NetWare 2024 & SocSys 2024

PANEL #3

Trends in Sensors and Sensing Data Processing

Panel #3

NICE
FALL 2024

Moderator

Prof. Dr. Sung Ho Cho, Hanyang University, Republic of Korea

Panelists

Prof. Dr. Manuela Vieira, CTS-UNINOVA, Portugal
Prof. Dr. Valentina Zhukova, UPV/EHU, Spain
Prof. RNDr. Rastislav Varga, DrSc. RVmagnetics a.s., Slovakia
Prof. Dr. Paula Louro, ISEL-IPL/CTS-UNINOVA-LASI, Portugal

Chair Intro

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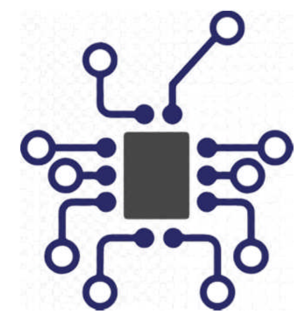
Trends in Sensors and Sensing Data Processing

- **Advancements in Sensor Technologies**
  - » **Types of Sensors:** The latest developments in sensor technologies, such as MEMS (microelectromechanical systems), optical, wireless, wearable, bio, and environmental sensors.
  - » **Miniaturization of Sensors:** How advancements in nanotechnology and MEMS are enabling smaller, more efficient, and lower-cost sensors for a variety of applications.
  - » **Sensor Accuracy and Sensitivity:** Improvements in the precision and reliability of sensors, which are critical for accurate data collection.
- **Sensor Applications in Various Industries**
  - » **Healthcare and Wearables:** Use of bio/medical sensors in medical diagnostics, patient monitoring, and fitness trackers.
  - » **Industrial IoT and Smart Manufacturing:** The role of sensors in automation, predictive maintenance, and improving production efficiency, and human security/safety.
  - » **Smart Cities:** How sensors are being used in traffic management, energy grids, pollution monitoring, and public security/safety.
  - » **Agriculture:** Precision farming and environmental monitoring through soil moisture sensors, weather sensors, and drones.
  - » **Autonomous Vehicles:** The importance of lidar, radar, and camera sensors for navigation and safety in self-driving cars.
- **Sensor Networks and IoT**
  - » **Wireless Sensor Networks (WSNs):** The growing importance of WSNs in IoT systems, enabling distributed monitoring and control across a wide range of applications.
  - » **Integration with AI and Automation:** How sensor data is feeding into AI-driven automation systems to enable smarter, more efficient processes in industries like manufacturing, energy, and logistics.

Sung Ho Cho
Hanyang University
South Korea



Chair Intro

- **Data Processing for Sensing Systems**
  - **Edge vs. Cloud Processing:** The balance between processing sensor data at the edge for real-time decisions versus sending it to the cloud for deeper analytics.
  - **Data Fusion:** How combining data from multiple sensors (sensor fusion) can improve accuracy and provide richer insights.
  - **AI and Machine Learning for Sensing Data:** Leveraging AI and ML to process and interpret large volumes of sensor data, enabling predictive analytics and automated decision-making.
- **Challenges in Sensing Data Processing**
  - **Handling Big Data from Sensors:** The explosion of sensor-generated data and the challenges of storing, processing, and analyzing it efficiently.
  - **Latency and Real-Time Processing:** The need for low-latency processing in critical applications like autonomous vehicles and industrial automation.
  - **Power Efficiency:** The challenge of managing power consumption in sensors, especially in battery-operated or energy-constrained environments (e.g., IoT devices, remote monitoring systems).
- **Emerging Trends in Sensors**
  - **Wearable and Flexible Sensors:** Innovations in wearable and flexible sensors for health monitoring, fitness, and smart textiles.
  - **Self-Powered Sensors:** The development of energy-harvesting sensors that can operate without external power sources, using technologies like piezoelectric, thermoelectric, and solar power.
  - **Quantum Sensors:** Potential breakthroughs in sensitivity and accuracy with quantum sensor technologies in fields like navigation, communications, and medical imaging.
  - **5G/6G and Connectivity for Sensors:** How 5G/6G networks are enabling faster and more reliable data transfer for IoT devices and sensor networks, leading to better real-time analytics.

Sung Ho Cho
Hanyang University
South Korea

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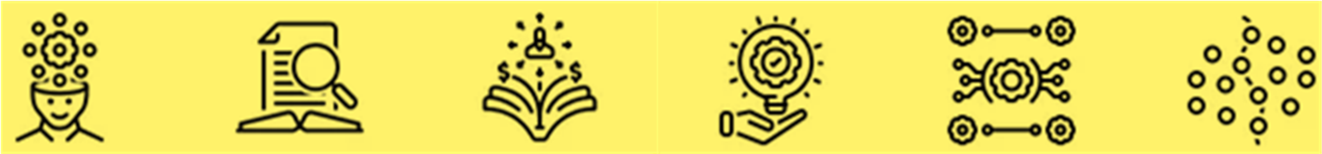
- **Security and Privacy Concerns**
  - **Data Security in Sensor Networks:** Ensuring data integrity and protection in sensor networks, especially in critical sectors like healthcare, finance, and defense.
  - **Privacy in Sensing Systems:** How to balance the need for data collection with privacy concerns, particularly in wearable devices and smart home applications.
  - **Cybersecurity Risks:** The vulnerability of sensor networks to cyberattacks and the potential for exploitation of sensitive data.
- **Sensor Standardization and Interoperability**
  - **Standardization Efforts:** The need for global standards to ensure interoperability between different sensor types and systems across industries.
  - **Open-Source Sensor Platforms:** How open-source frameworks can accelerate innovation and adoption of sensing technologies by promoting collaboration.
- **Business and Economic Implications**
  - **ROI of Sensor Technology:** Evaluating the return on investment (ROI) of deploying sensors in industries like manufacturing, healthcare, and smart cities.
  - **Market Growth and Opportunities:** The expected market growth for sensors and related technologies, and the economic opportunities for businesses adopting these trends.
  - **Monetization of Sensing Data:** How businesses can generate value from the data collected by sensors, either through internal improvements or by selling data to third parties.

Sung Ho Cho
Hanyang University
South Korea



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- **Future Trends and Innovations**
  - **Next-Generation Sensor Materials:** Advances in sensor materials, such as graphene, which offer higher sensitivity, flexibility, and durability for future sensor applications.
  - **AI at the Edge for Sensor Data:** The future of deploying AI at the sensor level to process data locally and reduce the need for cloud-based computation.
  - **Self-Learning Sensors:** How self-adapting sensors that can learn and optimize themselves through AI will play a critical role in evolving sensor networks.
- **Sustainability and Environmental Impact**
  - **Eco-Friendly Sensor Materials:** The development of sensors made from biodegradable or recyclable materials to minimize environmental impact.
  - **Energy-Efficient Sensing Systems:** The role of low-power sensors and energy harvesting in reducing the environmental footprint of sensor networks, especially in remote or large-scale deployments like smart cities.
- **Case Studies and Success Stories**
  - **Successful Implementations:** Present real-world examples where sensor technologies have made a significant impact on operations, efficiency, security/safety, or human wellness.
  - **Lessons Learned:** Challenges and lessons learned from deploying sensor networks in complex or large-scale environments.

