smart skills

smart sustainable agriculture

Course 1:

Digital Farming and Precision Agriculture

IoT devices, sensors, actuators, converters

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Learning Outcomes

Describe the fundamental components of automated control systems in agriculture, including sensors, controllers, and actuators.

Explain how these components interact to optimise various farming operations.

Understand the principles and applications of SCADA, and PLC systems in agricultural contexts.

Evaluate the role of automation in improving efficiency, precision, and productivity in tasks such as irrigation and crop monitoring.

Assess the broader impact of automation on modern agricultural practices and its potential to transform the industry.

Understand…

…the role and importance of control systems in modern agriculture.

Identify…

…key components of control systems, including sensors, controllers, and actuators.

Explain…

…the basic functions of SCADA and PLC systems in farm automation.

contents

Click to type..

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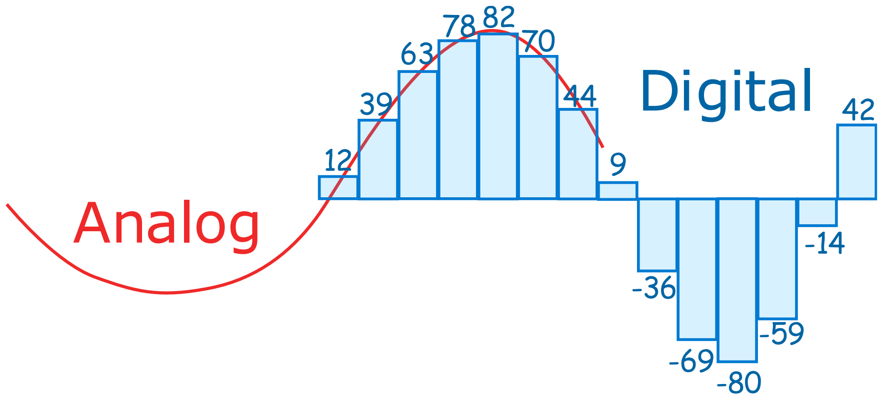
01

Introduction

From Analog to Digital: Understanding Digitization

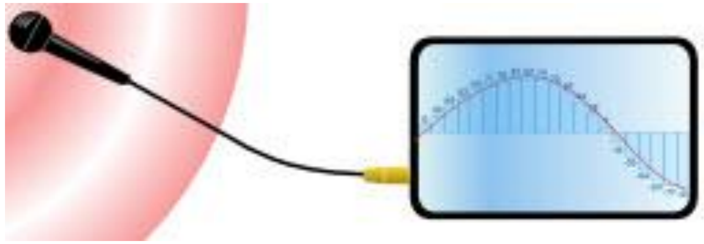
Digitization is the process of converting analog signals—like the smooth red sine wave shown—into digital form, represented by discrete numerical values. This involves sampling the analog signal at regular intervals and assigning each sample a number that reflects its amplitude. The result is a series of values, such as 12, 39, 63, etc., which together form a digital approximation of the original wave. This transformation allows data to be stored, processed, and transmitted more efficiently and reliably in digital systems.

A similar digitization process involves converting an analog image—like a photo of a dog—into digital data using a camera, which translates the visual information into numerical color values.

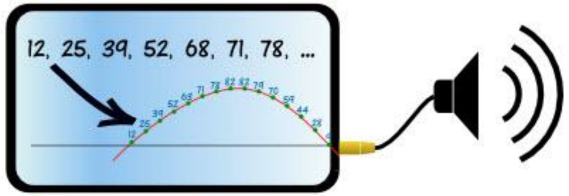


Interaction of electronics and the surrounding world

The process of digitization and its reverse—actuation—connects the physical world with the digital one. On the left, devices like microphones, 3D scanners, cameras, and thermometers capture real-world data and convert it into digital signals ("reality → virtual"). On the right, digital data is transformed back into physical actions or outputs through devices such as speakers, 2D/3D printers, electric motors, and relay switches ("virtual → reality"). This two-way interaction enables technologies like smart homes, robotics, and virtual reality to function seamlessly.



