UNIVERSIDAD POLITECNICA DE VALENCIA

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IGIC
Instituto de investigación para la gestión integrada de zonas costeras

DEPARTAMENTO DE COMUNICACIONES

Modern Technologies for Closing Farmers to Precision Agriculture

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IARIA

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Short Bio

Dr. Sandra Sendra (sansenco@upv.es) received her degree of Technical Engineering in Telecommunications in 2007. She received her M.Sc. of Electronic Systems Engineering in 2009 and her Ph.D. in electronic engineering (Dr. Ing.) in 2013. Currently, she is an associate professor at the Polytechnic University of Valencia (Spain). She is Cisco Certified Network Associate Instructor since 2009 and HP-ATA instructor since 2015. She is chair of the Membership development section inside the IEEE Spain Section for the term 2022-2023 and she has been vocal inside the IEEE Spain Section for the term 2020-2021, and active member inside the IEEE WIE Spain for the term 2016-2018. She has authored 6 book chapters and 2 books. She has more than 145 research papers published in national and international conferences, international journals (more than 55 with JCR – Impact index Clarivate Analytics). She has been the co-editor of 10 conference proceedings and guest editor of several international journals.

She is guest editor in several SI in International Journals related to underwater communications, sensors and actuator networks. She has been associate editor in 6 international journals: “Network Protocols and Algorithms”, “International Journal On Advances in Intelligent Systems”, “International Journal On Advances in Networks and Services”, “International Journal On Advances in Telecommunications”, “Designs”, “Signals” She has been involved in more than 120 Program committees of international conferences, and more than 50 organization and steering committees. She has been involved in 18 research projects related to the development of a WSN for environmental monitoring. She has been the general chair (or co-chair) of 4 International conferences. Her research interests, but no limited, include saving energy techniques in electronic circuits, sensor deployment, WSN, UWSN and the application of these technologies for environmental monitoring.

Our Research Group

Communications and Networks Research Group

1 Full Professor and 3 associate Professors + 7 external collaborators


Prof. Jaime Lloret


Dr. Sandra Sendra


Dr. Jesus Tomás


Dr. Oscar Romero

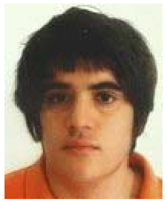
3 Postdoctoral Students


Dr. Jose M. Jiménez


Dr. Laura Garcia


Dr. Lorena Parra

5 Ph.D. Students + 2 jr. Researchers


PhD.
Javier Rocher


PhD.
Sandra Viciano


PhD.
Ali Ahmad


PhD.
Arman


PhD.
Aika Miura


PhD.
Francisco Javier

Outline

1. Introduction
2. What do we need to develop our networks and applications?
3. Wireless Technologies for WSN and IoT
4. Digital Twins: A new tool for Precision Agriculture?
5. Examples of developed sensors and applications for precision agriculture and rural environment

Introduction

Project 1: Project GO TECNOGAR

GoTecnoGAR Tecnificación del garbanzo

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

iMiDRA Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario

area verde MG PROJECTS S.L.

QUILES AGRO SIEMPRE JUNTOS

burcol El arte de cuidarte

apag coagral

La Garbancera Madrileña

AGROSA Agroindustrial de Oleaginosas, S.A.

Plantae

VIVEROS DUBAGAN

Project 2: Project PID2020-114467RR-C33

BIOCISTUS 4.0 MONITORIZANDO LOS BIOPRODUCTOS DEL JARAL

iMiDRA Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Project 3: Project TED2021-131040B-C31

AGRICULTURE 6.0

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Funded by:

GOBIERNO DE ESPAÑA — MINISTERIO DE CIENCIA E INNOVACIÓN

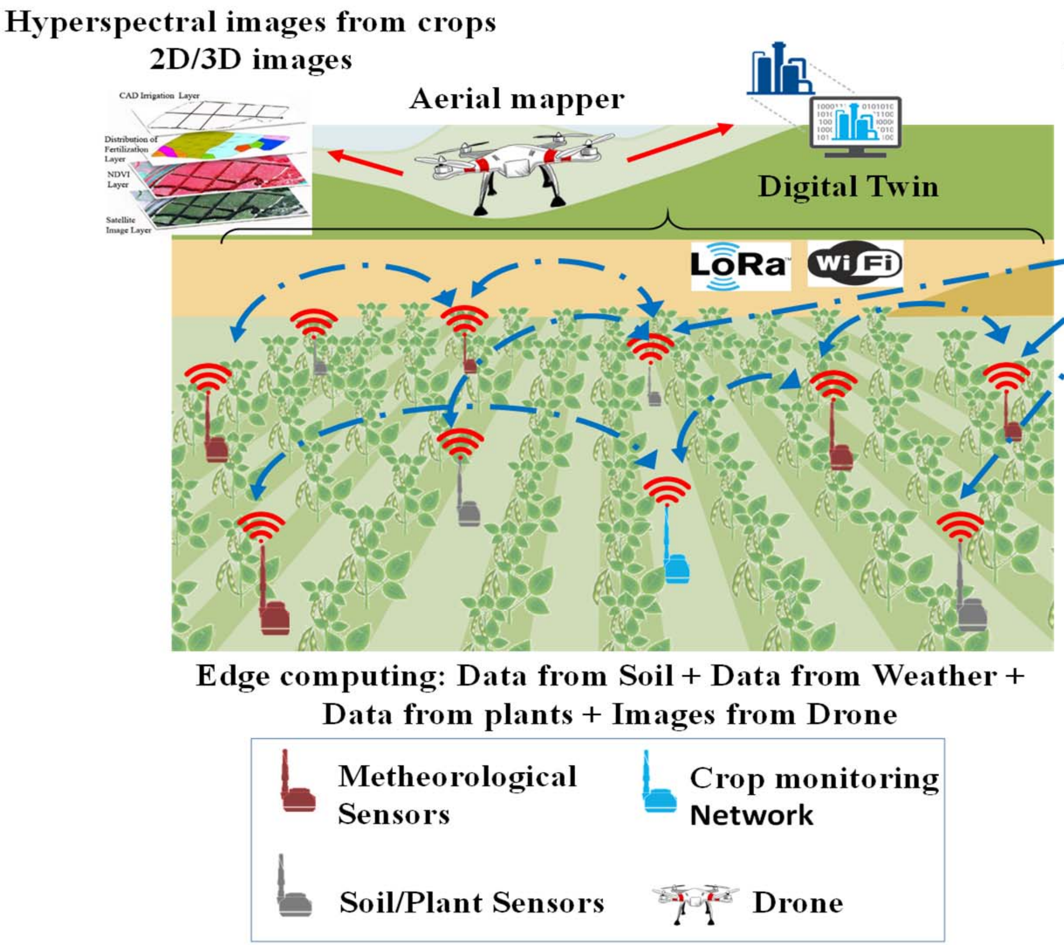
AGENCIA ESTATAL DE INVESTIGACIÓN

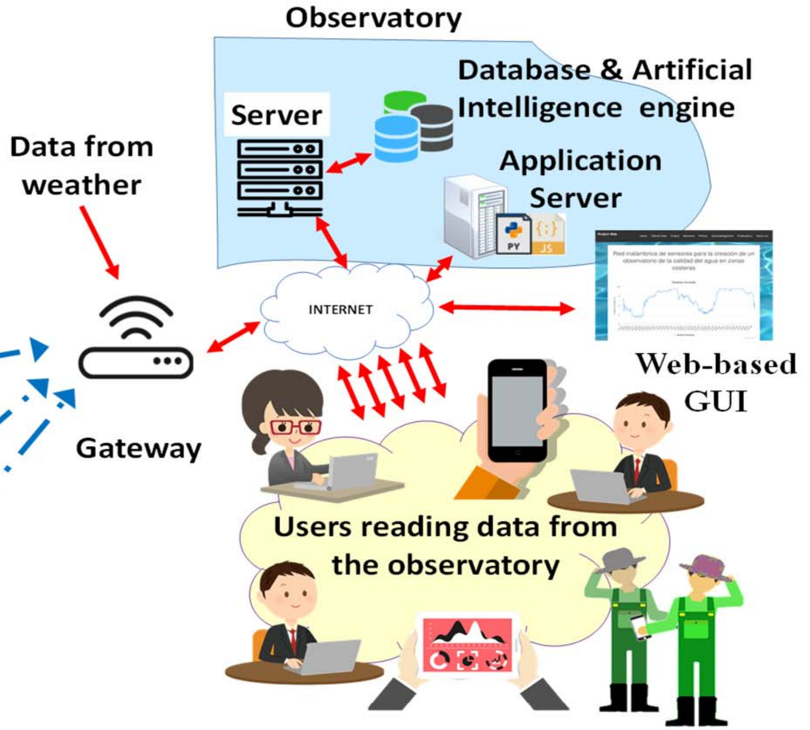
Unión Europea — Fondo Europeo Agrícola de Desarrollo Rural — Europa invierte en las zonas rurales

GOBIERNO DE ESPAÑA — MINISTERIO DE AGRICULTURA, PESCA Y ALIMENTACIÓN

PNDR Programa Nacional de Desarrollo Rural 2014-2020

Modern networks in precision agriculture

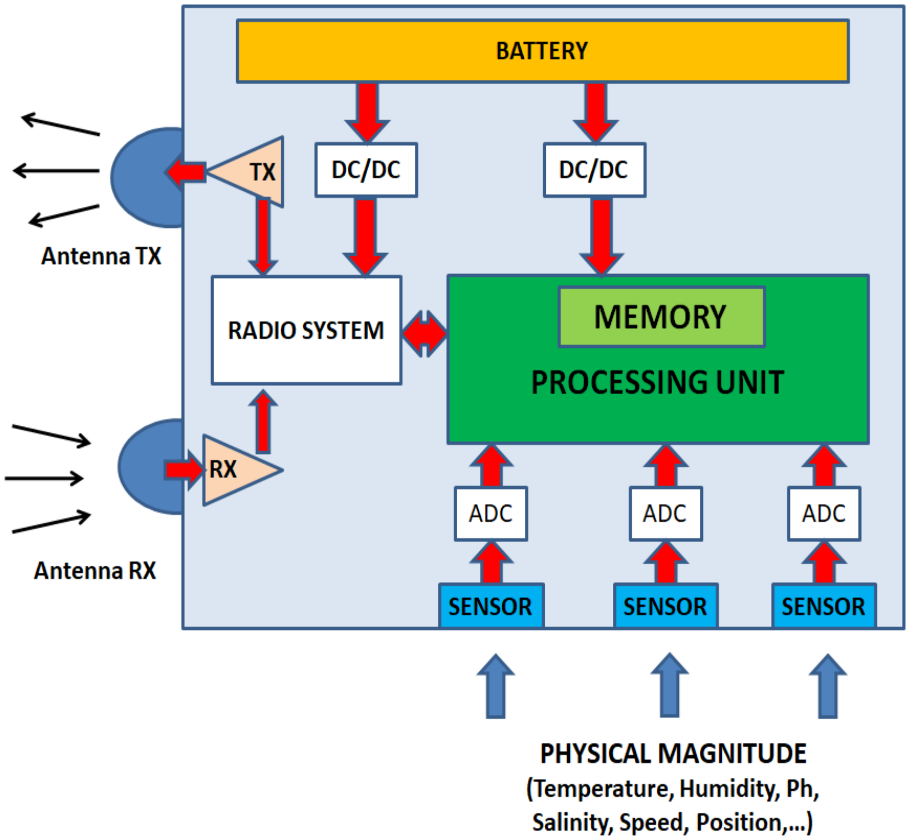




- Public entities (ministers, City hall, etc)
- Farmers.
- Companies related to farming environment.
- Reserarchers (from NGO, Universities; private companies, etc…)
- Environmental Consultancies
- Consumers
- Etc…

Introduction

What is a sensor node like?