Sung Ho Cho
Hanyang University
South Korea

IARIA

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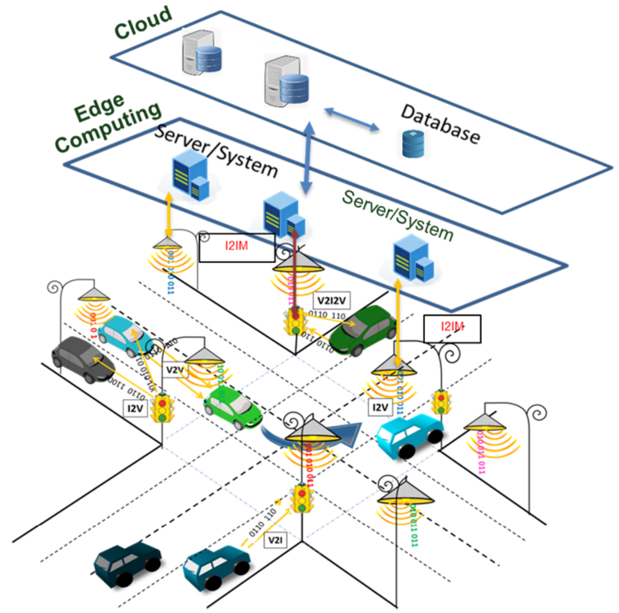
▪Trends in Sensors and Sensing Data Processing using Visible Light Communication (VLC) Sensing



Manuela Vieira
ISEL/CTS/UNINOVA

•Edge Computing for VLC: ,

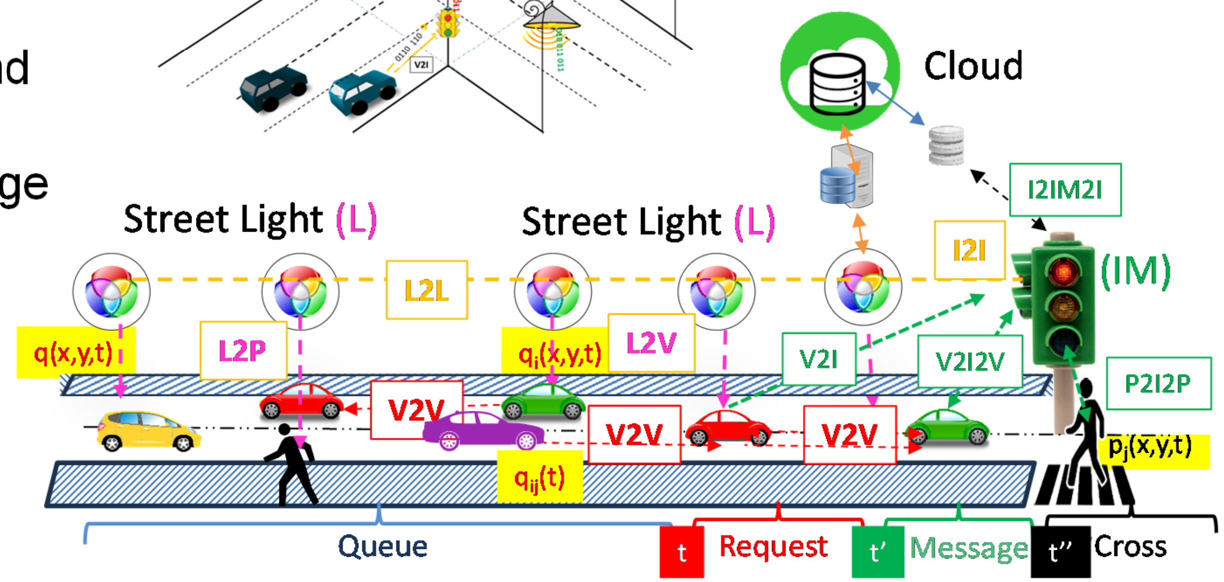
- Implementing edge computing to process VLC sensor data locally, minimizing latency and bandwidth usage. This is particularly crucial for high-speed, real-time VLC applications.

•Real-time Analytics in VLC Sensing:

- Using multiple VLC-enabled devices (such as LEDs and photodiodes) to create a distributed sensing network, improving data collection coverage and precision in large environments like smart cities or buildings.

• Distributed VLC Sensing:

- Analyzing VLC data in real time, enabling immediate response in smart lighting systems, communication networks, or autonomous vehicles.



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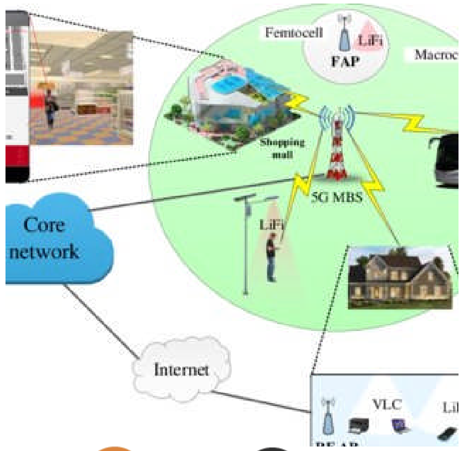
Manuela Vieira
ISEL/CTS/UNINOVA

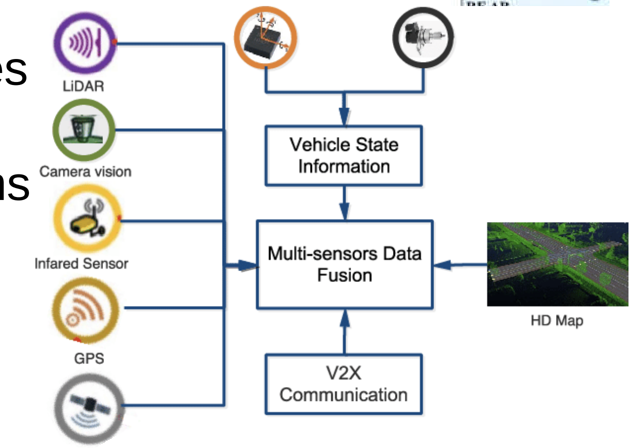
•Hybrid VLC Sensors:

- Integrating VLC sensors with other types of sensors (such as RF or infrared) to improve data transmission and sensing accuracy in environments where VLC may have limitations (e.g., obstacles or lighting conditions).



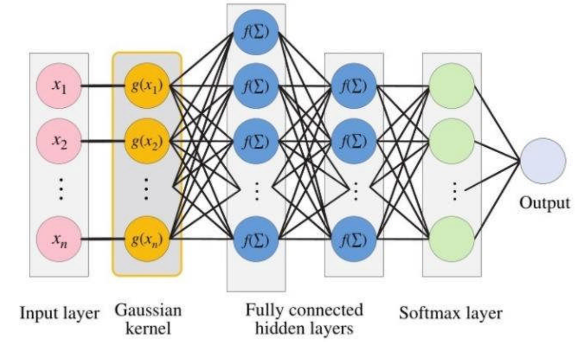
•Data Fusion for VLC Systems:

- Combining VLC sensor data with other sensor modalities (such as motion, temperature, or acoustic sensors) to enhance the overall quality of information for applications like indoor positioning, smart homes, or healthcare monitoring.