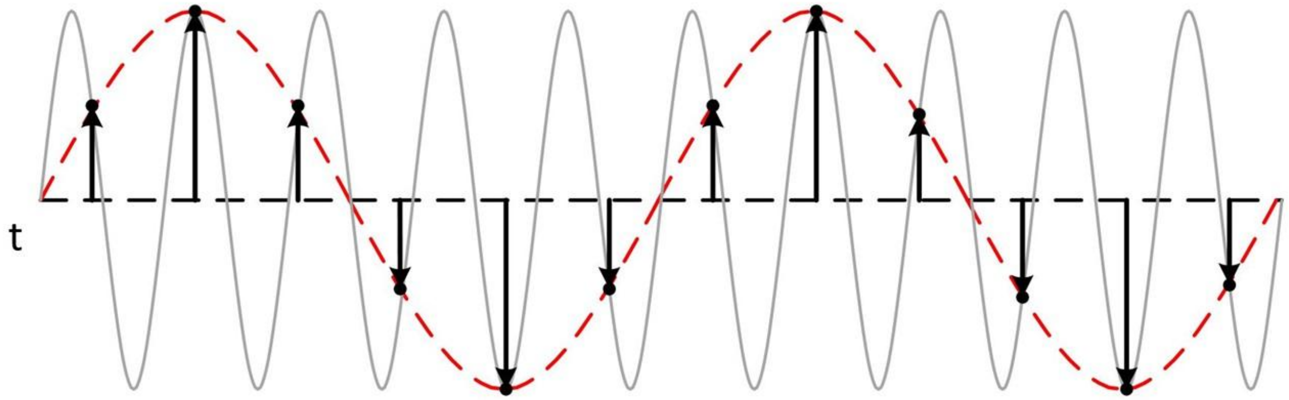
reality -> virtual
microphone
3D scanner
camera
thermometer



virtual -> realita
speaker
printer 2D/3D
electric motor
relay switch

Shannon-Kotelnikov Theorem (Sampling Theorem)

This theorem states that a continuous (analog) signal can be perfectly reconstructed from its samples if it is sampled at a rate at least **twice the highest frequency** present in the signal. This minimum sampling rate is called the **Nyquist rate**. The image illustrates this by showing a smooth analog wave sampled at regular intervals. The red dashed line shows how the original signal can be accurately reconstructed from these samples, demonstrating that no information is lost if the sampling is done correctly.



02

IoT devices

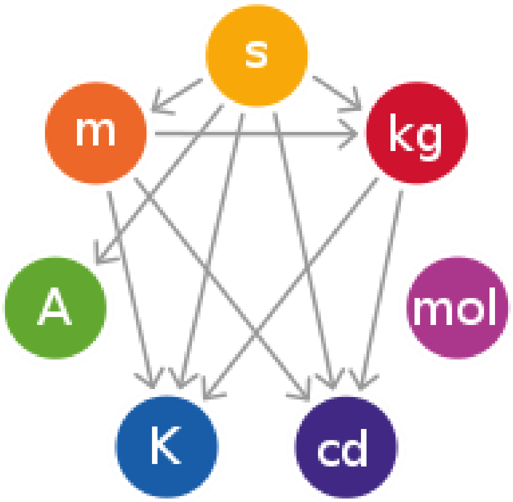
IoT Device Classification by Design and Application

Devices can be categorized based on their **technical design**, and by **area of use**