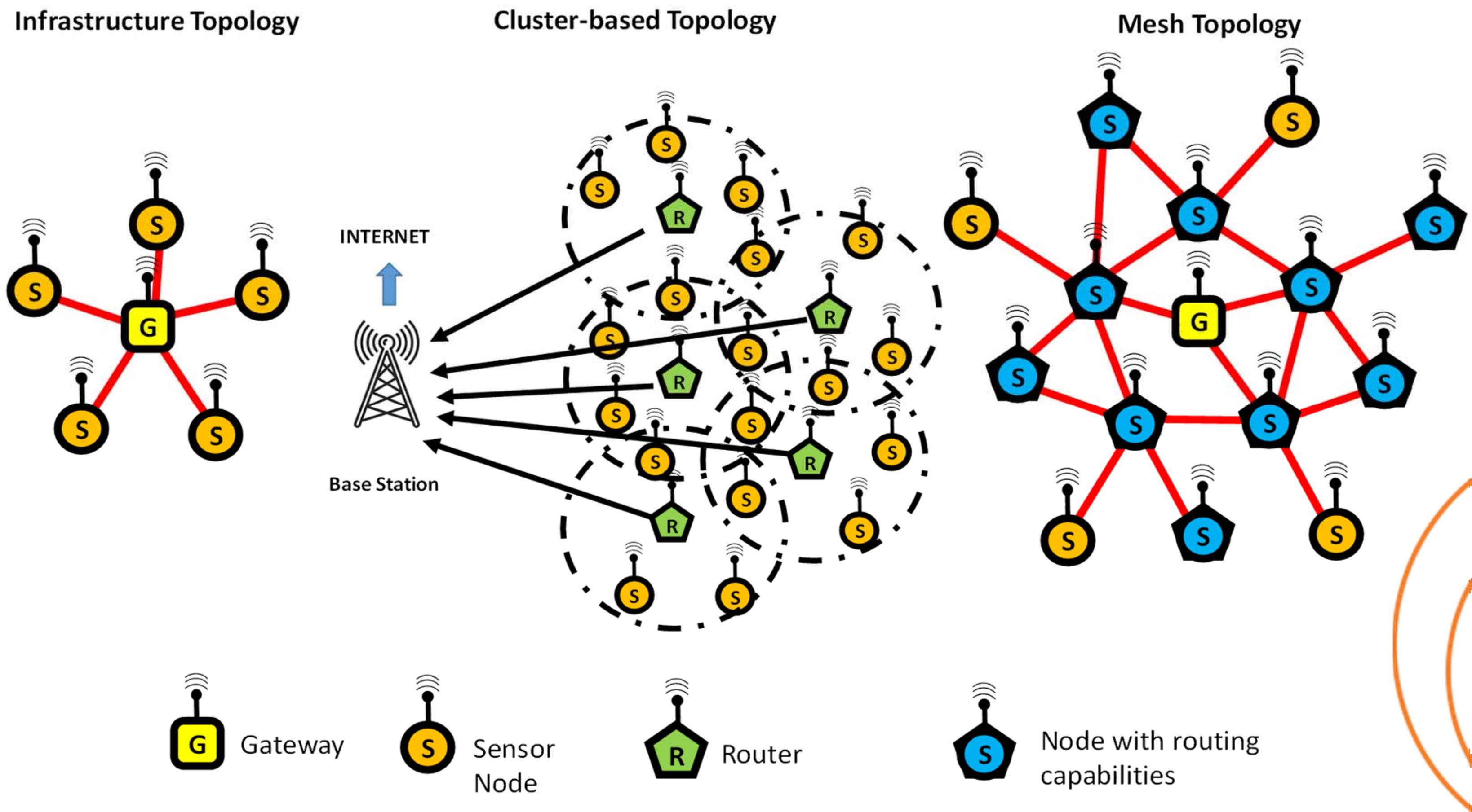
- Limitations:
  - Battery life → Sleep mode
  - Limited processing capacities.

- WSNs have self-healing and self-organizing capabilities → if a node fails, the network will find new ways to route data packets.

- The capabilities developed for WSNs were not possible with other technologies

Introduction

Topologies for efficient WSNs



Introduction

- WSNs are based on low-cost, low-power devices (nodes) that are capable of obtaining information from the environment around them.

- Tasks:
  - Collect information from the environment
  - Communicate it through wireless links to a central coordinating node or other nodes.

- Nodes can have different roles:
  - They only collect data and send to the coordination center.
  - They act as a network element to forward messages transmitted by more distant nodes to the coordination center.
  - They can be fixed or mobile.

- We measure parameters such as:
  - Temperature, air/soil humidity, vibration, pressure, movement or contaminants.

Introduction

Advantages

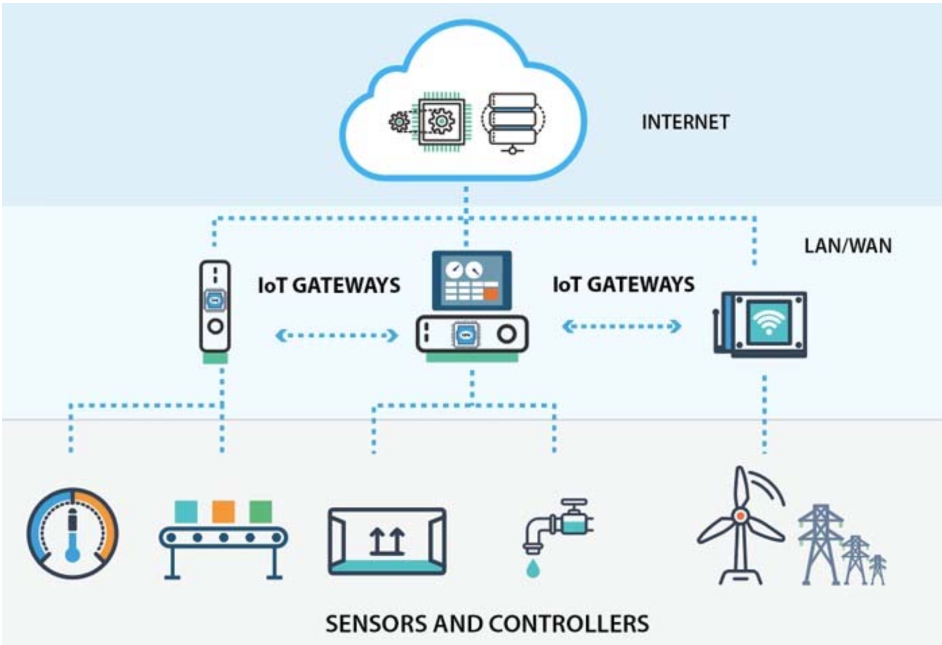
- Ease and speed of installation and deployment
- Low consumption
- Scalability
- Devices with own autonomy and without cables
- Reduced maintenance
- Remote monitoring in real time, which reports to the client optimization of resources and processes
- Versatility to adapt the system to the client's needs
- Ability to couple several sensors in a single communication node
- High capacity of self-organization and self-configuration with the rest of the nodal devices of the network, which allows the mobility of the devices.

Introduction

A step beyond WSNs, what is IoT?

- The Internet of Things (IoT) describes the network of physical objects ("things") that incorporate sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

- From common household objects to sophisticated industrial tools.

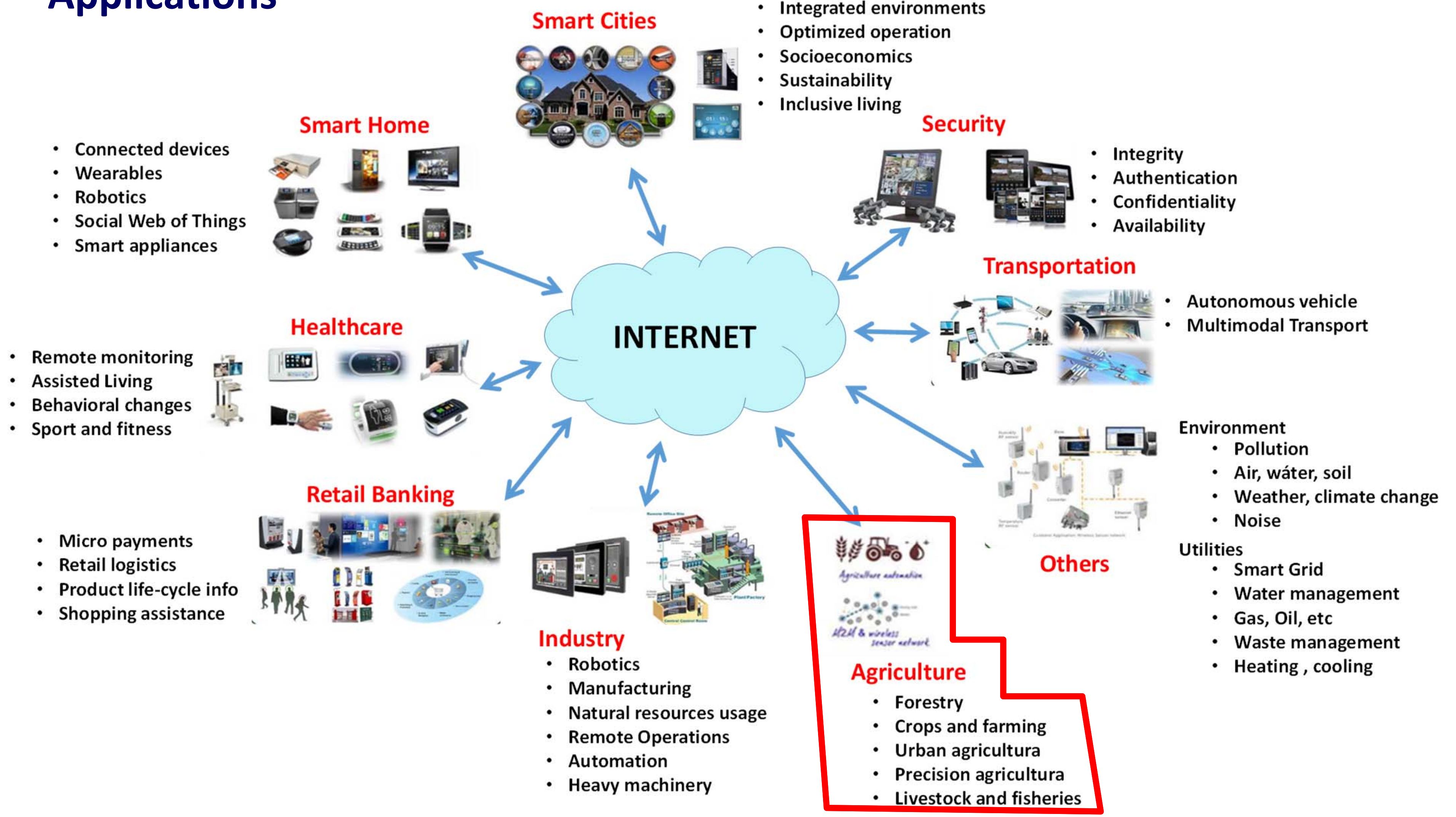


Introducción

Where does the success of WSNs and IoT lie?:

- **Cheaper communications:**
  - We have low-cost Internet access, with great coverage, etc.
  - Other new low-consumption local communications protocols (SIGFOX, LoRaWAN, etc.).
- Depending on the type of project and its requirements, some of the following strategies are being applied:
  - Use of smartphone-type multimedia devices with a direct connection to the Internet. This option supposes a high consumption of battery.
  - Use of less intelligent devices, cheaper, placed in inaccessible places and with a battery that does not last long.
- Acquire **sensors and actuators at a very low cost**: they make it possible to create our own projects in a simple way.
- **IoT platform:** application responsible for receiving the information from all the sensors, processing it, applying the necessary logic, and triggering a response.
  - Develop an app by ourselves
  - Use existing applications in the market.