• Machine Learning with VLC Sensing:

•Using machine learning models to interpret VLC data for applications such as object detection, gesture recognition, or environmental monitoring, improving accuracy and functionality.



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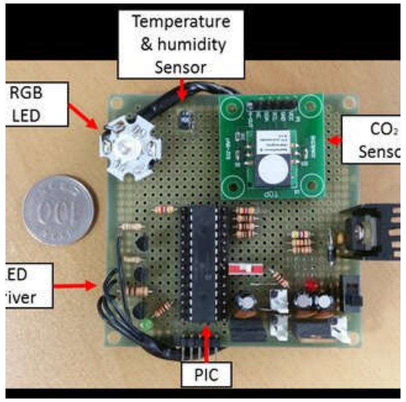
- **VLC Sensor Miniaturization:**

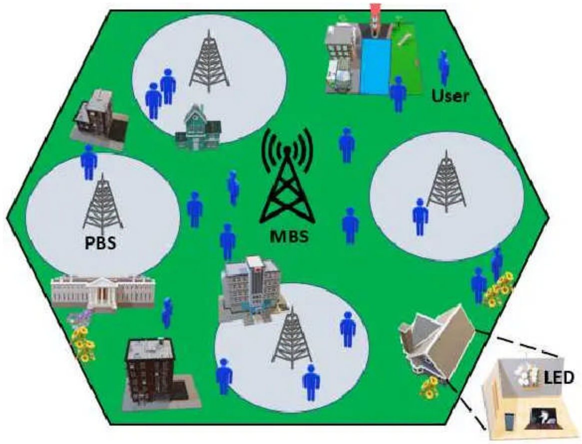
•Developing smaller VLC transmitters and receivers (e.g., miniaturized LEDs and photodiodes), making them easier to integrate into portable devices, wearables, or IoT applications.



Manuela Vieira
ISEL/CTS/UNINOVA

- **Energy Efficiency in VLC Systems:**

•Optimizing VLC systems for low energy consumption, especially in power-constrained environments like mobile devices or battery-powered IoT systems, while maintaining high performance in data transmission and sensing.



By focusing on **VLC sensing**, this list addresses the specific challenges and opportunities in the growing field of visible light communication technology.

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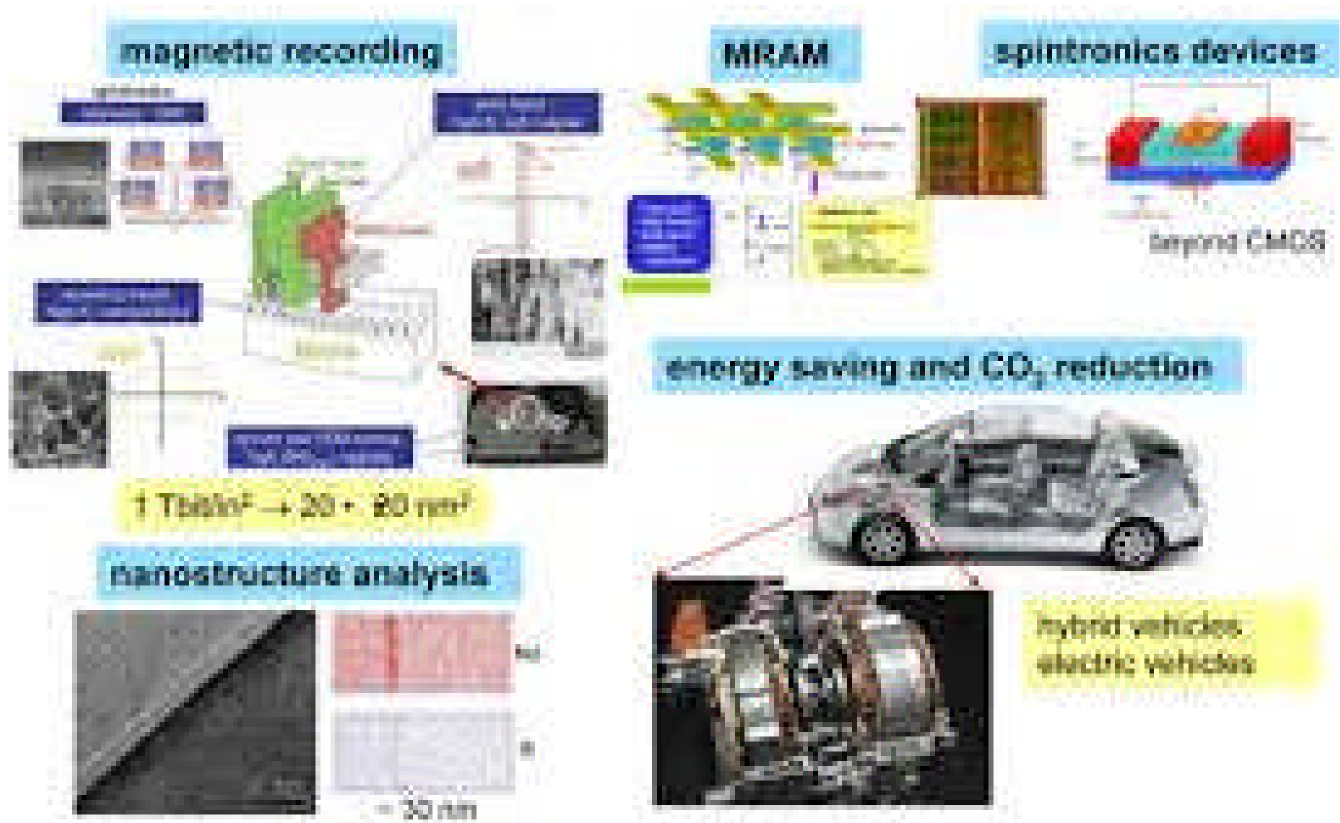
Valentina
Zhukova
UPV/EHU