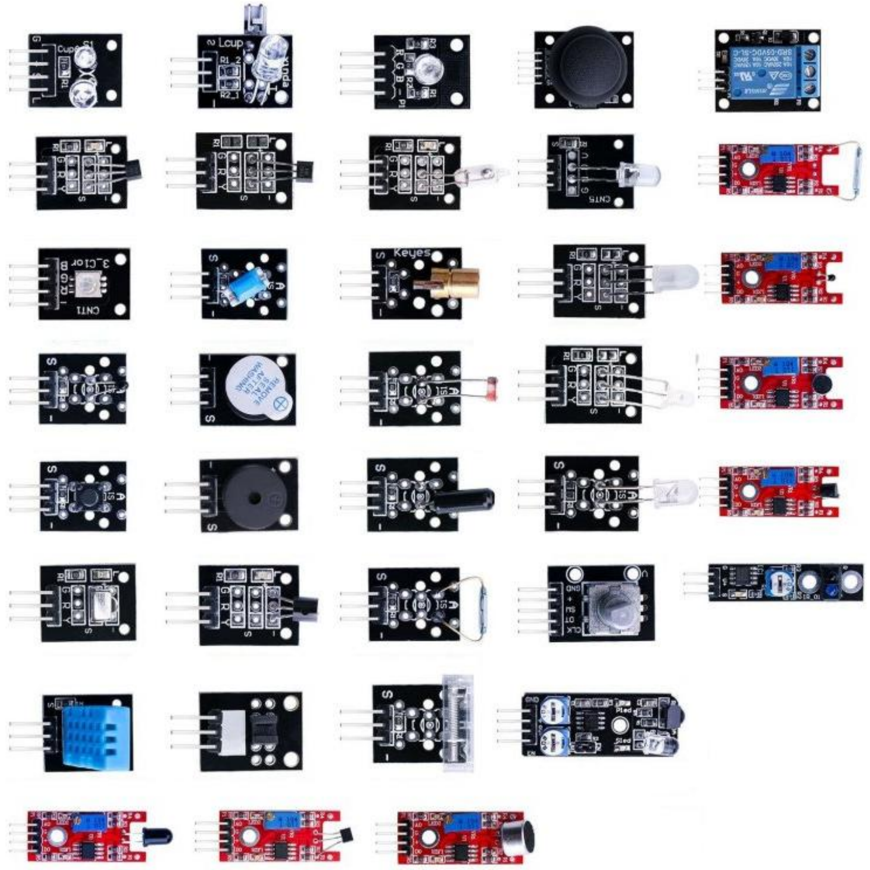
- According to the technical design
  - The resistance of the device: IP, IK, Ex
  - Power supply method (230V, 5/12/24V, battery)
  - Method of data transfer(datalogger, wired, wireless broadband, wireless LPWAN)
- According to the area of use
  - Professional (in industry, transport, etc.)
  - For home use
  - For research, development, testing

The physical principles of sensing

The International System of Units (SI) provides the foundation for measuring physical quantities such as length, mass, time, and temperature. Various sensors and modules—like temperature sensors, gas detectors, and heart rate monitors—convert real-world phenomena into measurable data based on these units.



- Impact
- sensorVibration
- sensorPhotoresisto
- ButtonTemperature
- sensorHall
- sensorMagnetic
- sensorOptical
- barrier module
- Heart rate detector
- Power relay 5V
- Gas detector
- And more….



Final mechanical design

This image presents various sensors used in agriculture and environmental monitoring, such as weather stations, soil moisture sensors, and temperature-humidity sensors. These devices help collect real-time data to support efficient farming and sustainable environmental management.

Case Study: Weather Station Integration with Farm Management System

Farmers often rely on regional forecasts, which may not reflect microclimates on their own land. IoT weather stations installed directly on the farm can monitor rainfall, temperature, wind speed, humidity, and pressure. This data integrates into farm management platforms, improving decisions about planting, pesticide application, and harvest timing. However, weather sensors must be rugged and accurate, and data must be cross-validated to prevent errors in critical decisions.

- **Problem:** Weather variability affects farm operations
- **Solution:** On-site IoT weather stations linked to digital dashboards
- **Data used for** sowing, spraying, harvesting decisions
- **Benefits:** Increased timing precision, risk reduction
- **Challenges:** Data validation, sensor durability in harsh weather

IoT Sensor example

IoT Weather Station

Accurate, Reliabile and Continuous Wather Monitoring

WTS506

- All-in-One Weather Station
- Robust and Rugged
- Various Application Scenarios
- Easy Configuration via NFC
- Solar-Powered & Chargeable Batteries Backup
- Data Storage and Retransmission
- LoRaWAN® Based

LoRaWAN®

Case Study: Light Sensor for Crop Monitoring

Light intensity plays a critical role in plant growth and photosynthesis. In agriculture, light sensors such as PAR (Photosynthetically Active Radiation) or LUX sensors are used to measure the amount of light plants receive. These sensors help optimize growing conditions in greenhouses and monitor shading or exposure in open fields. Farmers can use the data to control shading systems or activate supplemental lighting. Accurate placement and calibration are essential for meaningful results, especially in heterogeneous environments.

