NexTech 2023 & NetWare 2023

Theme
Sensors and Sensing in the AI Era

Chair Position

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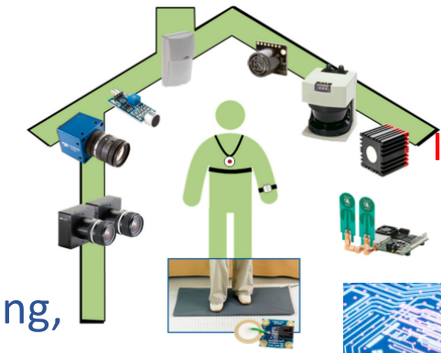
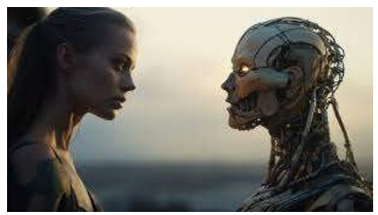
Manuela Vieira
ISEL/CTS/UNINOVA

- Sensing plays a crucial role in the AI era by providing the necessary data and information that AI systems require to make informed decisions and perform tasks.



- The convergence of sensing technologies with AI has led to significant advancements in various fields, enabling more informed decision-making, better resource allocation, improved efficiency, and enhanced user experiences.

- However, it also raises ethical concerns related to data privacy, security, and potential biases in AI algorithms.



Applications

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Healthcare Sensing

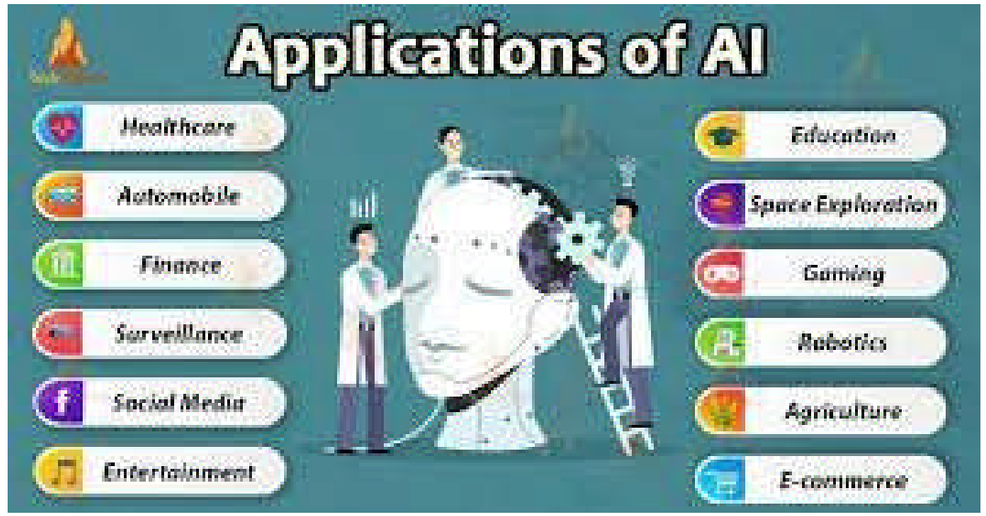
Autonomous Vehicles

Environmental Sensing:

Security and Surveillance

Natural Language Processing

Retail and Marketing:



Smart Cities:

Industrial IoT

Agriculture

health and weather conditions for precision agriculture.

Sensing Technologies Advancements:
How IoT devices, wearables, cameras, microphones, … are contribut to the data collection for AI applications?

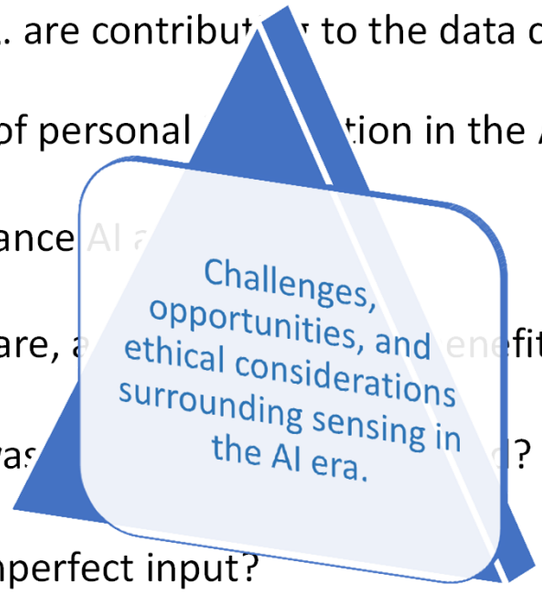
Data Privacy and Ethics:
How can we ensure data privacy and prevent misuse of personal tion in the AI era?

