NexComm 2024 & DigitalWorld 2024

Theme: Sensing/Networking

Focus: Applications of Mobile Devices, Internet of Things, Sensing Systems, and Data Processing

CONTRIBUTORS

Moderator

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Panelists

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- Dr. Laura García, Universidad Politécnica de Cartagena, Spain
- Prof. Dr. Ryosuke Yamanishi, Kansai University, Japan
- Dr. Roger Tilley, Sandia National Laboratories, California, USA

IARIA

Panel

Barcelona
May 2024

Paulo E. Cruvinel, Ph.D.
Scientific Researcher
Moderator

Sensing and Data Processing

Applications of Mobile Devices, Internet of Things, Sensing Systems, and Data Processing for Decision Making

Applications of Mobile Devices

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A mobile application (APP) is a computer program application designed to run on a mobile device such as a phone, tablet, or watch, among others.

Mobile applications often stand in contrast to desktop applications which are designed to run on desktop computers, and web applications, running in mobile web browsers rather than directly on the mobile device.

Internet of Things (IoT)

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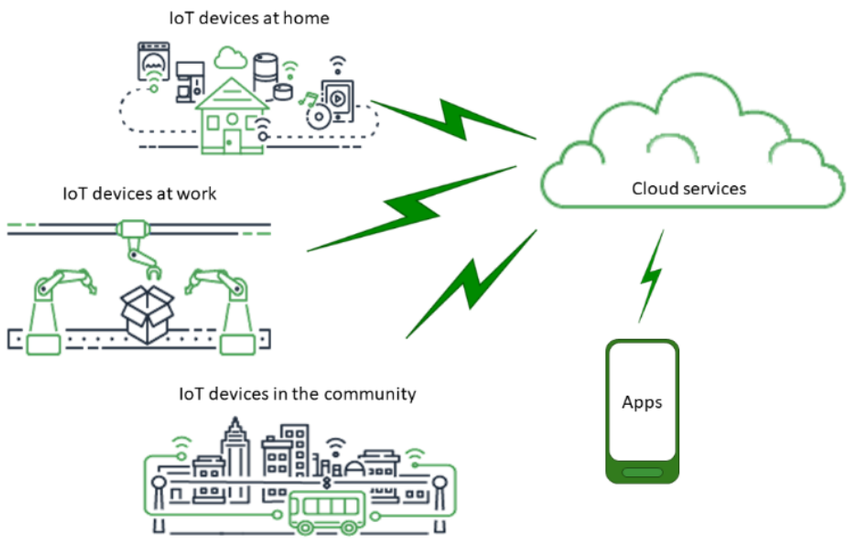
The term refers to the collective network of connected devices and the technology that facilitates communication between them and a cloud infrastructure, as well as between the devices themselves.



Internet of Things (IoT)

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For over two decades, the IoT has transformed industries by enabling businesses and consumers to remotely monitor, analyze, and control devices.

Use cases for IoT are constantly increasing, and there are now billions of connected devices worldwide.

Greatest IoT challenges are still from the beginning., i.e., becoming more pronounced as IoT becomes more prolific and accessible.

Challenges

IoT security
Coverage
Scalability
Interoperability
Bandwidth availability
Limited battery life
Remote access

Sensing Systems

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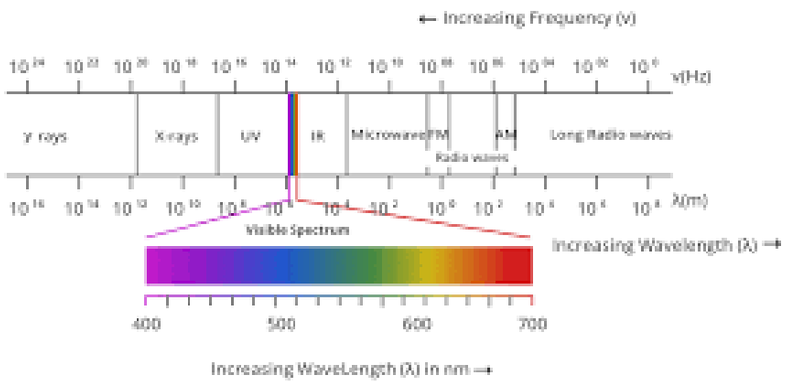
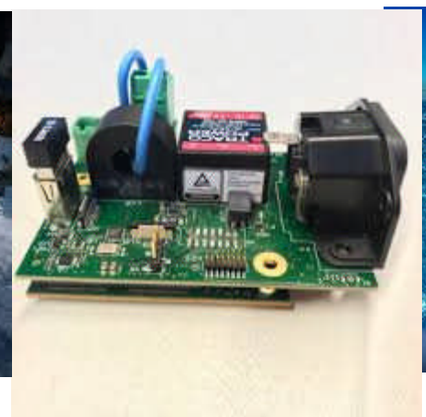
Sensors capture parameters from the observed environment (Physical, Chemical, Biological) and convert them into observable electrical signals. At the sensor system is the sensing element.