Trends in Sensors and Sensing Data Processing

Applicaions of Magnetic materials



Magnetic materials for data storage and energy saving by nanostructure control

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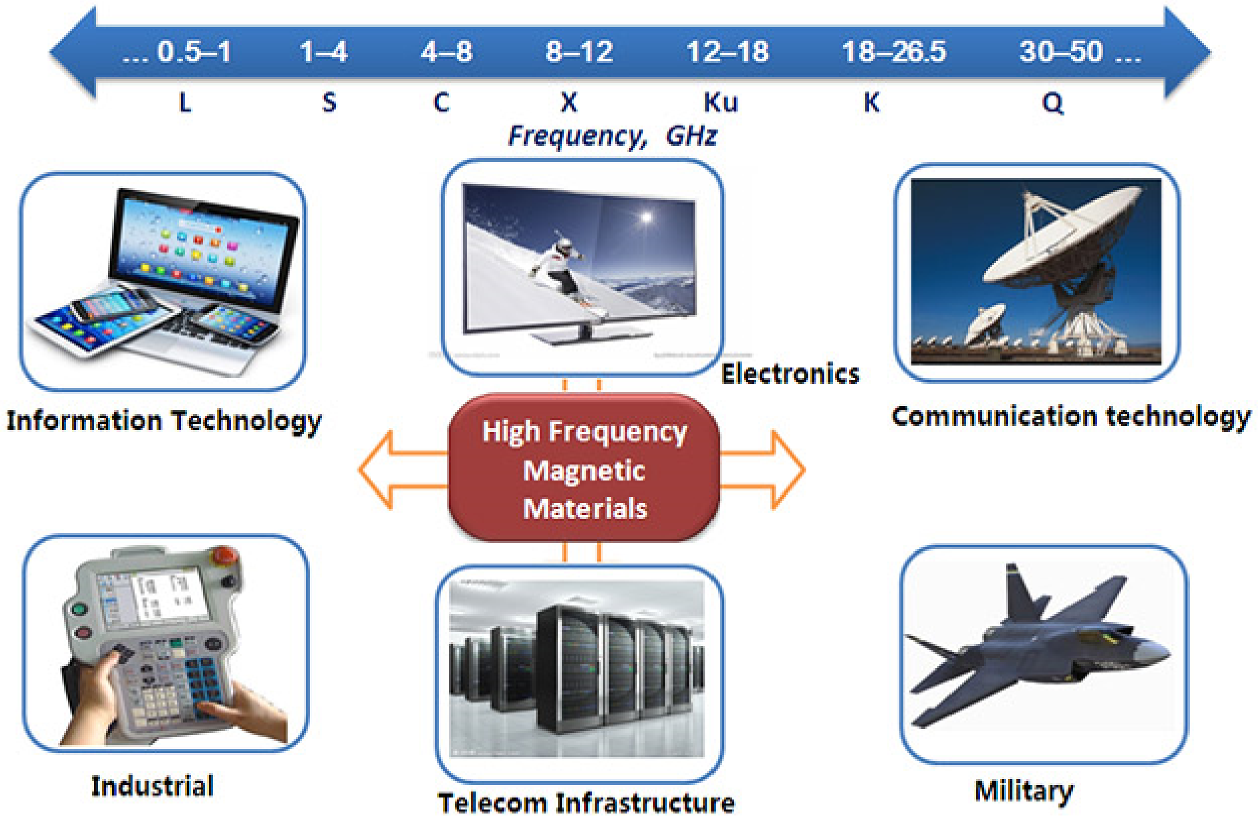
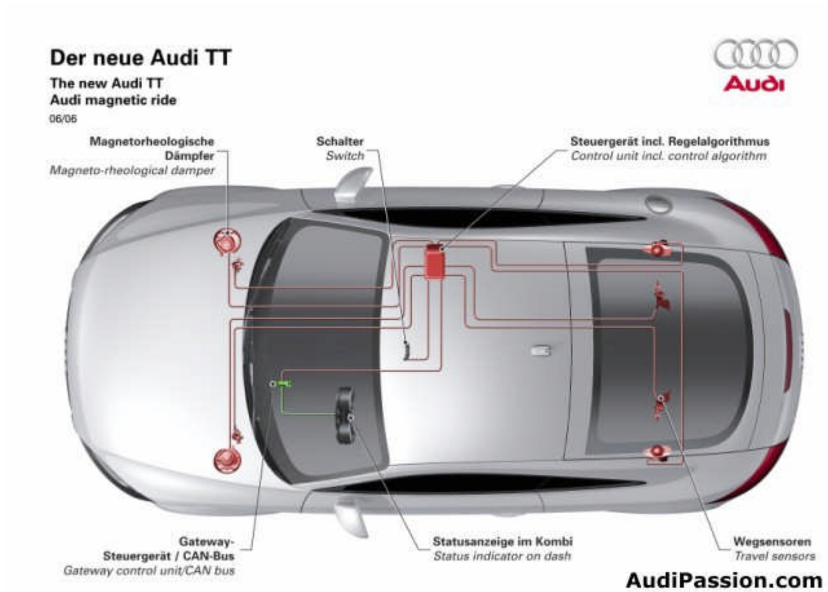
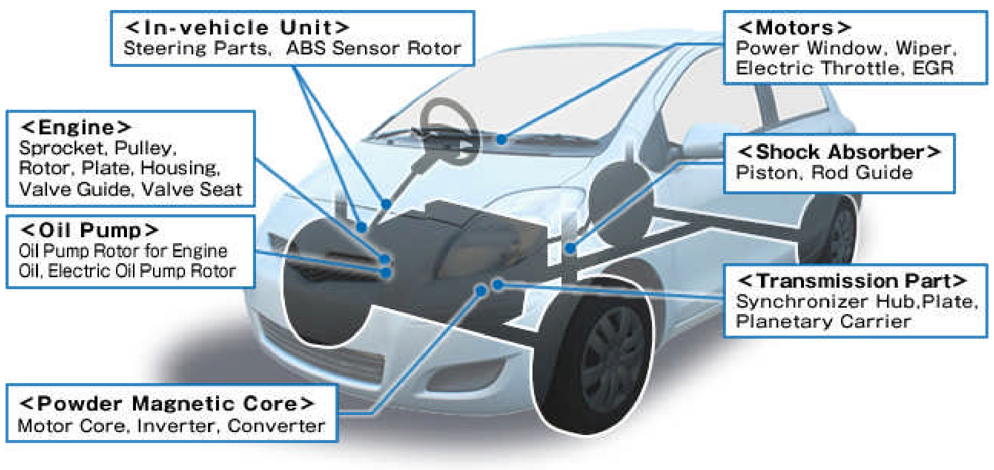
Applicaions of Magnetic materials





Valentina Zhukova
UPV/EHU



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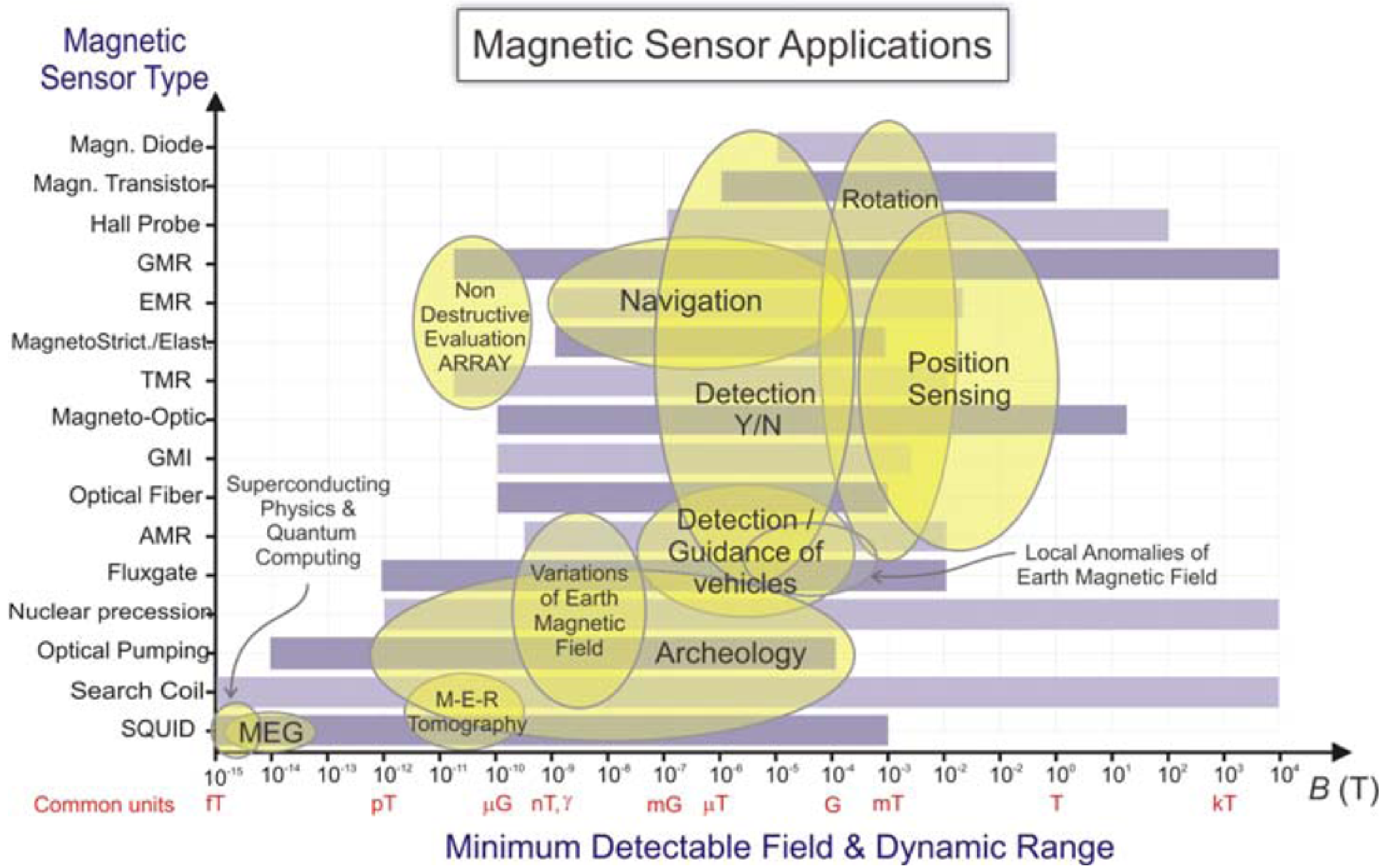