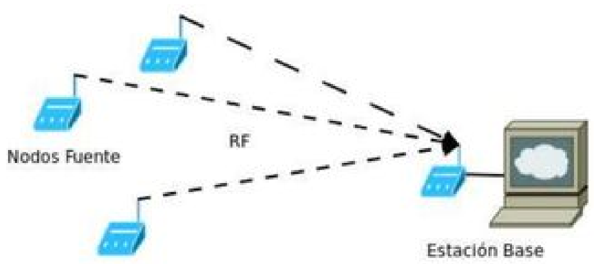
Applications

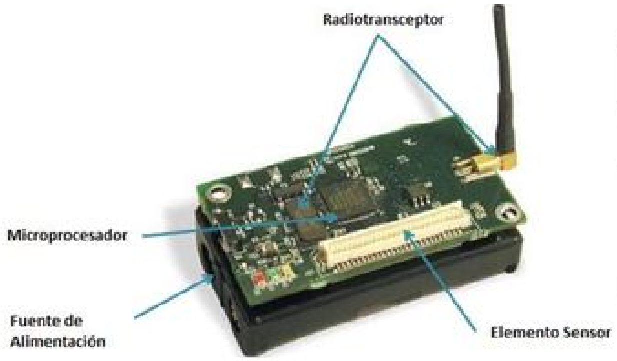


What do we need to develop our networks and applications?

Devices

WSNs or IoT solutions → **Nodes** → **Applications**





Modules to develop IoT solutions for Precision Agriculture

Devices

Rapid prototyping boards

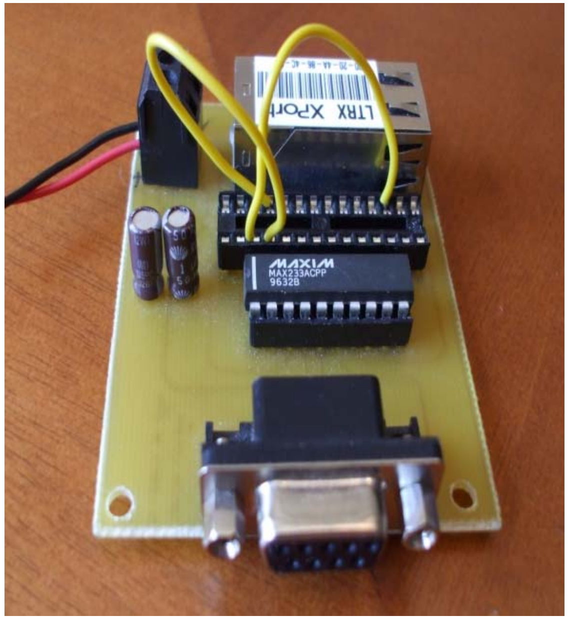
- Rapid prototyping boards or microprocessors have become popular due to their low cost and ease of use, allowing an idea to be quickly turned into a prototype.

ARDUINO

Raspberry Pi

Devices

WiFi modules for IoT - Customized Modules

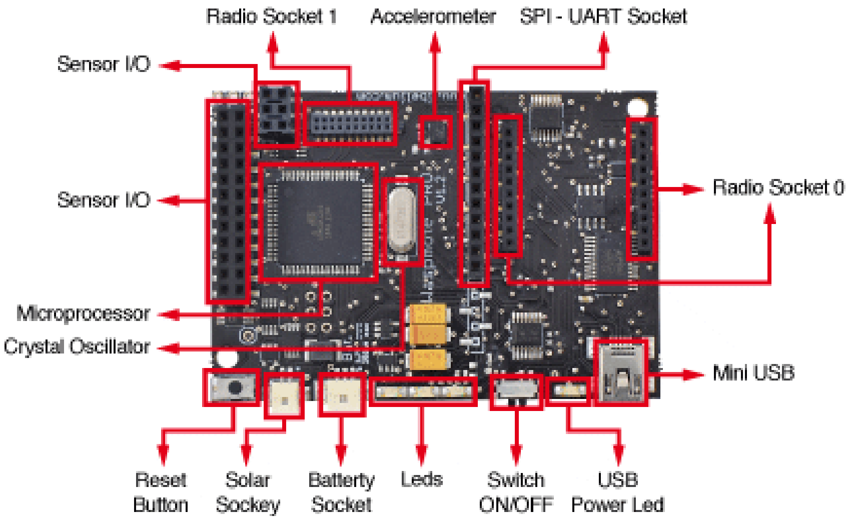


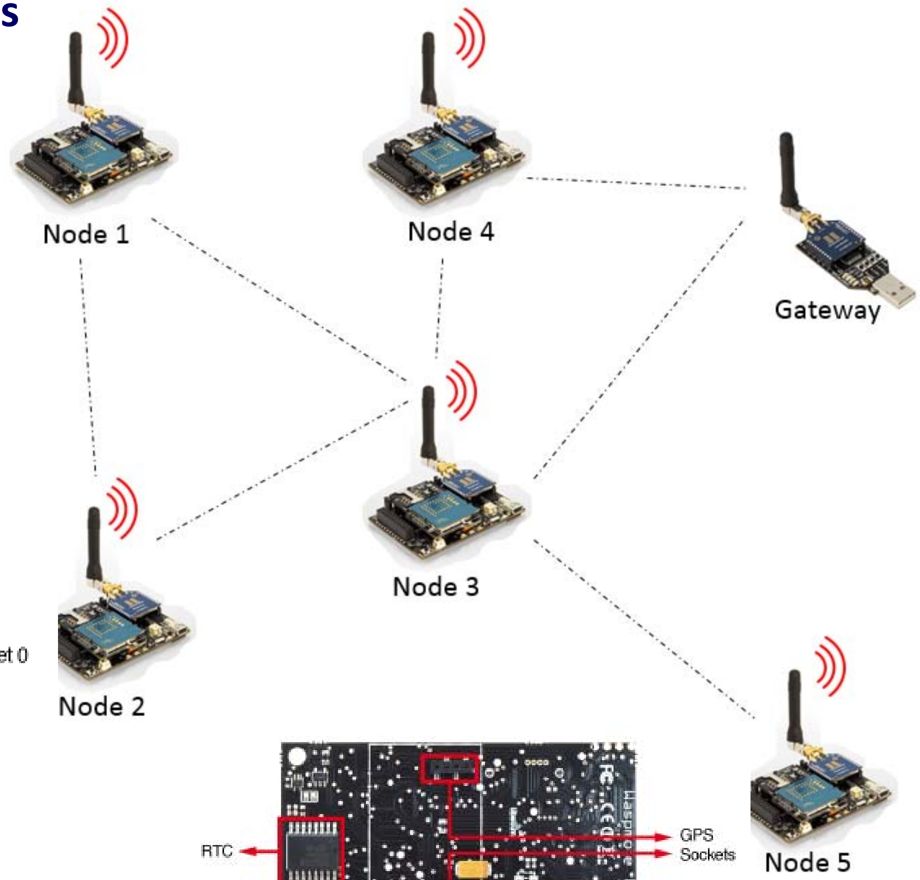
XPort and Matchport, by Lantronix

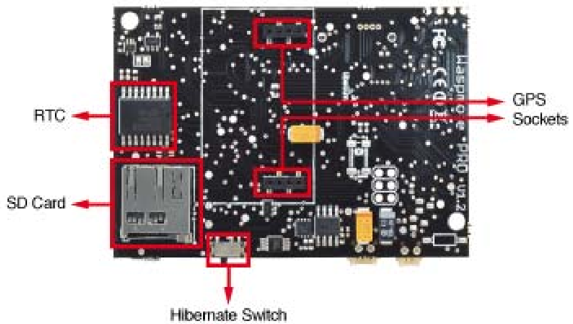
Devices

WiFi modules for IoT - Commercial Modules

Waspmote (Libelium)



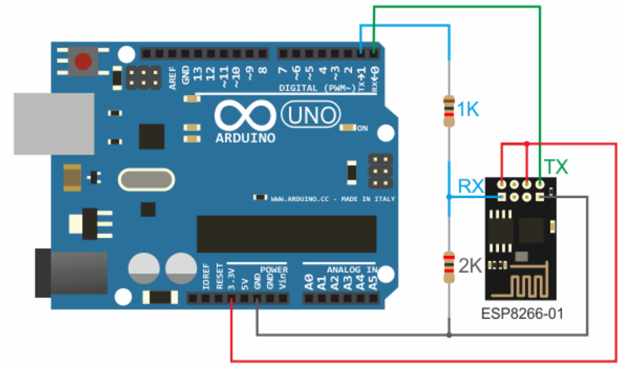




Devices

WiFi modules for IoT - Commercial Modules

8266- ESP01



ENTRY LEVEL	UNO, LEONARDO, 101, ESPLORA, MICRO, NANO, MINI, MKR2UNO ADAPTER, STARTER KIT, LCD SCREEN
ENHANCED FEATURES	MEGA, ZERO, DUE, MEGA ADK, M0, M0 PRO, MKR ZERO, MOTOR SHIELD, USB HOST SHIELD, PROTO SHIELD, MKR PROTO SHIELD, 4 RELAYS SHIELD, MEGA PROTO SHIELD, MKR RELAY PROTO SHIELD, ISP, USB2SERIAL MICRO, USB2SERIAL CONVERTER
INTERNET OF THINGS	YÚN, ETHERNET, TIAN, INDUSTRIAL 101, LEONARDO ETH, MKR FOX 1200, MKR WAN 1300, MKR GSM 1400, MKR1000, YUN MINI, YÚN SHIELD, WIRELESS SD SHIELD, WIRELESS PROTO SHIELD, ETHERNET SHIELD V2, GSM SHIELD V2, MKR IoT BUNDLE

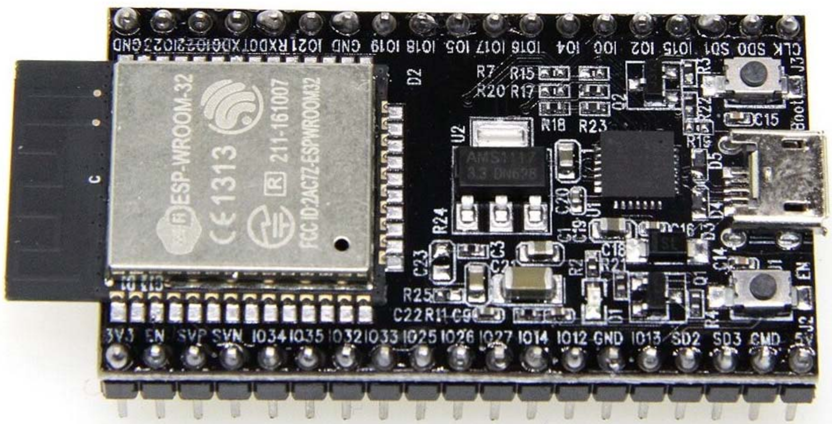
Devices

WiFi modules for IoT - Commercial Modules

ESP32 WiFi + Bluetooth Ultra-Low power consumption

Dual Core ESP-32S ESP32 ESP8266

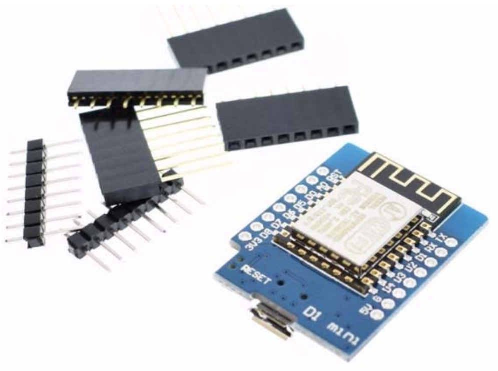
http://espressif.com/en/products/hardware/esp32-devkitc/overview