Challenges

Noise and Interference

Data Processing and Analysis

Sensor Fusion

Environmental Conditions

Size, Scalability, and Electrical Characteristics

Energy Consumption

Lifetime and Durability

Cost and widespread use

Security and Privacy

Standards and Compatibility

Data Processing for Decision Making

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Data processing for driven decisions: help to reduce risks, also used for automation, and form analytical processes

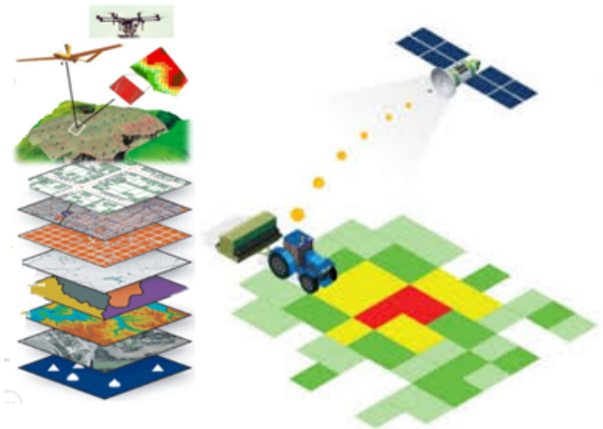
1. Problem Identification
2. Identification of Decision Criteria
3. Modelling and Decision Criteria
4. Development of Alternatives
5. Evaluation of the Alternatives
6. Selection of the Best Alternative

Data processing involves transforming raw data into useful information

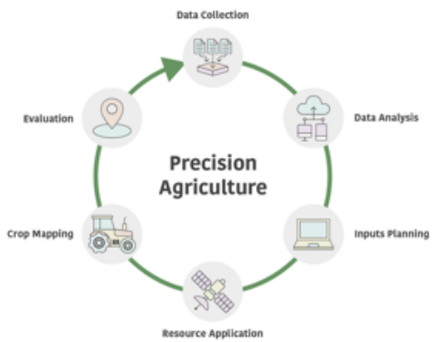
Stages of data processing include collection, filtering, feature extraction, classification, analytics, and analysis.

Data processing lies also on data quality, tools and techniques to ensure accurate and valuable output

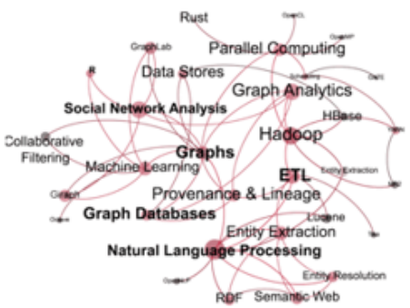
Sensing and Data Processing in Agriculture



- ✓ Phenomenology related to the interaction soil-plant-environmental systems → understanding and modelling
- ✓ Sensors and signal processing for decision making → diversity in agroecosystems, climate conditions and customization
- ✓ Huge amount of data and computational infrastructure → BigData, advanced statistics, embedded architectures and software's for Machine Learning, Deep Learning, and Artificial Intelligence.
- ✓ Interoperability, mobile devices and IoT → friendliness, portability in the field, communication protocols and expansion in the use of sensors



- Challenges
  - New sensors and networking;
  - Interoperability;
  - Field truth and customization;
  - Proprietary and public data;
  - Standards and public policy.



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Dr. Gábor Gulyás, PhD
Vitarex Studio Ltd.
Managing Partner

- **Is the smart city concept dead? Where are developments we have anticipated (like in 2010)?**
- **However, commercial efforts and smart CCTV surveillance seem to be on the rise.**

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There may be more unsolved questions than solved ones.
(both regulatory and technically)

- How effective are regulations like the GDPR? Or would be the AI act?
- How should we regulate ethics, e.g.. dark patterns?
- Where is the right trade-off between personal interests (regulation) and economic development?
- Can we effectively regulate complex corporal data processing systems? (e.g., who combine online footprints & offline activities)
  - We still have not solved such “simple” issues like anonymization in general.