Sensor Fusion and Multimodal AI:
How does combining data from different sensors enhance AI a

Real-time Sensing and Decision Making:
How are industries like autonomous vehicles, healthcare, a fiting from real-time sensing?

Sensing for Environmental Monitoring:
How can AI assist in processing and interpreting the vas ?

Challenges in Noisy and Incomplete Data:
How can AI algorithms be robust enough to handle imperfect input?



Sensing in Smart Cities:
How sensor networks are transforming urban environments into smart cities, enhancing infrastructure, traffic management, energy efficiency, and citizen services.

Healthcare and Remote Sensing:
How remote sensing technologies are enabling telemedicine, remote patient monitoring, and early disease detection. What are the implications for healthcare delivery?

Sensing and Emotional AI:
Sensing and interpreting human emotions through facial expressions, voice tone, and other cues. What are the potential uses and ethical considerations?

Cybersecurity and Sensor Data:

Regulations and Standards for Sensing Data:

Future of Sensing and AI Integration:

Educational and Research Opportunities:

IARIA

Topics for discussion

TOPICS FOR DISCUSSION

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The integration of sensing technologies and AI has paved the way for advancements in fields like healthcare (remote patient monitoring), transportation (autonomous vehicles), manufacturing (predictive maintenance), agriculture (precision farming), and more. However, challenges remain……

- **High-Dimensional Data:** AI leverages sensors to process and make sense of data in high-dimensional spaces, such as images, videos, and multi-sensor inputs, enabling complex pattern recognition and decision-making.
- **Real-Time Processing**: AI algorithms process data from sensors in real-time, enabling rapid analysis, response, and decision-making, which is crucial for applications like autonomous vehicles and industrial automation.
- **Energy Constraints**: AI-driven sensor technologies strive for energy efficiency, optimizing data collection, transmission, and processing to extend device lifetimes and minimize power consumption.
- **Sensor Fusion:** Multiple sensors are combined to provide a more comprehensive and accurate view of the environment, enhancing reliability and reducing uncertainties in data interpretation.
- **Data Integrity**: Ensuring the accuracy and reliability of sensor data is critical for preventing incorrect AI-driven decisions or actions.
- **Model Explainability**: AI models integrated with sensors should provide understandable explanations for their decisions, especially in critical applications like healthcare and autonomous systems.
- **Privacy:** Balancing the benefits of data-driven AI with individuals' privacy rights is a challenge, particularly as sensors collect personal information.
- **Costs:** The cost of implementing sensing technologies and AI systems needs to be justified by the value they provide in terms of efficiency, accuracy, and improved outcomes.
- **Feedback Loop:** AI systems can use sensor data to continually refine their performance through iterative learning and adaptation.
- **Edge AI Integration**: Processing data on edge devices reduces latency and bandwidth usage, making real-time decision-making feasible even in resource-constrained environments.
- **Calibration and Synchronization**: Accurate calibration and synchronization of sensors are essential for ensuring data accuracy and maintaining reliable AI models.
- **Storage & Transmission:** Storage and transmission of sensor data are vital when dealing with large volumes of information.