Valentina
Zhukova
UPV/EHU

Source: M. Díaz-Michelena *Sensors* 2009, *9*(4), 2271-2288; doi:10.3390/s90402271

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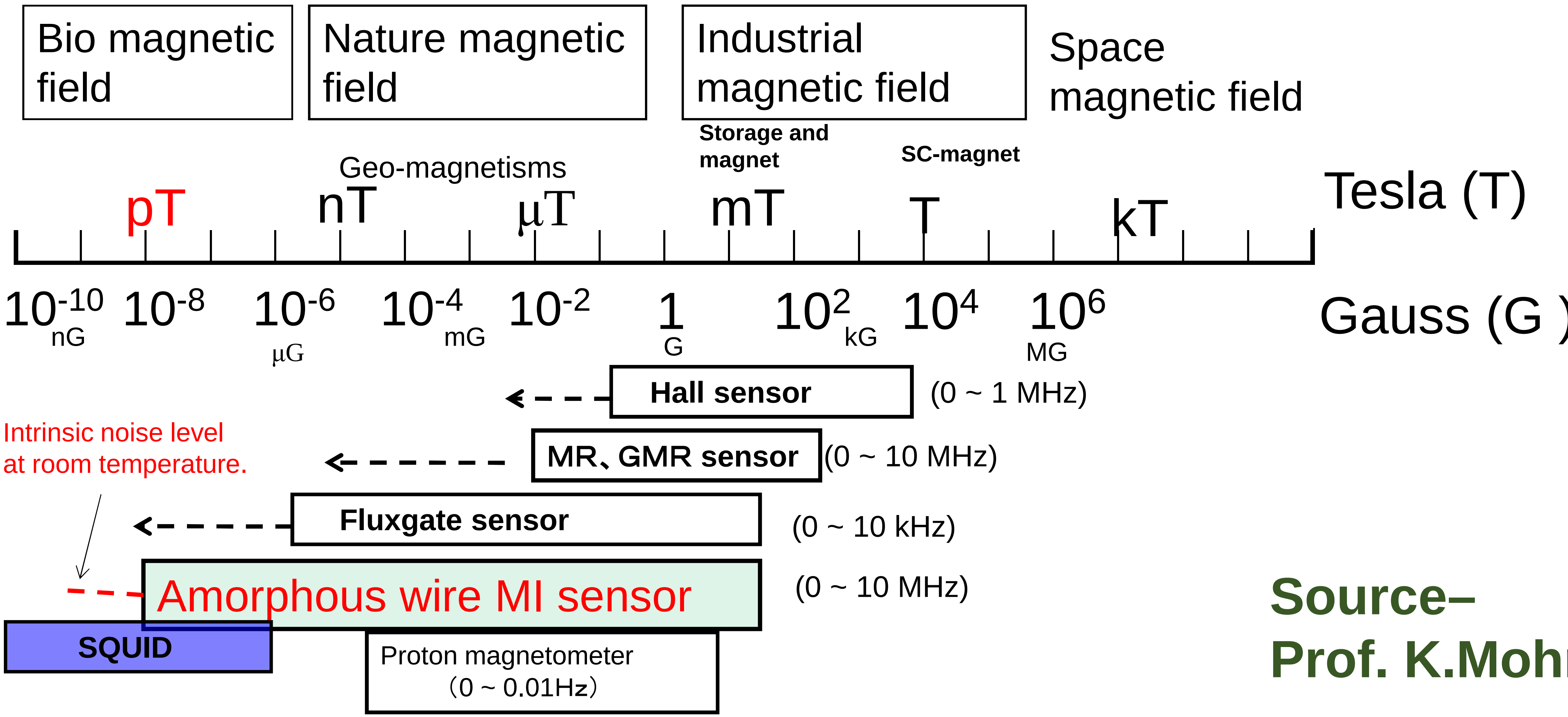
Magnetic Field and Magnetic Sensors