Dr. Gábor Gulyás, PhD
Vitarex Studio Ltd.
Managing Partner

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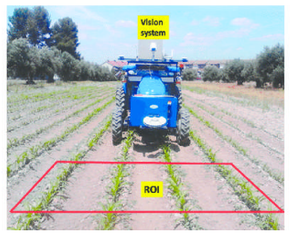
- **Digitalization of Agriculture – From WSN to decentralized computing applications**

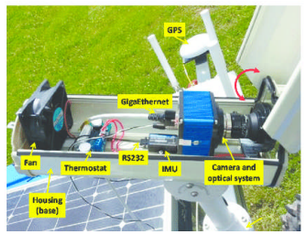
Laura García
Universidad Politécnica de Cartagena

- **Network limitations in remote environments**
  - Challenged remote environments with lack of infrastructure and access to the power grid limited the applications that could be deployed in agricultural fields.
  - The adoption of a variety of **complimentary wireless communication technologies** (LoRa, 5G, WiFi, etc.) forming **heterogeneous networks** allows for new and more resource demanding sensor devices and solutions.
  - There is still a **need for seamless high bandwidth networks in remote areas** for the introduction of AI solutions and real-time image/video traffic enabling **computer vision** tools to be deployed in agricultural vehicles.

Computer Vision Cameras

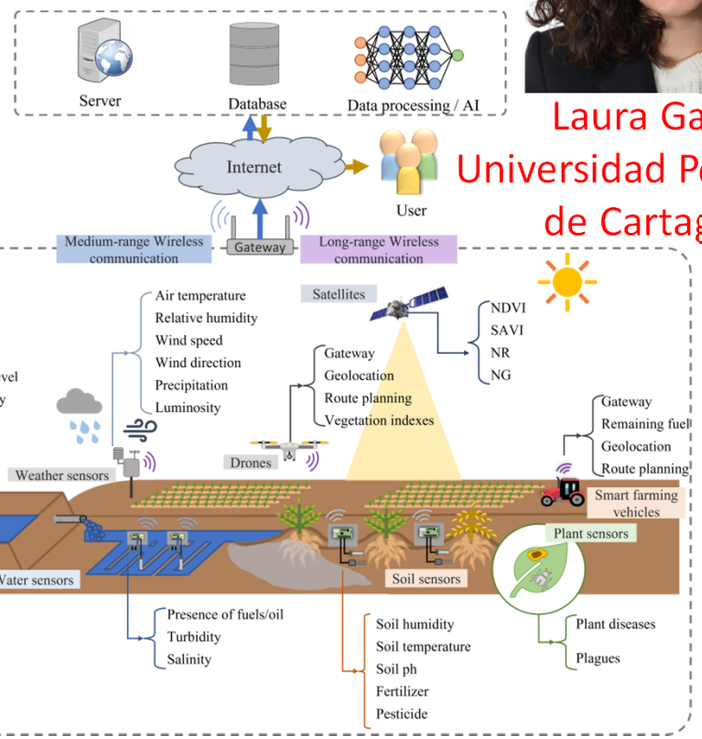
Static





Mounted on vehicles

Source: Pajares, G., García-Santillán, I., Campos, Y., Montalvo, M., Guerrero, J. M., Emmi, L., ... & Gonzalez-de-Santos, P. (2016). Machine-vision systems selection for agricultural vehicles: A guide. *Journal of Imaging*, *2*(4), 34.



Source: García, L., Sendra, S., Lloret, J. (2024). Sensing Systems for Precision Agriculture. In: Priyadarshan, P.M., Jain, S.M., Penna, S., Al-Khayri, J.M. (eds) Digital Agriculture. Springer, Cham. https://doi.org/10.1007/978-3-031-43548-5_18

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Laura García
Universidad Politécnica de Cartagena

The Edge-Cloud continuum in Agriculture

- **Distributed computing** is presenting itself as a solution to the limitations of currently deployed networks in remote areas, specifically for AI solutions where **federated learning** and **frugal AI** can be employed for real-time data analysis at the edge.

The Reality-Virtuality continuum

- The use of **Digital Twins** as the next step for IoT integrated solutions is also reaching agriculture as a tool for 3D data visualization, farm management, predictions and simulations.

The sensing continuum?

- AI is now an essential part of agricultural data processing leading to the development of **virtual sensors** based on the data gathered by conventional sensors either to obtain new information or to reduce the number of physical sensors.

What's to come?

Agriculture 4.0	Agriculture 5.0	Agriculture 6.0
Big Data	Intelligent systems	Edge-cloud continuum
IoT	AI	Circular-economy
Robots	Digital solutions	Carbon footprint
Drones	Automation	Social solutions
Remote sensing		Green

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Ryosuke “Leo” Yamanishi
Kansai University

- Question: What can influence our feelings/emotions?
  - **Reviews are the only way** to know the emotions of people now.
  - Everyone checks the reviews before enjoying the content: restaurants, hotels, and games.

