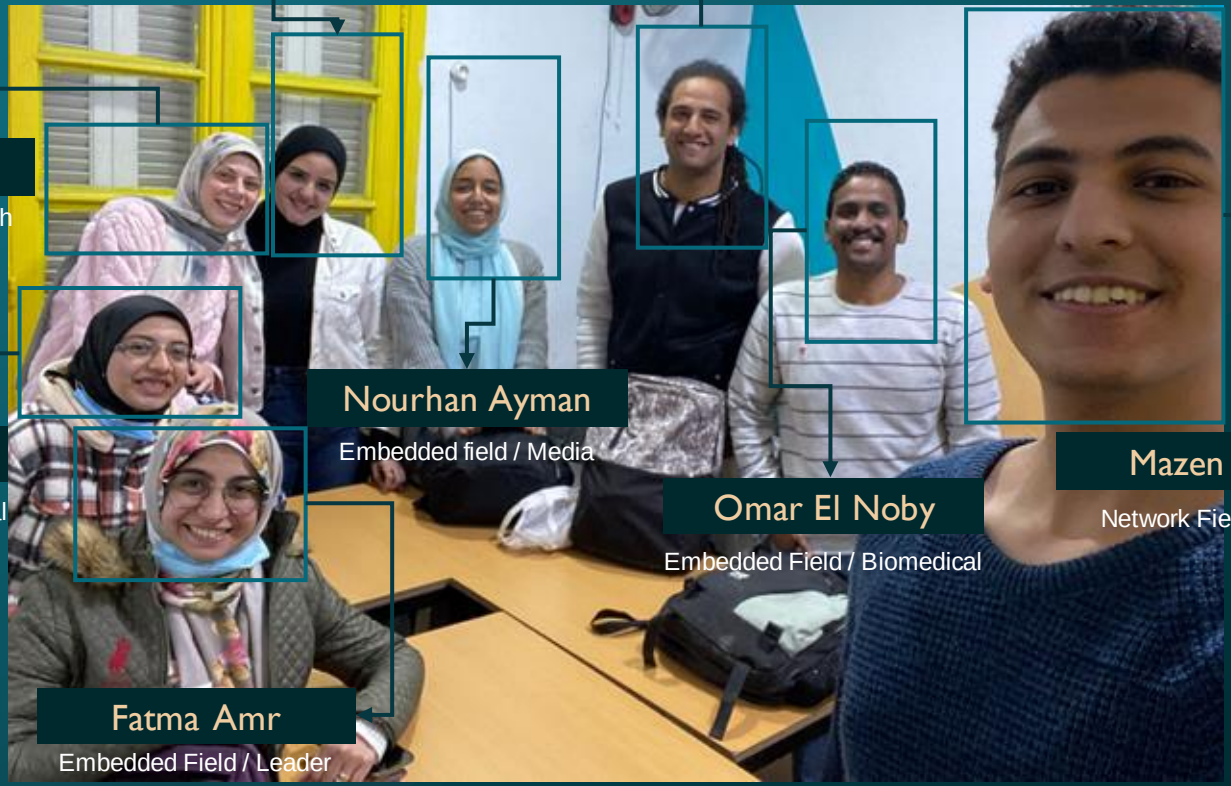
Network Field / Documentation

Bassam Hagag
Network Field / Business

Fatma Mohamed
Network Field / Research



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Mazen Adel
Network Field / Budget

Fatma Amr
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THANK YOU!