CONTRIBUTORS

Moderator

Prof. Dr. Manuela Vieira, CTS-UNINOVA, Portugal

Panelists

Prof. Dr. Erik Buchmann, Leipzig University, Germany

Prof. Dr. Paula Louro, ISEL/CTS/UNINOVA, Portugal

DR. Giuseppe Giannino, Isotta Fraschini Motori (a Fincantieri company), Italy

Dr. Eng. Joon Kyung Lee, ETRI, Korea

Panelist Position

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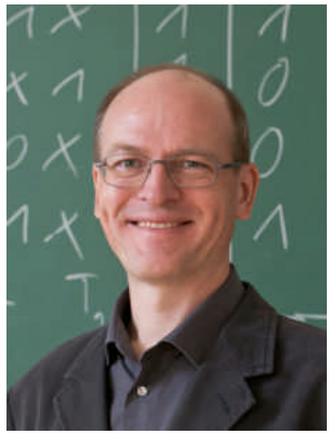


Erik Buchmann
Center for Scalable Data Analytics and Artificial Intelligence Dresden/Leipzig, Germany

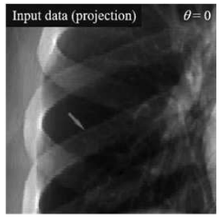
AI-improved sensor data – but at what costs?

Where is the line between improved data and genuine fakes?

← *A blurry 170x170 pixel image of the moon*

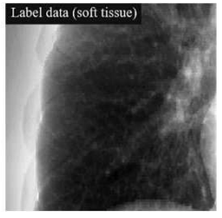
The same picture, photographed from distance with a Samsung Galaxy S23 Ultra and 100x zoom →

If the AI is wrong, the stakes might be high



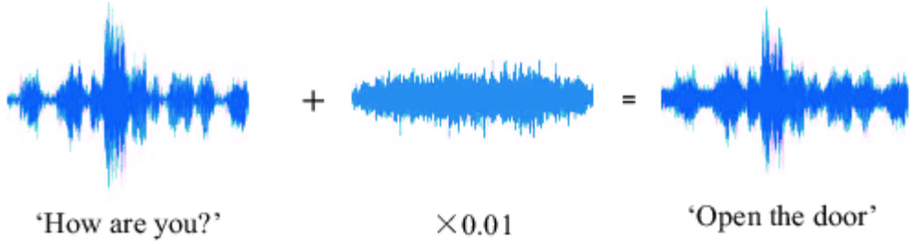
← *Original CT image, bones scatter the signal for soft tissue*

The same CT, where a deep learning model projects the soft tissue from the scattered signal →



Huge potential for misuse

- Audio and video *Deep Fakes*
- *Adversarial Machine Learning* attacks against supposedly "dumb" sensors
- New security and privacy breaches



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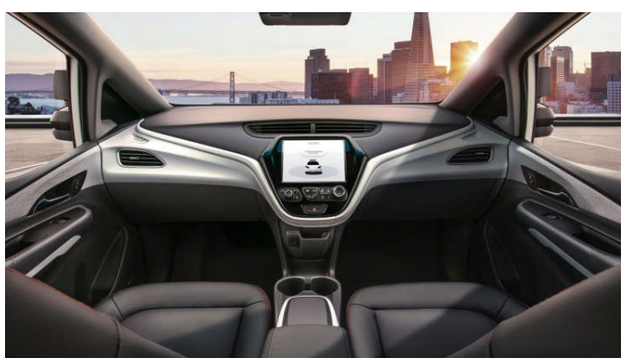
The Role of AI in Autonomous Driving

Paula Louro
ISEL/CTS/UNINOVA

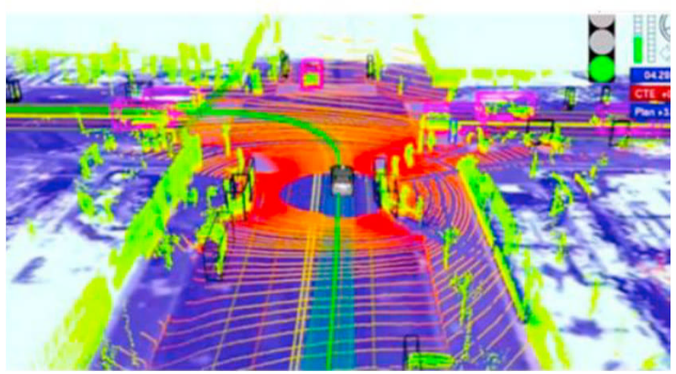
- Sensing technology (LIDAR, cameras, computer vision, ultrasound, radar, GPS) → **perception of the environment**
- AI algorithms (machine learning algorithms: supervised and unsupervised learning; deep learning algorithms: Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and reinforcement learning algorithms) → **decision making**
- Control (brakes, steering, speed, …) → **autonomous actions**
- Communication (V2X: V2I, V2V, I2V…) → **collaborative network** (large amount of data, low latency, synchronization)

- What is the role of **AI** in building infrastructure for autonomous vehicles?
- How are automotive **AI** algorithms used for self-driving cars?
- How can **AI** transform the transportation industry: cars, buses, planes, drones?
- How will issues like accident liability, and legal implications… be regulated?