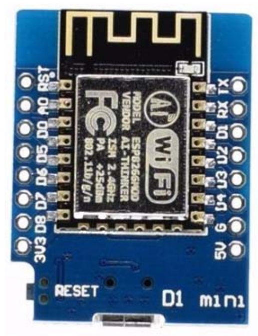


Devices

WiFi modules for IoT - Commercial Modules

D1 mini-Mini NodeMcu 4Mbytes ESP8266 Lua WIFI



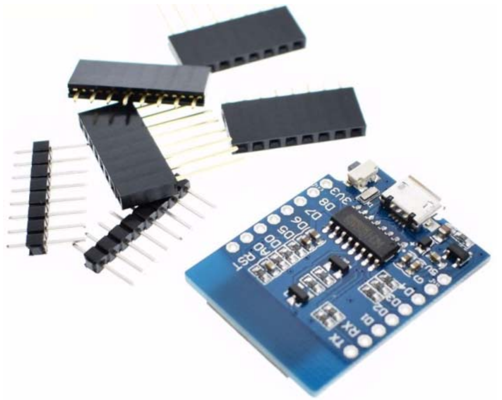


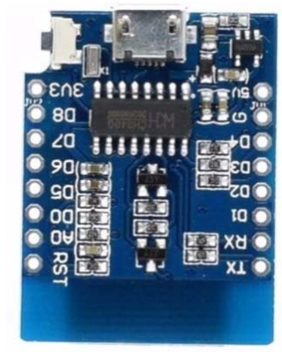
WeMos System

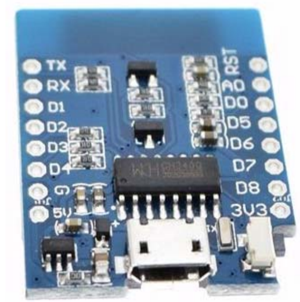
11 digital inputs/outputs

1 in analogic Imput (3.3 V max)

Micro USB connection







Devices

LoRaWAN modules for IoT - Commercial Modules

LoRa Lite by IMST

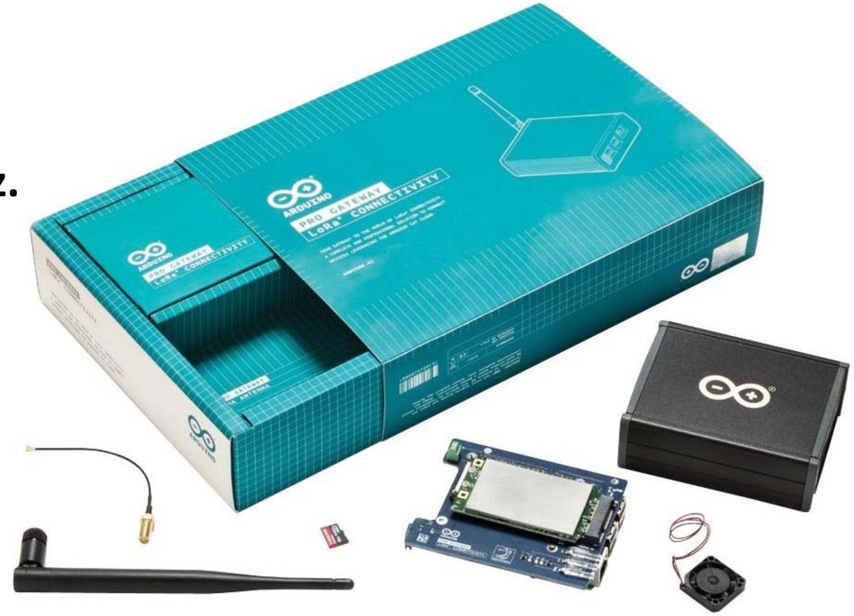
The LoRa Lite Gateway from German company IMST is a reasonably-priced eight-channel gateway based on their iC880A 868 MHz LoRaWAN concentrator and a Raspberry Pi, all fitted on a motherboard in a die-cast box:

The Things Indoor Gateway

Devices

LoRaWAN modules for IoT - Commercial Modules

Arduino Pro LoRa, 8 Channels LoRaWAN, 868MHz.



Sentrius RG1xx LoRa-Enabled Gateway (Larid)

Devices

LoRaWAN modules for IoT - Commercial Modules

TTGO LORA32 V2.0/433/868/915 MHz ESP32

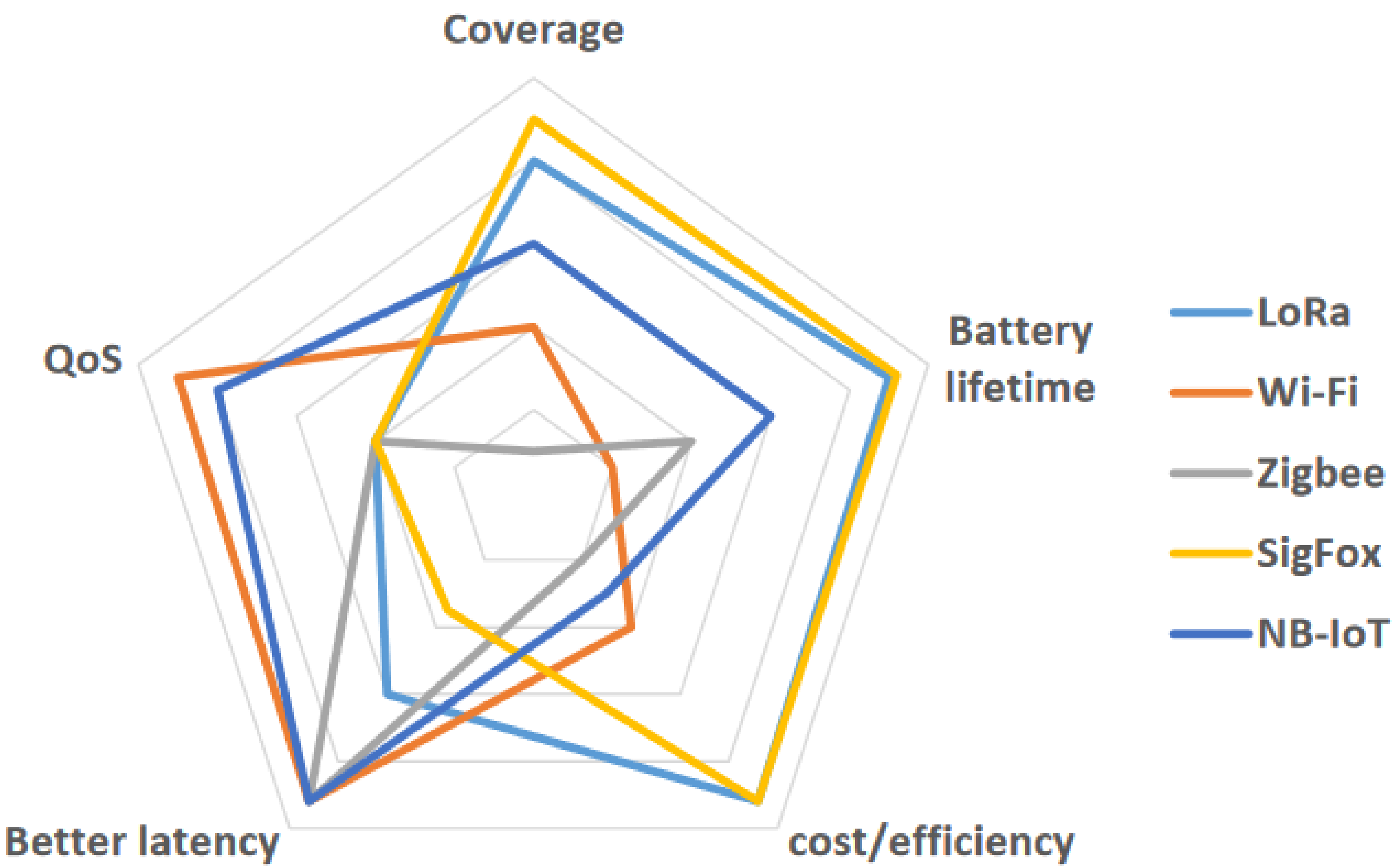
- Chip Wifi ESP32 @ 80 MHz - 802.11 b/g/n
- 900 Mhz LoRa Module
- Compatible with Arduino
- OLED Screen 128x64 px
- MicroUSB (powering and programming)
- Antenna de 2dBi with SMA connector

Wireless Technologies for WSN and IoT

Wireless Technologies

	LoRa	Wifi	ZigBee	SigFox	NB-IoT
Frequency	868 MHz (EU); 915 MHz (USA); 433 MHz (Asia)	2.4 GHz and 5 GHz	868 MHz (EU); 915 MHz (USA); 433 MHz (Asia); 2.4 GHz	868 MHz (EU); 915 MHz (USA), 433 MHz (Asia)	Depends on the frequency licensed to LTE
Standard	IEEE802.15.4g, LoRa Alliance	IEEE802.11	IEEE802.15.4	SigFox (Owner)	3GPP Standard
Coverage	5 km (urban),20 km (rural)	50 m (indoor), 40 km (outdoor, as a function of the visibility)	10–100 m	10 km (urban), 40 km (rural)	1 km (urban), 10 km (rural)
Modulation	LoRa, FSK, GFSK	BPSK, QPSK, 16 QAM, 64 QAM, 256 QAM, 1024 QAM	BPSK, OQPSK	BPSK, GFSK	QPSK, OFDM (DL, SC-FDMA (UL)
Power consumption	Low	High	Medium-Low	Low	Low
Theoretical Data Transfer Rate	22 kbps (LoRa), 100 kbps (GFSK)	2.4 Gbps (IEEE802.11 ax, 2 streams with 1024 QAM)	250 kbps at 2.4 GHz, 20 kbps at 868 MHz, 40 kbps at 915 MHz	100 bps	10 Mbps
Price of end devices	3–5 €	3–5 €	2–5 €	>2 €	>20 €
Price of Gateway/ Base Station	100 € Gateway/ >1000 € Base station	20–600 € Gateway	40–1000 € Gateway	4000 € Base station	15000 € Base station