Valentina
Zhukova
UPV/EHU

Source–
Prof. K.Mohri

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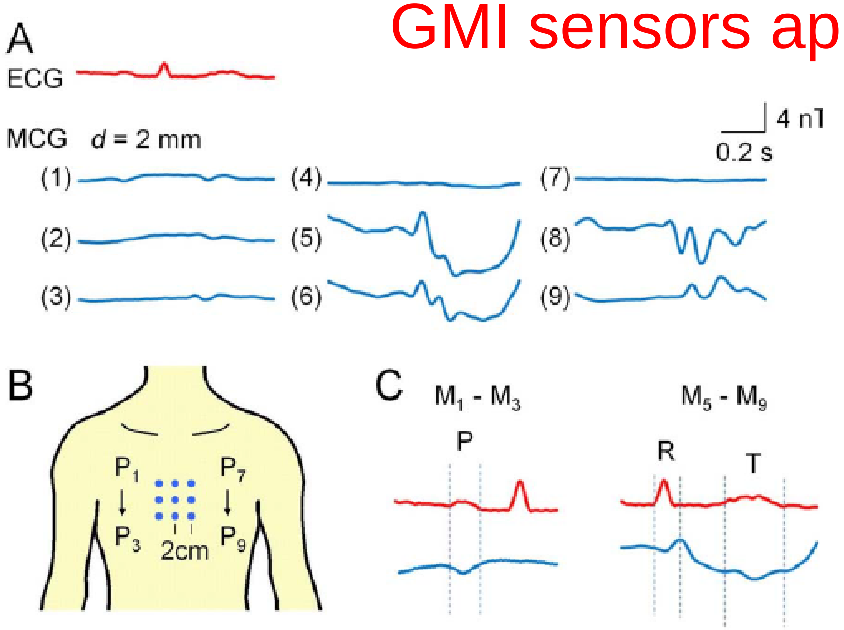
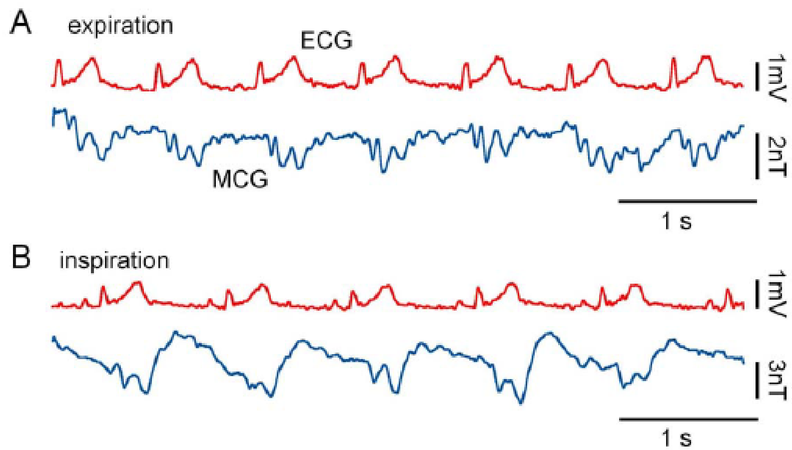
GMI sensors applications for health monitoring





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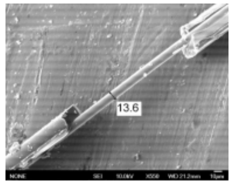
Pulse-Driven Magnetoimpedance Sensor Detection of Cardiac Magnetic Activity

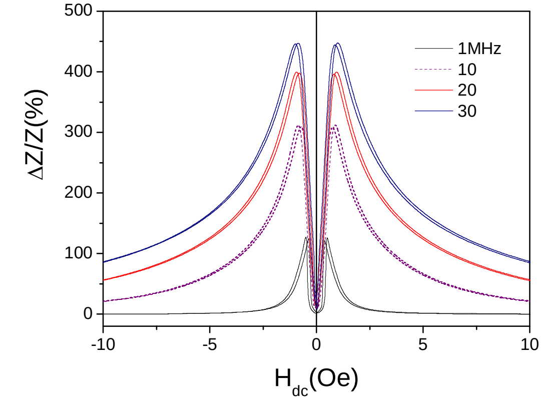
Shinsuke Nakayama[1], Kenta Sawamura[1], Kaneo Mohri[2], Tsuyoshi Uchiyama[2]*

1 Department of Cell Physiology, Nagoya University Graduate School of Medicine, Nagoya, Japan, **2** Department of Electronics, Nagoya University of Graduate School of Engineering, Nagoya, Japan

Valentina
Zhukova
UPV/EHU



GMI en microwires



GMI effect, high sensitivity
450%/Oe: 1 Oe = 0,1 mT)
1% MI change ≈0,0002 mT

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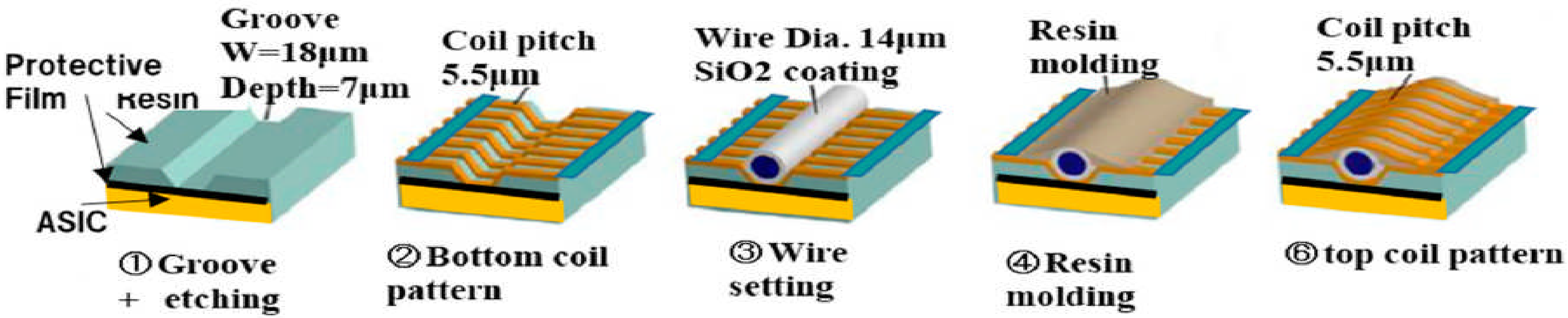
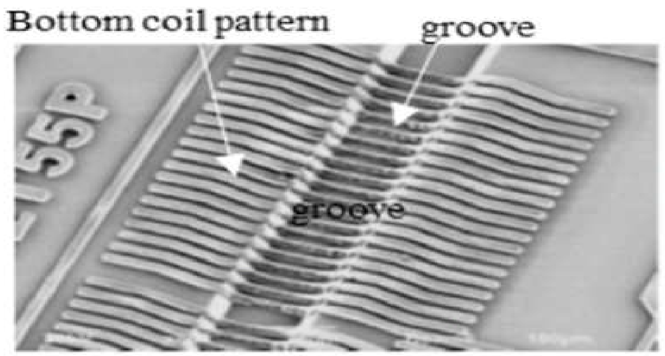
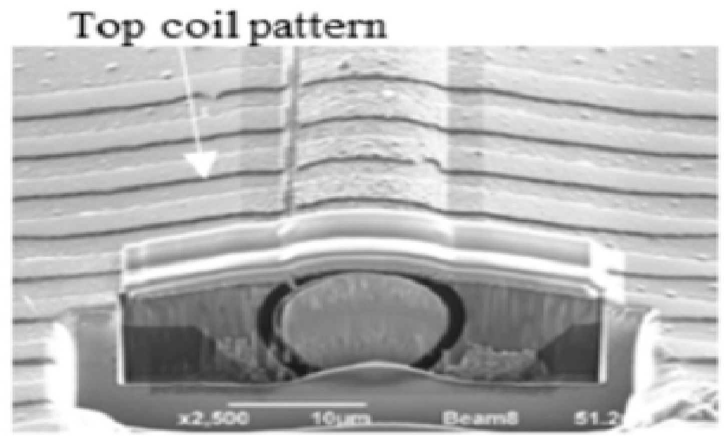
Microwires and compatibility with integrated circuits



Valentina Zhukova
UPV/EHU





sensors MDPI

Article

The Development of ASIC Type GSR Sensor Driven by GHz Pulse Current †

Yoshinobu Honkura [1,*] and Shinpei Honkura [2,*]

Sensors **2020**, *20*, 1023; doi:10.3390/s20041023

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Market overview and latest innovations

Valentina Zhukova
UPV/EHU

The sensor market size was valued at $256.2 billion in 2023 and is projected to grow to $652.2 billion by 2032, exhibiting a significant growth of 17.3%. The increased usage of sensor technology in various applications such as cameras and medical equipment and technological advances in gas sensors are the key market drivers enhancing the market growth.
The sensor market is mostly the domain of a few prominent players attributing to the fast industry growth. These market players are contributing significantly to the market growth by focusing on product innovations.