- Problem: Lack of real-time data on light conditions affects crop quality
- Solution: Light sensors (e.g., PAR or LUX) monitor light intensity
- Used in greenhouses and open fields for plant growth optimization
- Benefits: Informed shading, supplemental lighting, crop quality control
- Challenges: Sensor placement, data interpretation, calibration

IoT Sensor example

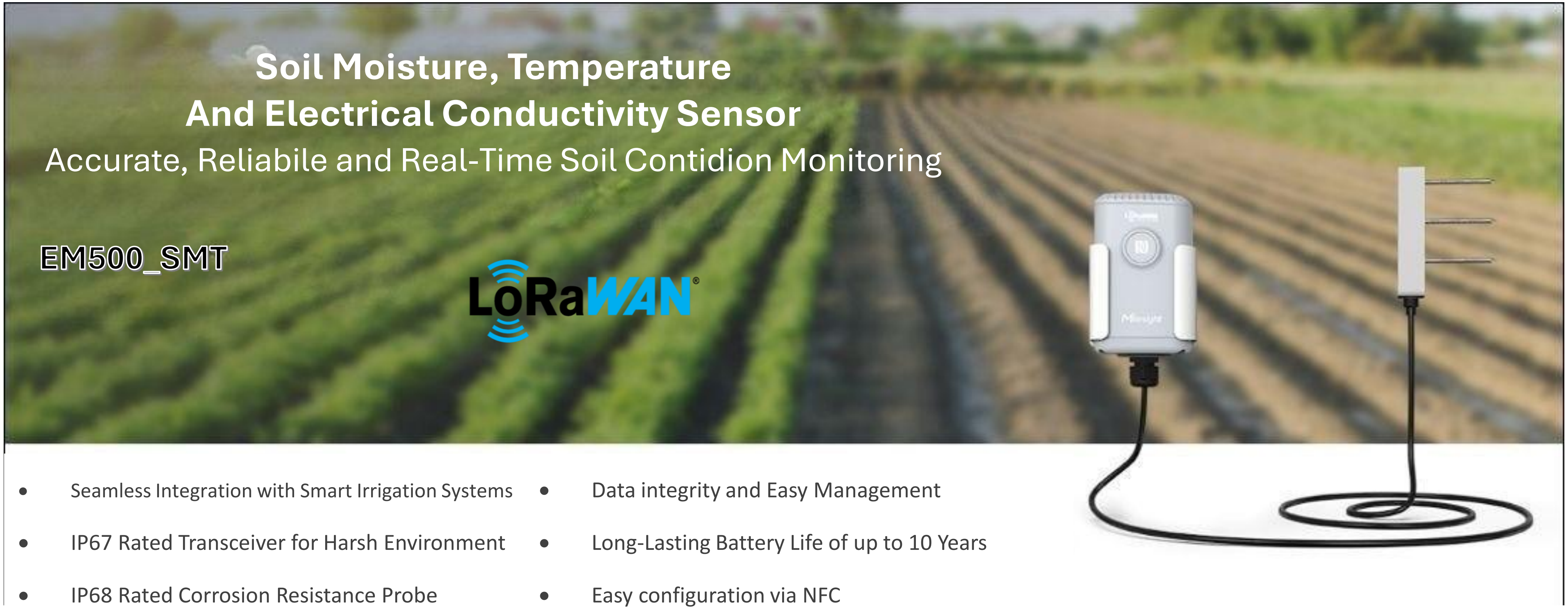
- Measuring Ranges from 0 lux to 100,000 lux
- Fast 1-Sec Response for Accurate Monitoring
- IP67 Rated for Harsh Environment
- LoRaWAN® Wireless Deployment with Low Power Consumption
- Dta Integrity and Easy Management
- Long-Lasting Battery Life of up to 10 Years
- Easy Configuration via NFC

Case Study: Smart Soil Monitoring

Traditional soil sampling can be labor-intensive and offer only snapshots in time. With smart in-field sensors, farmers can continuously monitor soil parameters like moisture, temperature, and electrical conductivity (EC). These sensors send data to a cloud platform via LPWAN (e.g., LoRaWAN), enabling timely decisions on irrigation and fertilization. However, maintaining sensor accuracy over time and ensuring reliable power sources (e.g., solar or battery) remains a challenge.

- **Problem:** Manual soil testing is time-consuming and inconsistent
- **IoT solution:** In-situ soil sensors (moisture, temperature, EC)
- Real-time data collection and cloud storage
- **Benefits:** Optimized irrigation and fertilization
- **Challenges:** Sensor calibration, maintenance, power supply

IoT Sensor example



Interface in sensors and control

- Digital inputs/outputs
- Analog inputs/outputs
- Serial communication with sensors (bus)
- Communication interface of the units
  - **Ethernet, wireless, etc.**