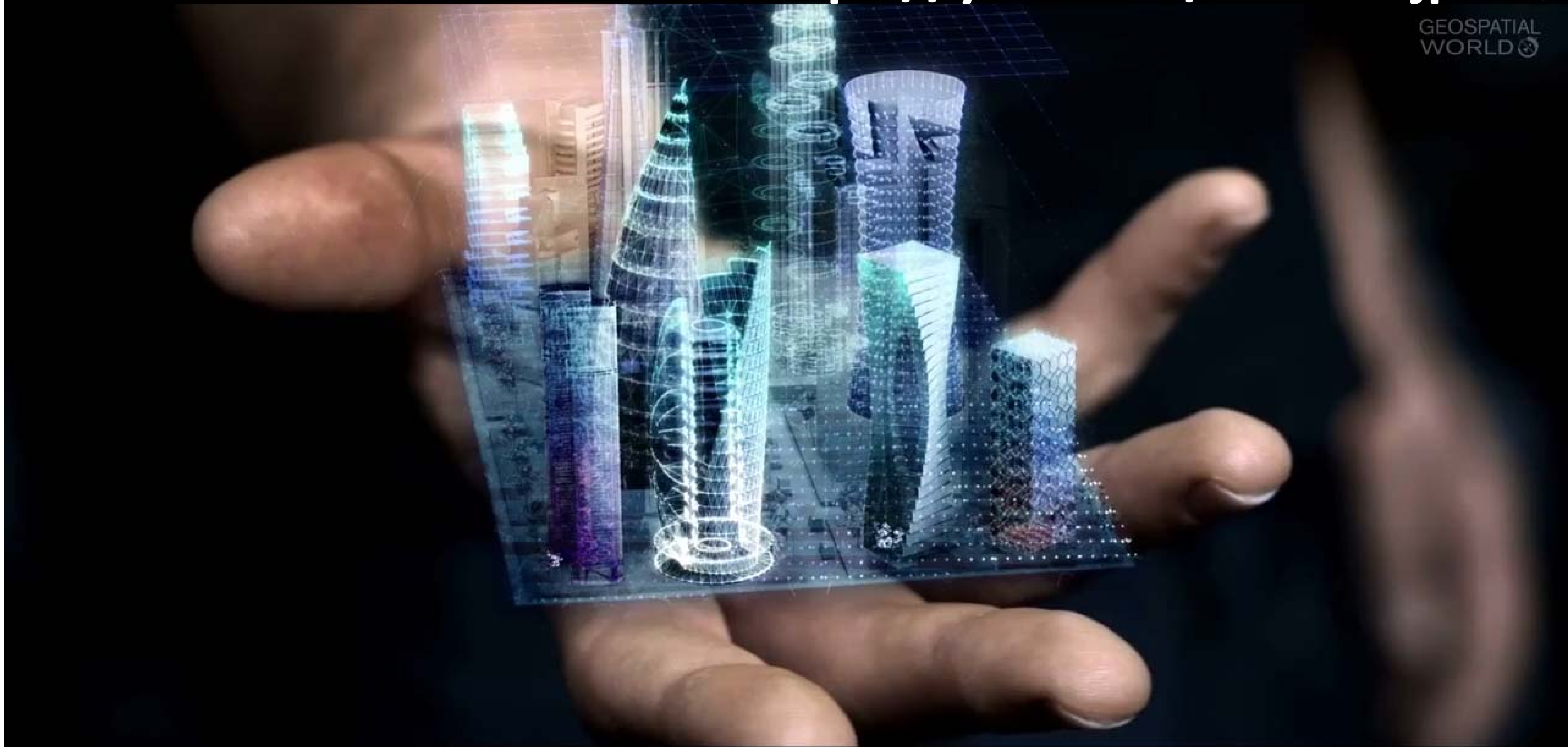
Wireless Technologies



Digital Twins: A new tool for Precision Agriculture?

Digital Twins

https://youtu.be/iVS-AuSjpOQ



Digital Twins

Digital Twins in Agriculture

- **Digital twins** are presented as a disruptive technology in the simulation and analysis of industrial processes, capable of **maximizing the benefits of the digital transformation of the industry**, in which many companies are already involved and which will intensify in the coming years.

- Digital twins allow the **digitization of physical reality** as a base element to be able to apply artificial intelligence techniques to large volumes of data.

- However, in the field of **agriculture**, the development of this tool is **very little consolidated**.
  - Great complexity of digitally representing a reality based on living beings such as plants, fruits or animals, in very different time frames and subject to very diverse, heterogeneous and complex variables.
  - In agriculture we still don't know all the variables that are relevant, nor the interactions that arise between them.

- Knowledge of the possible scenarios that could occur in this crop, through this digitization, will allow **reducing risks and optimizing decision-making**, as well as reducing costs and, consequently, generating profits.

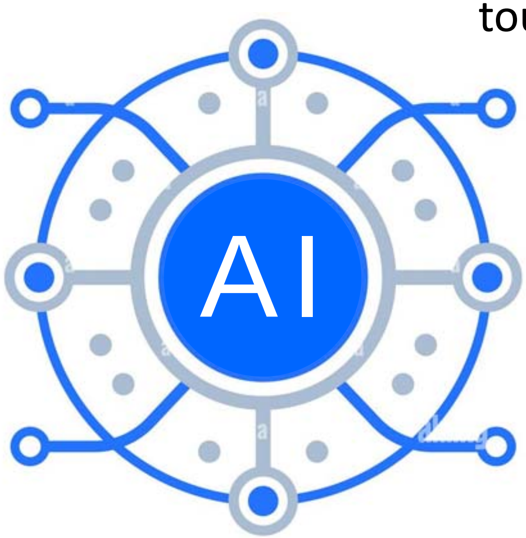
Digital Twins in Agriculture

Type of Crops

Knowledge about crops

Real images→ Drones

Real Data about weather, crop performance, environment



Artificial Vision→ virtual tours around the crop

Estimating the product considering the environmental conditions

Empowerment of the primary sector

Citizens are part of process→ Rural tourism

Examples of developed sensors and applications for precision agriculture and rural environment

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Applications

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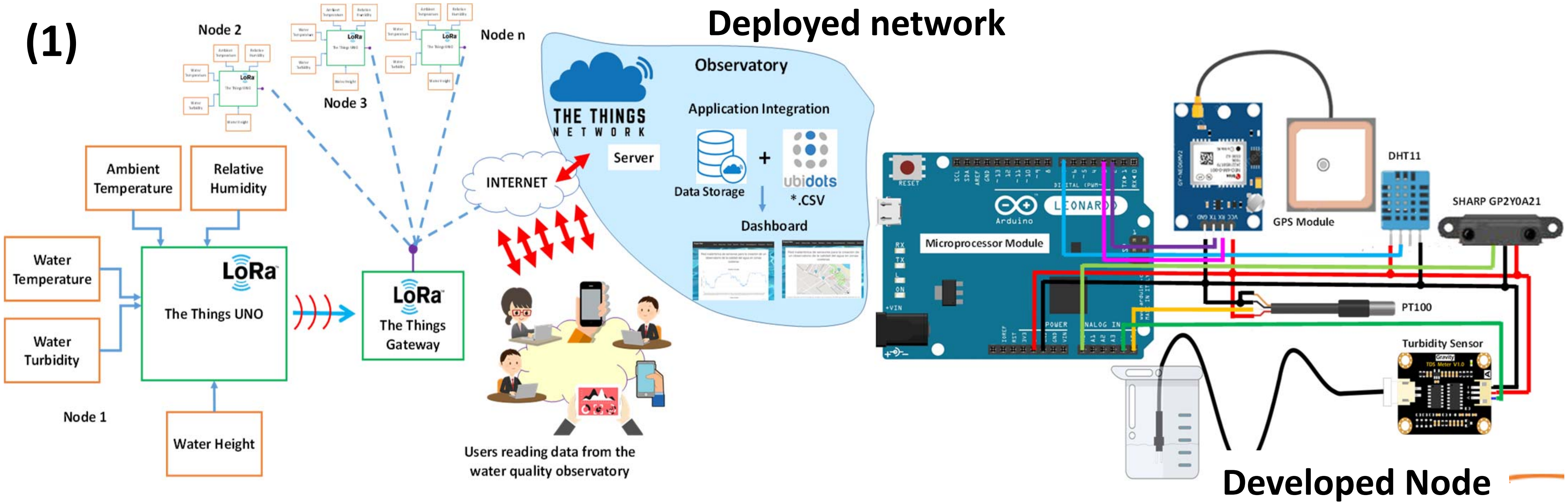
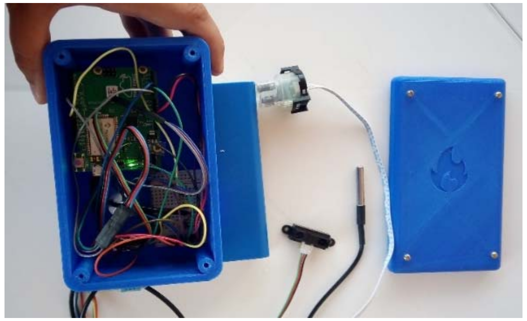
(1)



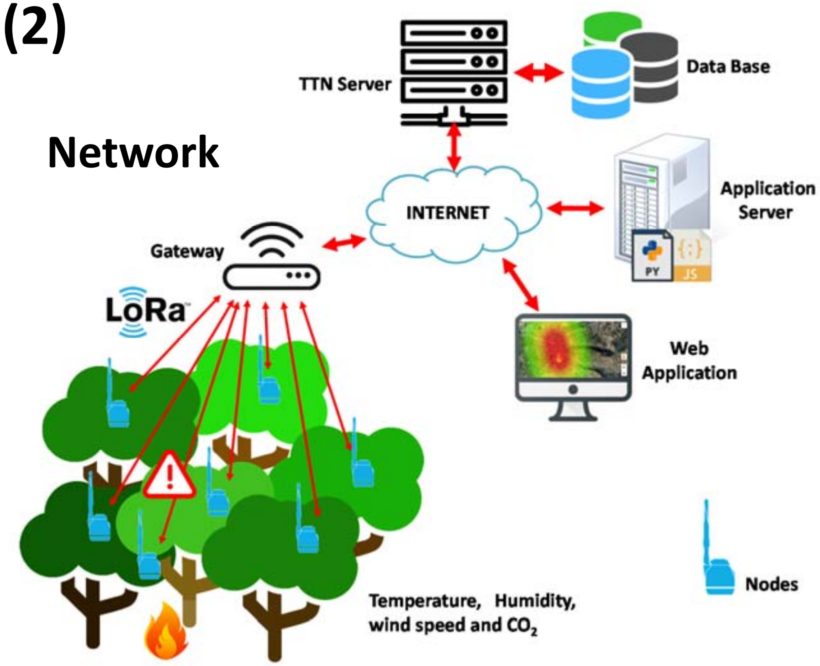


Sendra, S., Botella-Campos, M., Lloret, J., & Jimenez, J. M. (2020, December). Wireless Sensor Network to Create a Water Quality Observatory in Coastal Areas. In *International Conference on Industrial IoT Technologies and Applications* (pp. 100-118). Springer, Cham.