Conclusions

- Soft magnetic properties and GMI effect can be realized in magnetic microwires
- By appropriate post-processing we can considerably improve GMI effect and magnetic softness in Co-rich magnetic microwires

Panelist Position

- **Trends in Sensors and Sensing Data Processing –**
- **Contactless miniaturized multifunctional sensors.**

Rastislav Varga
Rvmagnetics, a.s.
UPJS

History of Sensors

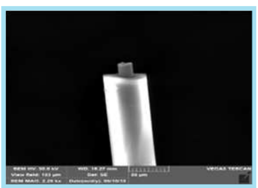
- **Temperature**
  - **Thermocouple – Seebeck 1821**
  - **Thermistor – Faraday 1833**
  - **RTD – Siemens 1871**
- **Stress/pressure**
  - **Strain Gauge – Simmons 1936**

Pros: Precision **Cons: Contacts**

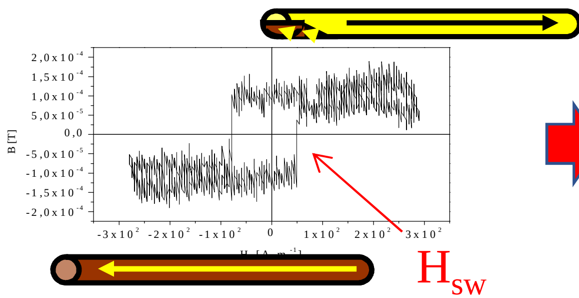
Panelist Position

- **Trends in Sensors and Sensing Data Processing –**
- **Contactless miniaturized multifunctional sensors.**

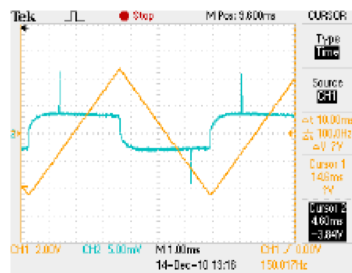
- **Contactless sensor based on magnetically bistable microwires**



Composite /magnetic materials

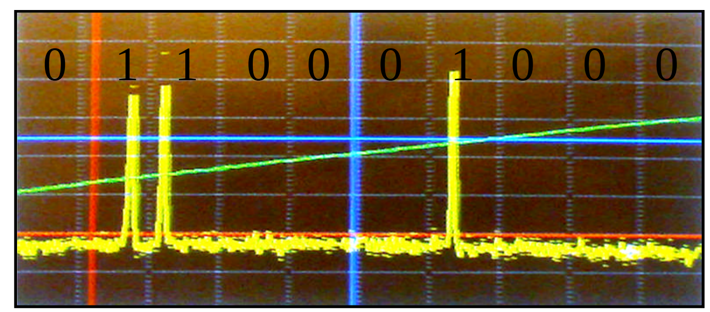


Bistability=> Switching sensitive to:
Temperature
Stress / torque, humidity, vibration
Magn. Field/ position, current



Separation possible

Rastislav Varga
Rvmagnetics, a.s.
UPJS



Single sensing system = multiple parameters / distribution

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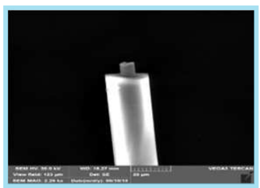
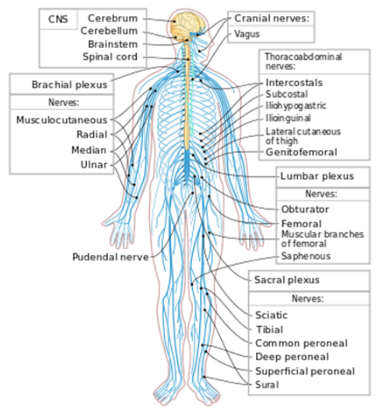
- **Trends in Sensors and Sensing Data Processing –**
- **Contactless miniaturized multifunctional sensors.**

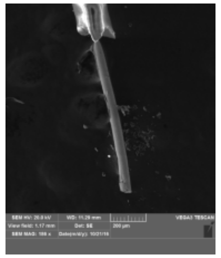
Rastislav Varga
Rvmagnetics, a.s.
UPJS

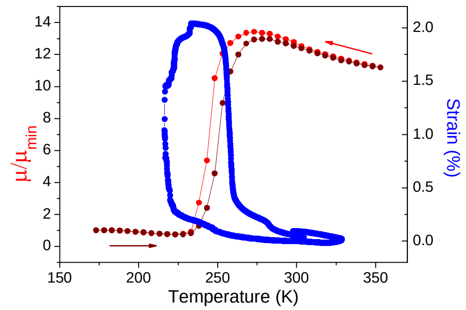
- **AI (brain) / Sensors (nerves)**

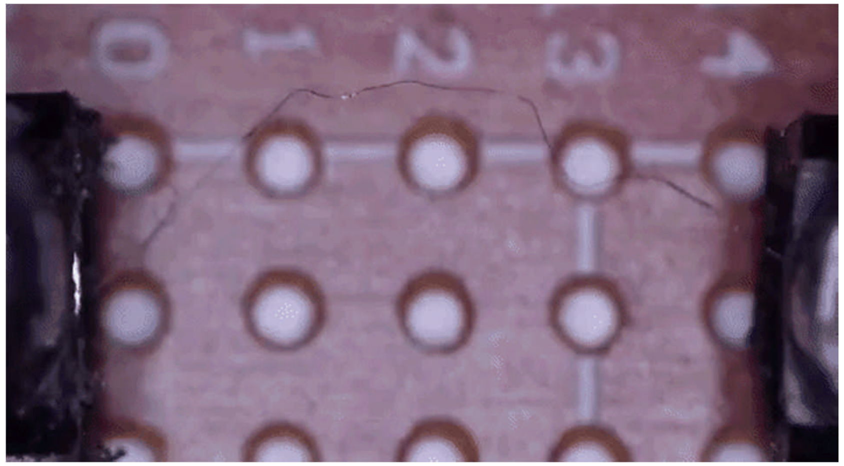




- **+ Shape memory = muscle**







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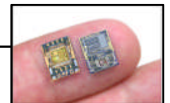
Paula Louro
ISEL-IPL
CTS/UNINOVA

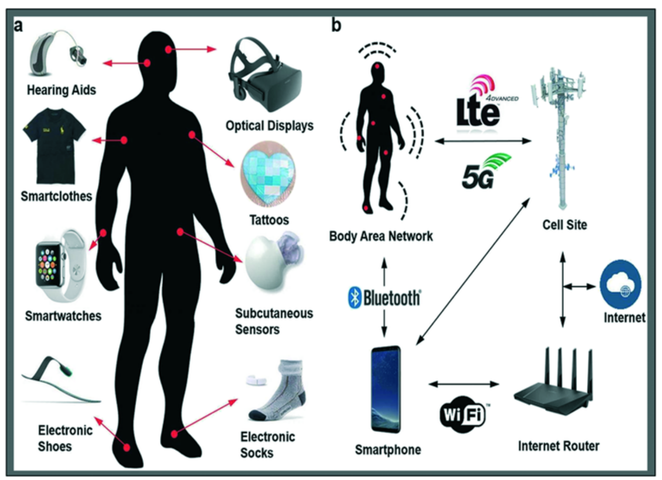
TRENDS IN SENSORS AND SENSING DATA PROCESSING