- Future: **emotions can be sensed** and applied to services.
  - Mobile devices are (almost always) sensing our vital information: heartbeat and steps.
  - **Can the sensed data represent emotions objectively?**
    - **Real feelings**
    - **Variation of emotions**

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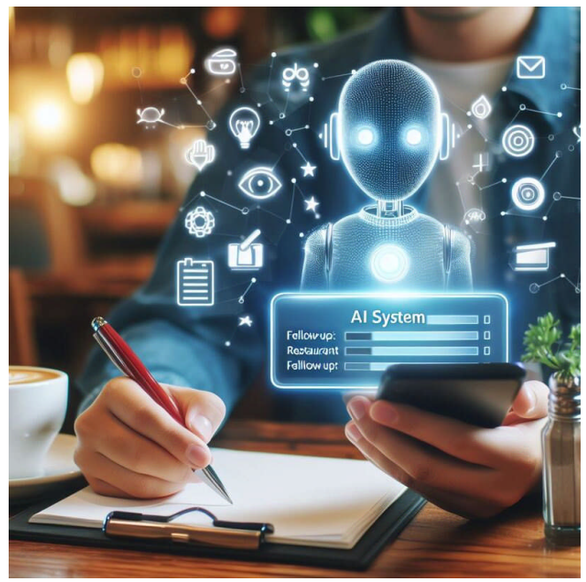
- The problems with knowing feelings by reviews:
  - **The reviews do not represent variations of emotions** through the experience; we can know “what,” but it is hard to know “how” clearly.
  - **People do not write reviews during the experience.** They usually write them in their homes after the experience: sometimes, **we recall only the most impressive things**.

AI systems may be capable of supporting people in writing reviews through follow-up interactions

But, it is still subjective ones.
Is it “a real feeling” during the experience?



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Roger Tilley
Sandia National Laboratories

- **Observations on The Sensing/Networking Theme with a focus on Mobile Devices, Internet of Things (IOT), Sensing Systems, and Data Processing.**
- **I found the following article which I feel summarizes the current challenges in the industry – "Sensor Networks, Data Processing, and Inference: The Hydrology Challenge"**

  A. Zanella, S. Zubelzu and M. Bennis, "Sensor Networks, Data Processing, and Inference: The Hydrology Challenge," in *IEEE Access*, vol. 11, pp. 107823-107842, 2023, doi: 10.1109/ACCESS.2023.3318739

- **In this paper the claim is "that information and communication technologies (ICTs) with Machine Learning (ML) Technologies are instrumental in developing more accurate hydrological models and effective water management strategies…" It discusses -**
  - ***Data Collection problem – data too sparse in time and space to provide for better information content of for modeling critical phenomena. Data is too regular in frequency and the content does not cover adequately critical events. Highlighting the need for better planning & use of sensors, adaptive sampling techniques to increase the quality of collected data.***
  - ***Data Processing – Once collected the available data is often of low quality (uneven, unbalanced and noisy) and must be processed to limit the amount of low quality data for refinement of models (in there case Hydrological models); reducing the size of the data sets, removing the outliers, aligning the generated time series of different sources, producing more representative data sets before presenting them to an ML algorithm (the flavor of the month is Artificial Intelligence – AI).***
  - ***Data Visualization problem – Develop methodologies to facilitate the reading and interpretations of patterns like 3D visual models, dynamic maps and augmented reality.***

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Roger Tilley
Sandia National Laboratories

- **This article proposes to be an introductory guide to the state of the art of Sensing/Networking and to many open challenges and I think it succeeds in that effort.**
  - **We are concerned about Sensing system types performing data collection around specific events we are trying to model.**
    - **Types (not inclusive list) --**
      - Satellites
      - IOT sensing devices
      - Mobile vehicles
      - UAVs (unmanned aerial vehicles)
      - Ground sensors
  - **Concerned with using mobile devices to predict phenomenon, control outcomes, and processing large amounts of data attempting to use AI as a catch all solution to the Sensing/Networking issues.**
    - Which, where and when sensing measurements shall be taken.
    - Practical real time monitoring of processes minimized by operational costs, logistic issues like deploying large fleets of UAVs to remote locations to monitor short term events.
    - Develop methodologies to dynamically adjust the sampling frequency, the location of detection nodes to better predict the occurrence of extreme events.
    - Determine how we combine the various sources of data to use in our database (time & position synchronization).
    - What other challenges should we be concerned about solving?