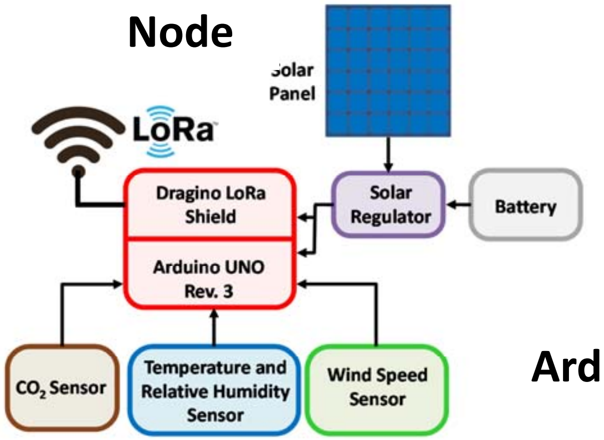
Applications

(2)

Network



Node



Arduino UNO + Shield LoRa

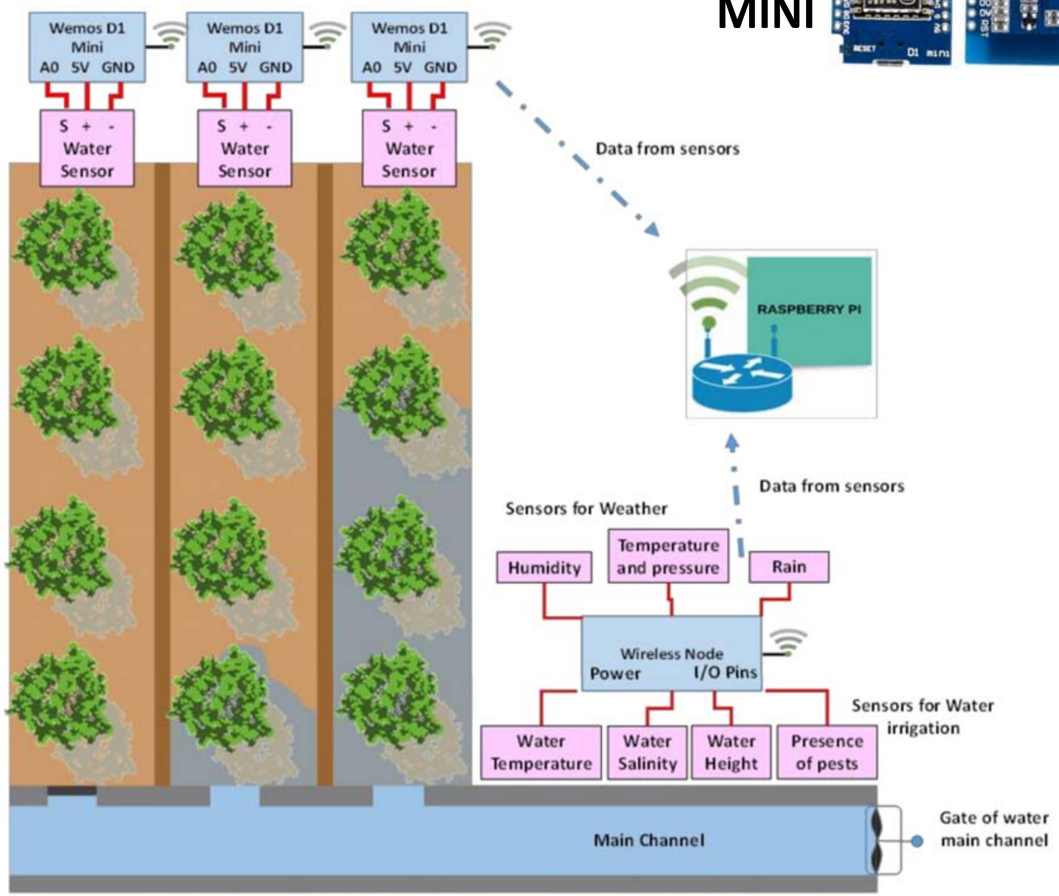
Web developed

Anemometer

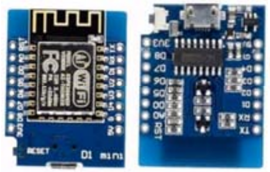
Sendra, S., García, L., Lloret, J., Bosch, I., & Vega-Rodríguez, R. (2020). LoRaWAN network for fire monitoring in rural environments. *Electronics*, *9*(3), 531.

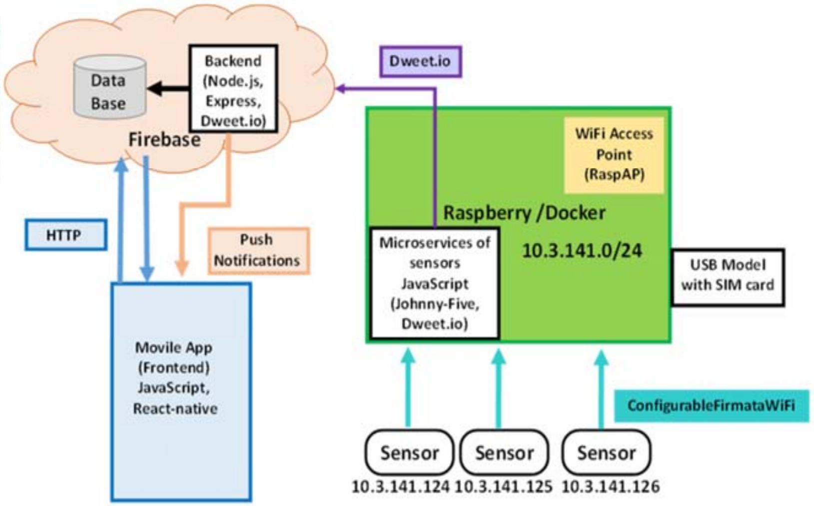
Applications

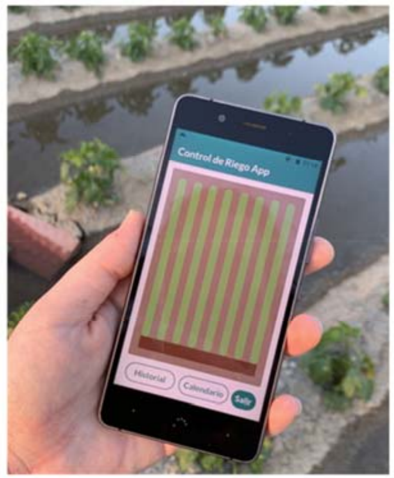
(3) Network



Wemos D1 MINI



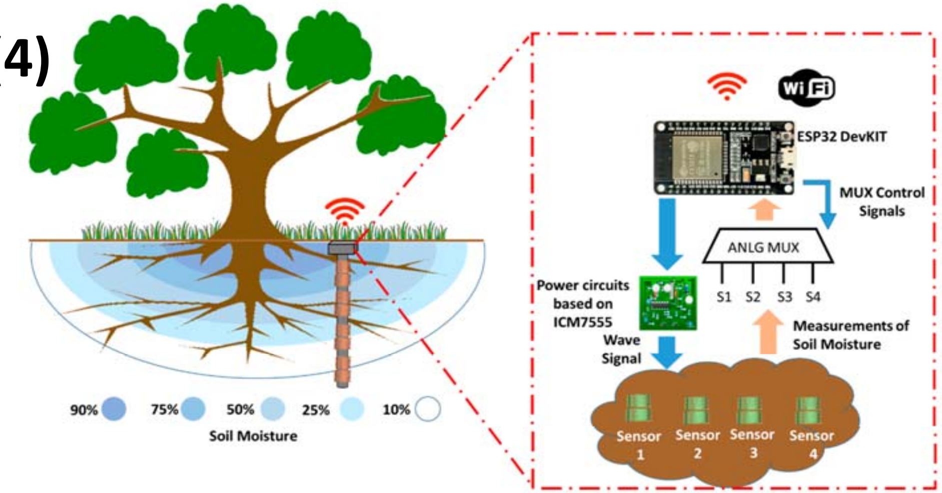




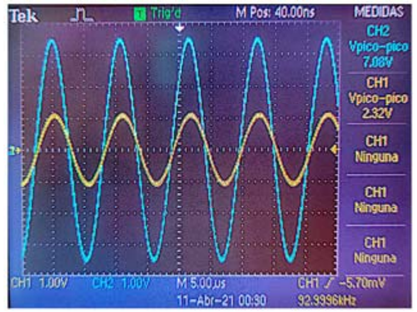
Lloret, J., Sendra, S., García-Fernández, J., García, L., & Jimenez, J. M. (2021). A WiFi-Based Sensor Network for Flood Irrigation Control in Agriculture. *Electronics*, *10*(20), 2454.

Applications

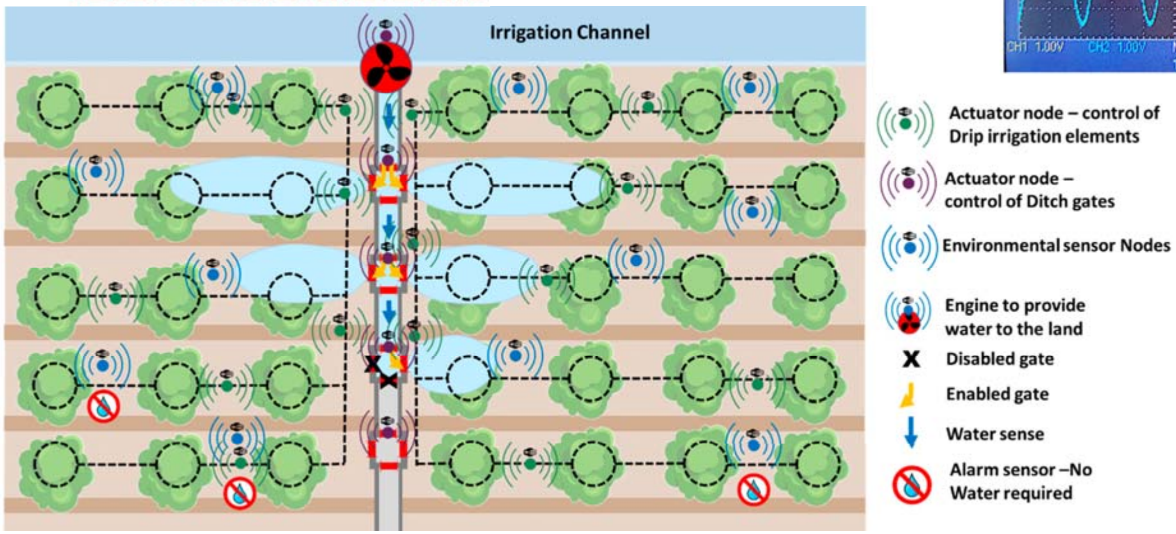
(4)



Designed Network



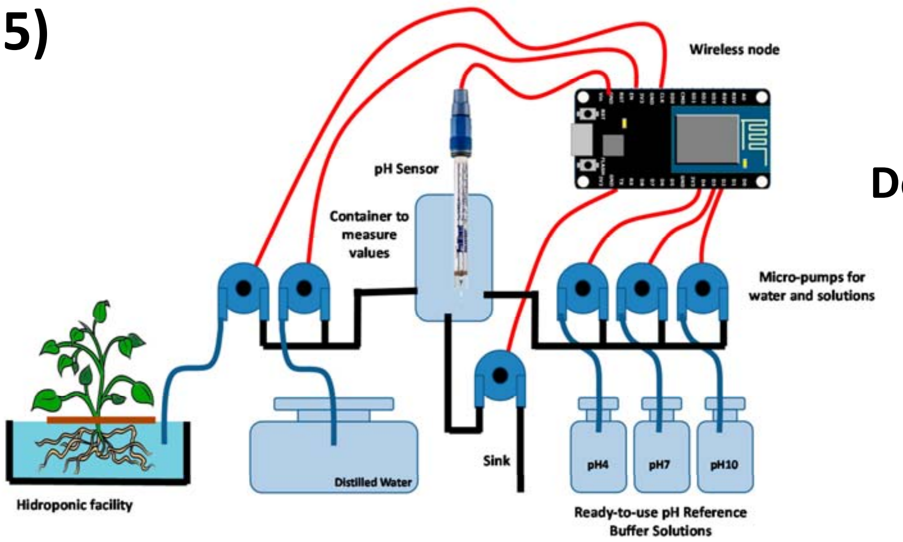
System developed and complete network of sensors