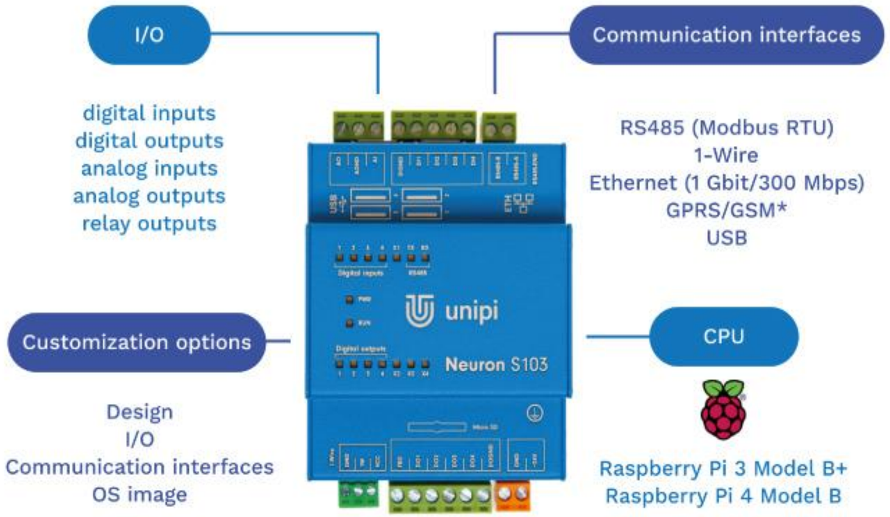


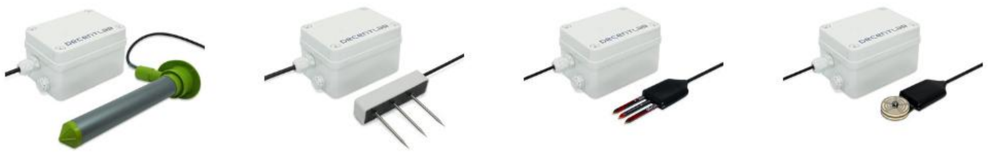
Figure about PLC (programmable logic controllers) is discribed at https://www.unipi.technology/

IoT control (PLC) device

IoT control devices, such as Programmable Logic Controllers (PLCs on figure), play a key role in modern automation systems by connecting sensors, actuators, and cloud services. These devices collect data from the physical environment, process it in real time, and trigger actions based on predefined logic. Integrated with the Internet of Things (IoT), PLCs enable remote monitoring, predictive maintenance, and seamless integration with smart infrastructure—making them essential in industries like manufacturing, agriculture, energy, and smart buildings.

"Industrial" IoT Wireless sensor devices

- Most of them are devices with higher resistance.
- The size of the device is ideally as small as possible.
- A simple battery change is not always the rule.
- Device configuration is specified by the device manufacturer.
- Periphery (specific sensor) is usually connected externally.
- Mostly well secured



IoT for accurate measurements

The Internet of Things (IoT) enables precise and continuous monitoring of physical conditions through a network of interconnected sensors and devices. By collecting real-time data on parameters such as temperature, humidity, pressure, and motion, IoT systems ensure high accuracy and reliability in fields like environmental monitoring, smart agriculture, industrial automation, and healthcare. These measurements support data-driven decision-making, predictive maintenance, and improved operational efficiency.

- Quantities are measured with high resolution and accuracy.
- Sensors must be calibrated regularly.
- Disturbing quantities are shielded

IoT device for positioning

IoT positioning devices use technologies such as GPS, GNSS, Wi-Fi, Bluetooth, or ultra-wideband (UWB) to determine the precise location of objects, people, or assets in real time. These devices are essential in applications like fleet tracking, smart logistics, agriculture, and indoor navigation, where accurate and continuous location data supports automation, safety, and operational efficiency.

- So called „IoT tracker“ (on figure)
  - Specialization in determining the position of the tracked object.