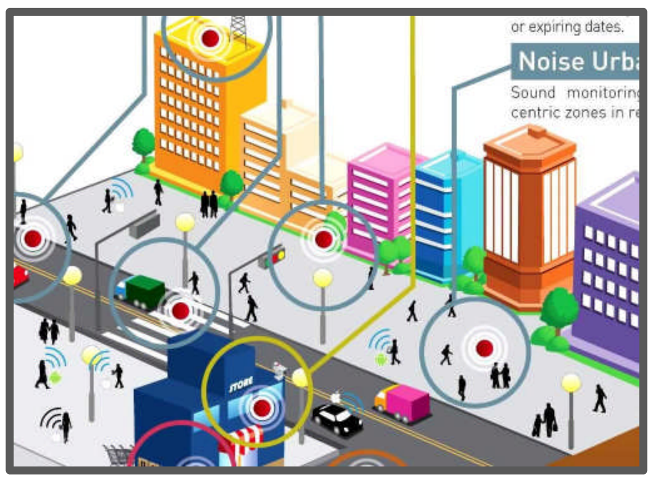


Miniaturization of Sensors: Sensors are becoming increasingly **smaller and more integrated**, allowing for deployment in a wide range of environments and applications: **wearables, IoT, smart environments.**

Wireless Sensing Technologies: The shift towards **wireless sensors and networks** is enhancing **flexibility**, enabling **remote monitoring** and real-time data collection without the need for extensive cabling which reduces installation costs: **Bluetooth, Zigbee**, and **LoRaWAN**.

Advanced Sensing Technologies: The development of advanced sensing techniques such as **optical sensors, biosensors**, and MEMS: higher accuracy and sensitivity, leading to applications in **healthcare, environmental monitoring, and industrial automation**.





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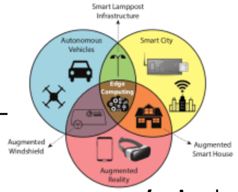
Paula Louro
ISEL/CTS/UNINOVA

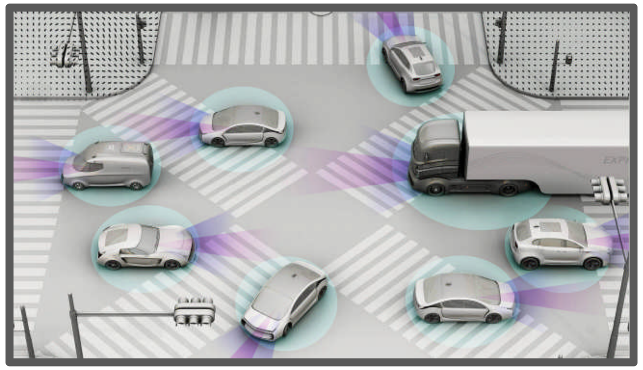
TRENDS IN SENSORS AND SENSING DATA PROCESSING

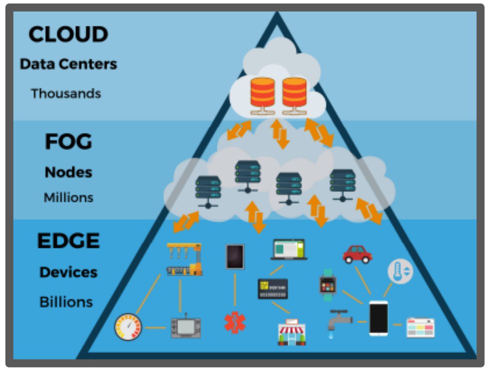
Data Fusion and Integration: Combining data from **multiple sensor sources** to enhance the **accuracy and reliability of information**. This is is critical in applications like **autonomous vehicles and smart cities**, where diverse data inputs must be synthesized for **informed decision-making**.

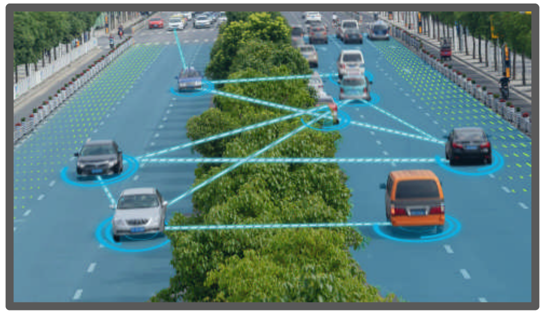


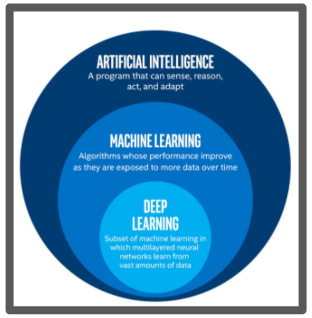
Edge Computing: Processing data closer to the source (at the edge) rather than in centralized data centers is becoming more common. This **reduces latency, lowers bandwidth usage, and enhances real-time processing capabilities**, which is crucial for applications like **industrial automation and smart homes**.

Artificial Intelligence and Machine Learning: Integrating AI and ML algorithms to analyze sensor data is transforming data processing capabilities. These tools enable **predictive maintenance**, **anomaly detection**, and more personalized user experiences in applications like smart healthcare and environmental monitoring









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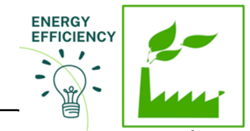
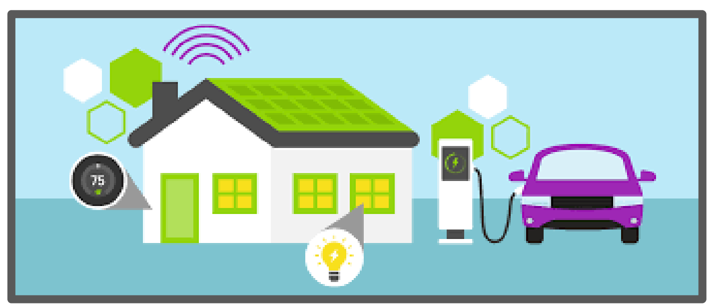
TRENDS IN SENSORS AND SENSING DATA PROCESSING

Paula Louro
ISEL/CTS/UNINOVA



Cloud Computing and Big Data: The integration of sensors with cloud platforms allows for extensive data storage and analysis. Organizations can leverage **big data analytics** to gain insights from vast amounts of sensor data, driving strategic decision-making and operational efficiency) must be synthesized for informed decision-making.

Sustainability and Energy Efficiency: There is a growing focus on developing sensors that are **energy-efficient** and support sustainable practices. Innovations in **energy harvesting and low-power sensors** are enabling sustainable monitoring in agriculture, smart grids, and urban planning.



Regulatory Compliance and Data Security: As sensor usage grows, so does the need for **compliance with data protection regulations and security protocols**. Organizations must prioritize data governance and security measures to protect sensitive information collected through sensors.

Open stage