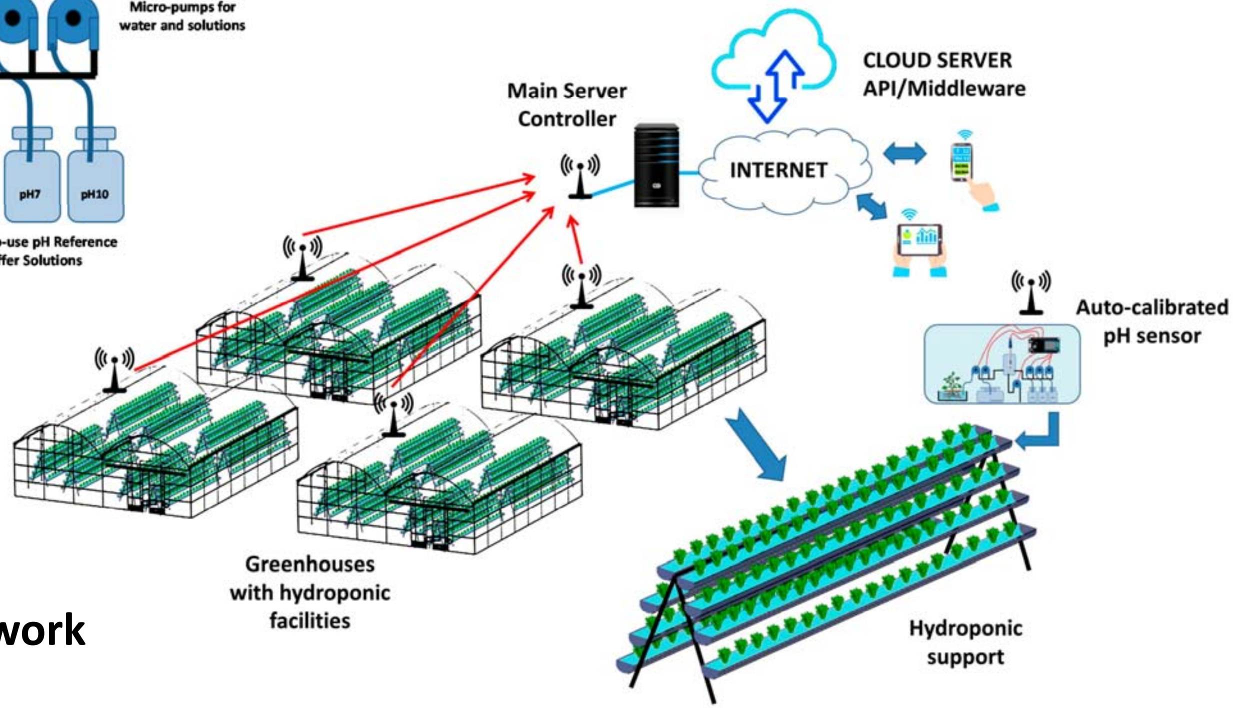
Lloret, J., Sendra, S., Garcia, L., & Jimenez, J. M. (2021). A Wireless Sensor Network Deployment for Soil Moisture Monitoring in Precision Agriculture. *Sensors*, *21*(21), 7243.

Applications

(5)



Developed system

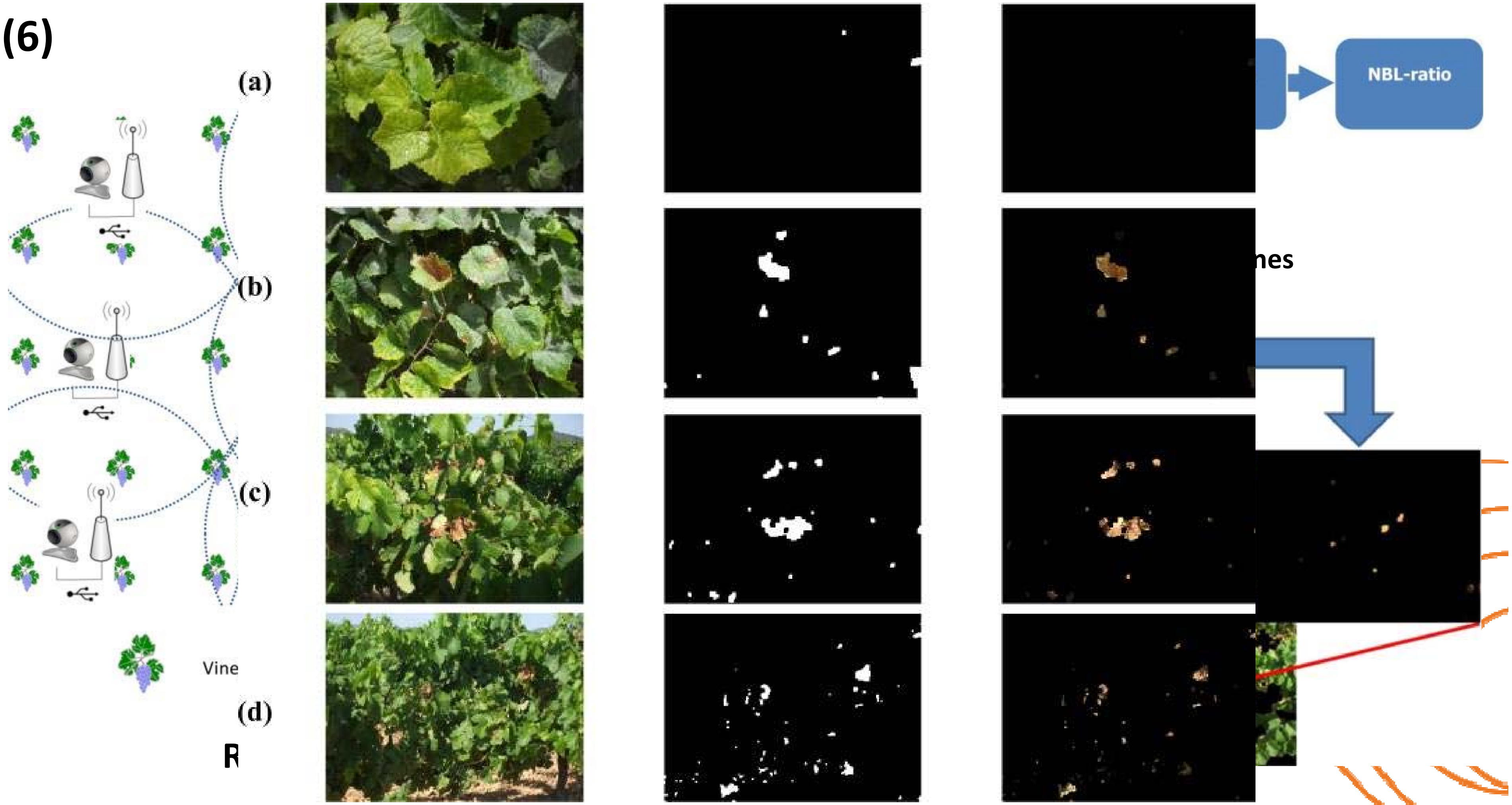


Proposed network

Cambra, C., Sendra, S., Lloret, J., & Lacuesta, R. (2018). Smart system for bicarbonate control in irrigation for hydroponic precision farming. *Sensors*, *18*(5), 1333.

Applications

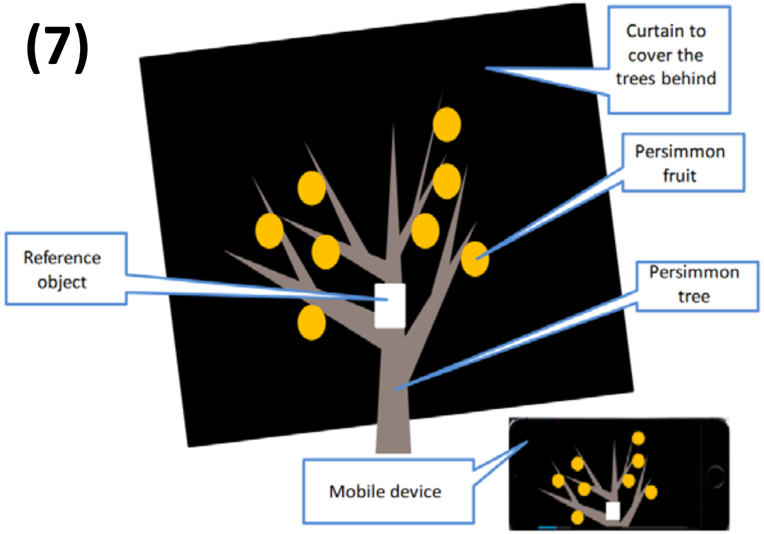
(6)



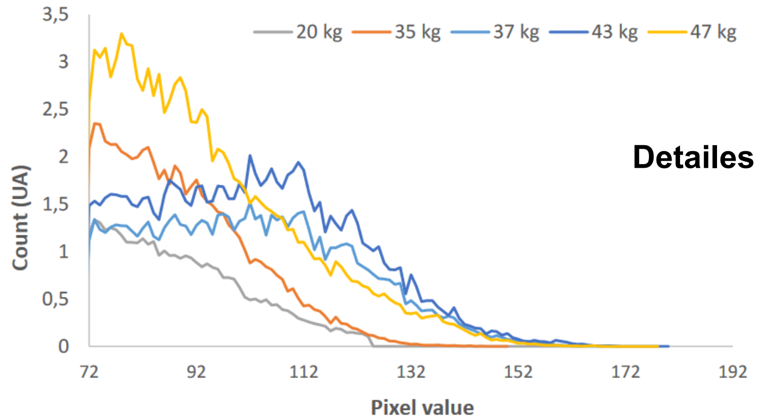
Lloret, J., Bosch, I., Sendra, S., & Serrano, A. (2011). A wireless sensor network for vineyard monitoring that uses image processing. *Sensors*, *11*(6), 6165-6196.

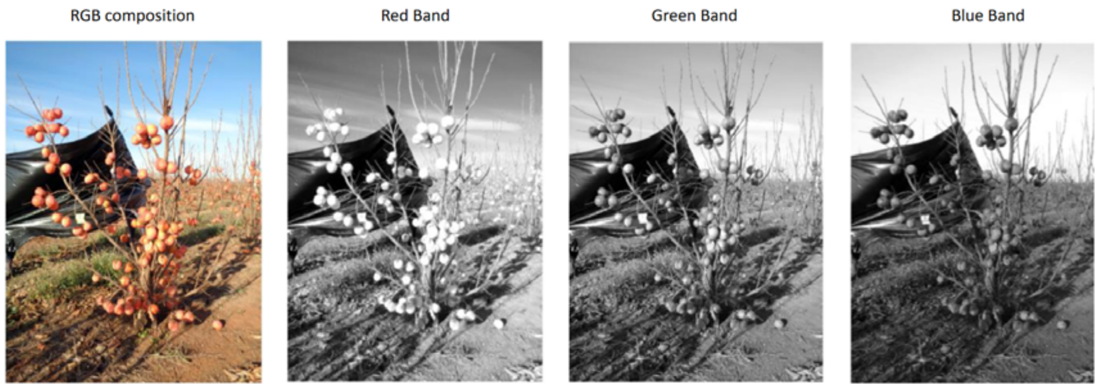
Applications

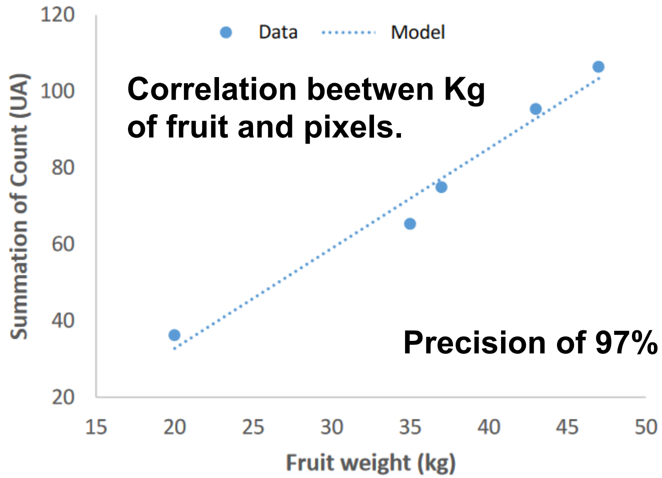
(7)



$$\frac{\sum_{72}^{171} Counts\ (UA) - 19.44}{2.61} = Fruit\ weight\ (kg) \qquad (1)$$