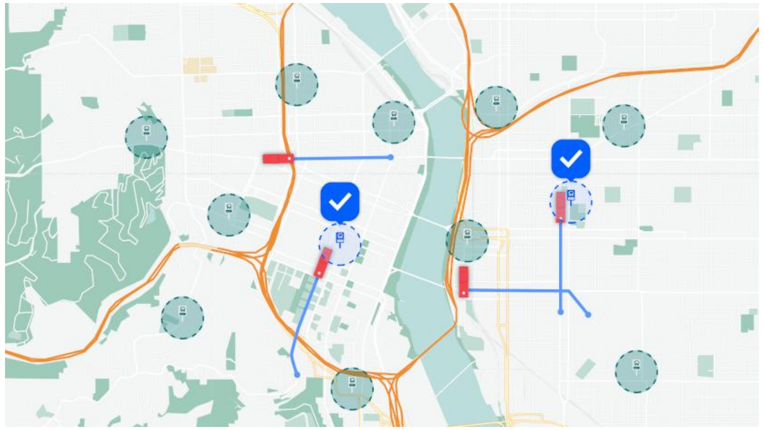


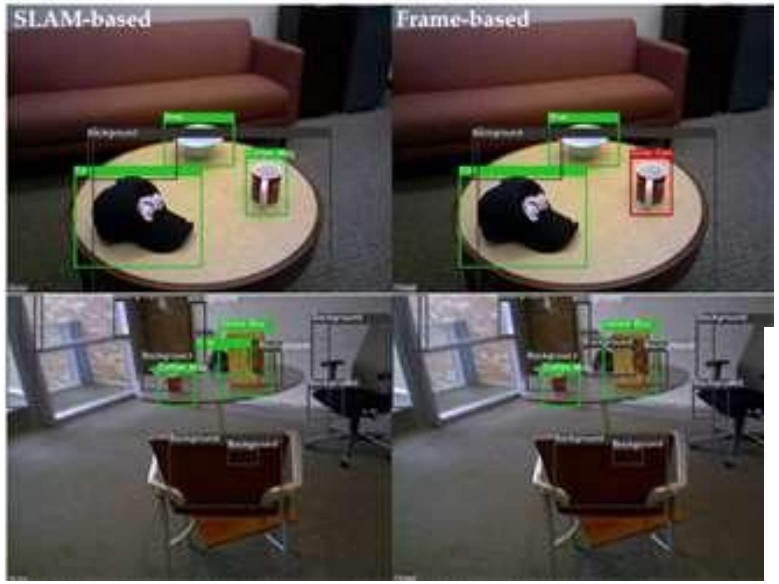
Fig. A: Position of the tracked object.

Fig. B: IoT tracker.

IoT Cameras

- The ability to recognize objects
- Universal use
  - Self-driving cars
  - License plate number (A)
  - Manufacturing processes (B)
    - quality control
    - goods counting
  - Temperature measurement (C)
    - the issue of lighting conditions

B



A

C

Using of IoT devices, sensor in Precision Agriculture

More information about **IoT**

[🡐 Smart Farming with IoT: Enhancing Soil Health with IoT Technology](#)

| AI Tech Hub

03

Personal data when scanning

Personal data when scanning

Issues of personal data according to the GDPR regulation

According to the GDPR, personal data means all information about an identified or identifiable natural person (so-called data subject), such as name and surname, identification number, location data (location data), one or more special elements of physical, physiological, genetic, psychological, economic, cultural or social identity of a certain natural person, or even a network identifier.

Case Study: GDPR & Data Ownership in Digital Farming

Many farmers are concerned about where their data goes—especially data from sensors on fields and machinery. Some cases show vendors storing data in the cloud and using it for commercial purposes, creating distrust. GDPR requires informed consent and transparency. A good practice is to define data ownership in contracts and enable farmers to access or delete their data.

- Problem: IoT platforms collect sensitive farm and location data
- Concern: Who owns the data? How is it used?
- Example: Disputes between farmers and vendors over cloud access
- Impacts: Trust issues, reluctance to adopt new tech
- Need: Clear agreements on data use, GDPR compliance

Call to Action

Practical Activity: *"Choose and Analyze a Sensor"*

Pick one type of IoT sensor or data collection device used in agriculture (e.g., temperature sensor, soil moisture sensor, GPS tracker, optical barrier sensor).

Task: Write a short paragraph explaining how it works, in which part of farming it is most useful, and what technical or ethical issues might arise during its deployment. Length: 100–150 words.

Optional: Attach an image or datasheet of the device..

Tip: Consider issues like accuracy, resistance, data transmission, or GDPR concerns.

Call to Action

Discussion Prompt:

What criteria should farmers consider when selecting IoT devices for data collection? How can we balance technological benefits with privacy and security?

Purpose:

To promote critical evaluation of real-world technologies and awareness of both technical and ethical dimensions in precision farming.

Well done!

You finished the second module of **Course 1**!
Keep going on this learning journey.

In the **next module** you will learn about IoT – Database and IoT.

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