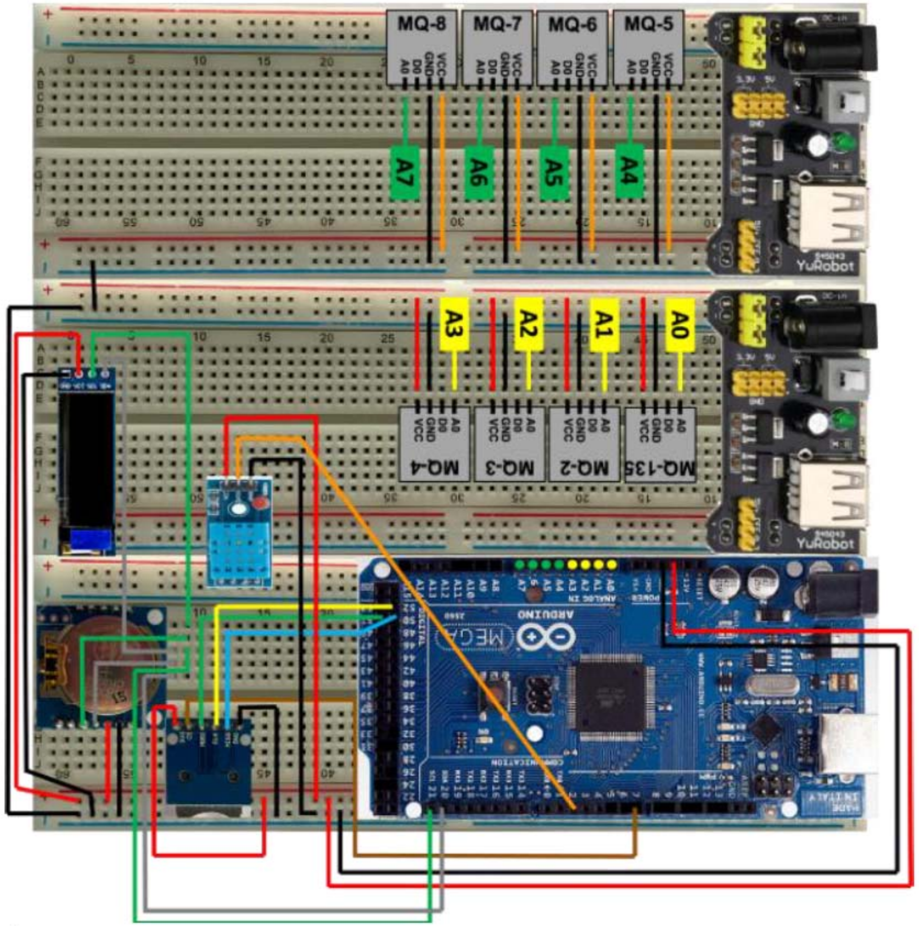


Garcia, L., et al. (2019). Quantifying the production of fruit-bearing trees using image processing techniques. The 8th Int. Conf. on Communications, Computation, Networks and Technologies, Nov. 24-28, 2019. Valencia, Spain

Applications

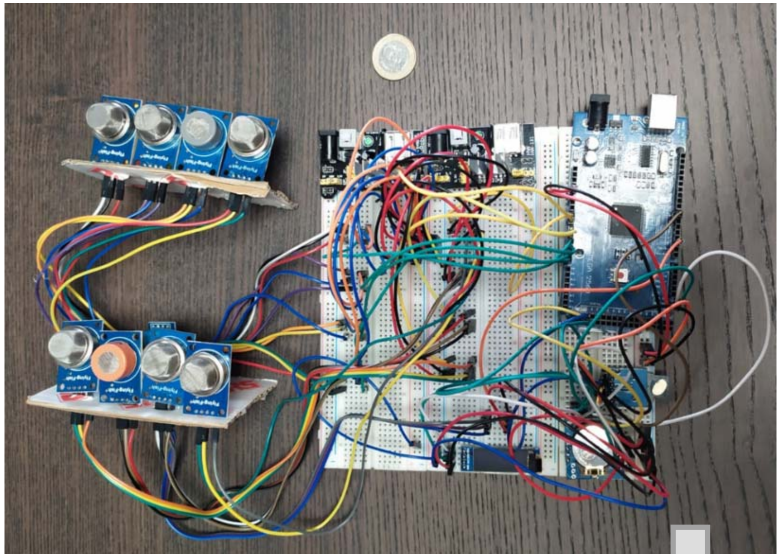
(8) Sensor node for ***Cistus Ladanifer*** leaf analysis

- **Gas Sensors:**
  - MQ-135: Air quality, NH3, NOx, alcohol, benzene, smoke, CO2 MQ-2: H2, LPG, CO, Alcohol, Propane
  - MQ-3: Alcohol, LPG, CH4, CO, Benzene, Hexane.
  - MQ-4: Methane, LPG, CO, Alcohol, Smoke
  - MQ-5: H2, LPG, CO, Alcohol
  - MQ-6: H2, LPG, CH4, CO, Alcohol
  - MQ-7: H2, LPG, CH4, CO, Alcohol
  - MQ-8: H2, LPG, CH4, CO, Alcohol
- **Mega 2560 board**
- **Real time clock (RTC) module**

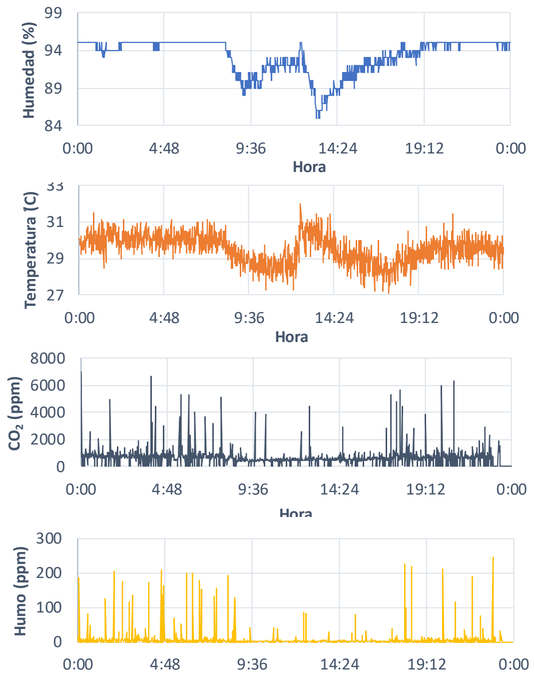


Applications

(8) Sensor node for ***Cistus Ladanifer*** leaf analysis



Sensors exposed to the vapors of the plant in a glass case.



Data captured

Applications

(8) Sensor node for ***Cistus Ladanifer*** leaf analysis

Raspberry Pi with a camera sensitive to several spectrums

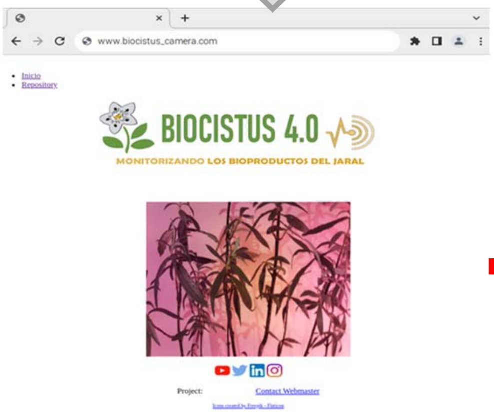
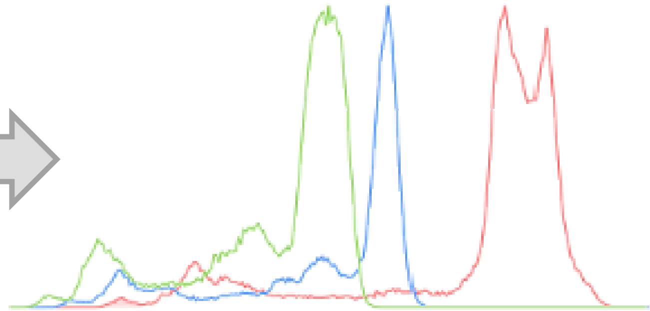
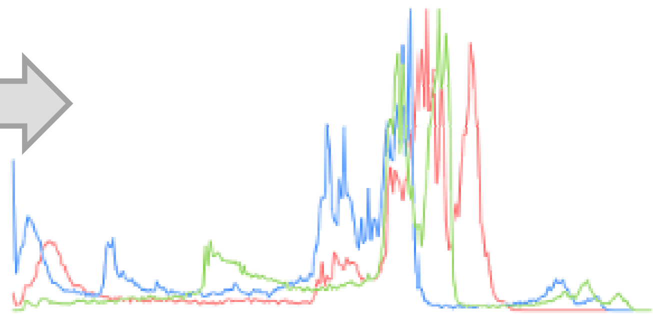


Photo withour filter IR



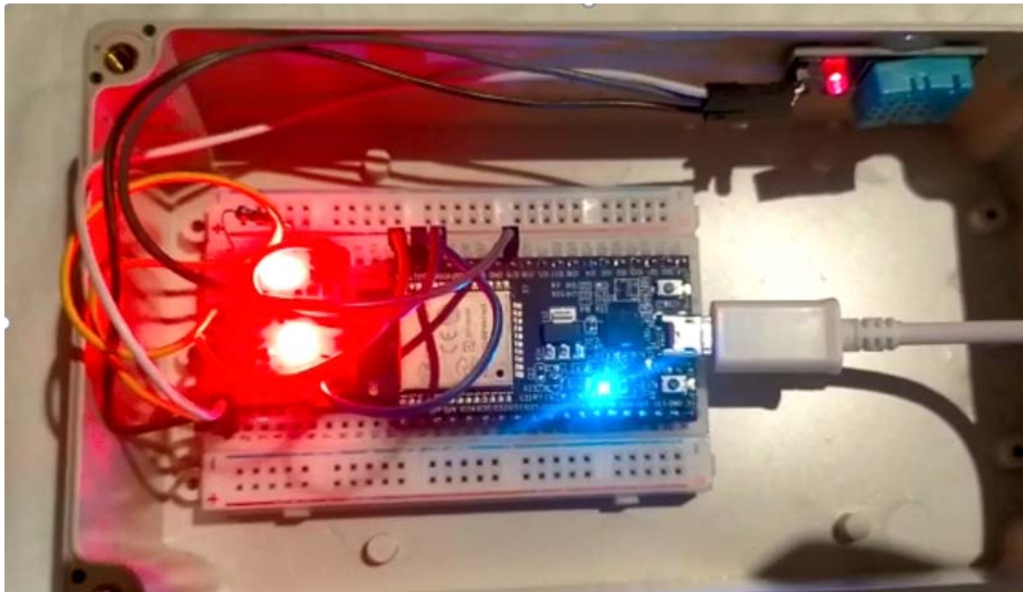
Histogram

Photo with filter IR



Applications

Telegram



Publications:

https://scholar.google.es/citations?user=emSqcUQAAAAJ

https://orcid.org/0000-0001-9556-9088

https://www.scopus.com/authid/detail.uri?authorId=35189596800

https://www.researchgate.net/profile/Sandra_Sendra

Do you have any question?

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