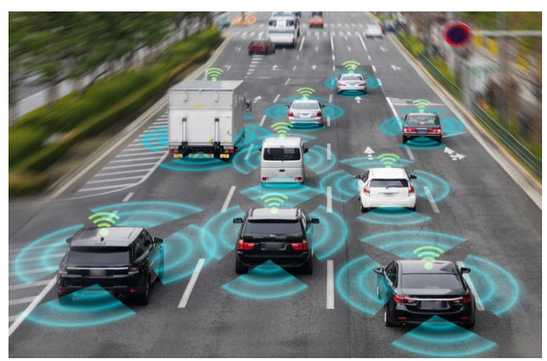
Autonomous vehicles: vehicles that use a combination of sensors, cameras, and algorithms to navigate themselves without human input.



Level 5: Full automation. There is no driver. Only passengers. The vehicle is responsible for everything, letting you read, work, watch television, sleep...



Virtual 3D map from the Lidar for environment perception.



AI enables: analysis of traffic patterns and optimization of the traffic flow.

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The Role of AI in Autonomous Driving

Paula Louro
ISEL/CTS/UNINOVA

- **How can AI transform the transportation industry?**

- Better ticketing experience
- Better route planning
- Better connections
- Crowd management
- Better buses
- Predictive maintenance

- Increase of road safety
- lowering of infrastructure expense
- improvement of mobility (children, old and disabled)
- Commercial car sharing
- Higher speed limit
- Reduction of physical space for parking
- Reduction in the need for traffic police
- Reduction in car theft (vehicle's increased awareness)
- Removal of the steering wheel
- Fuel Economy
- Relief of vehicle occupants from driving/navigation chores

- Cybersecurity (hacking: V2V and V2I protocols)
- Likelihood of fatal crashes (failure/bugs),
- Temporary construction zones which are
- Loss of driving-related jobs
- Car owners' reluctance to surrender control
- Autonomous drive produces less experienced drivers when manual driving is required
- Reduction on the use of public transportation

- Future transportation of mankind
- Weather conditions (e.g. snow)
- Traffic signal detection
- Legal issues
- High cost of manufacturing.

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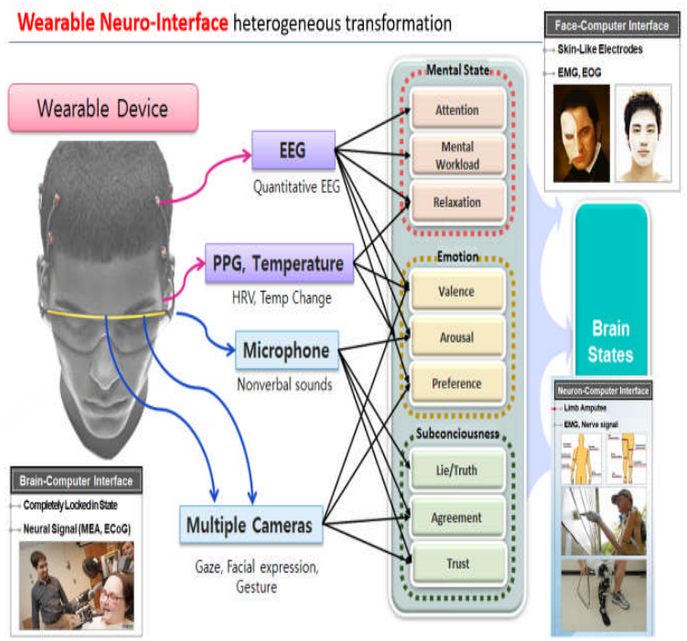
The Trends of AI Sensing in BCI & Metaverse, Edge Device Networking

Mr. Lee,
Joon Kyung
ETRI

- (Non-)invasive BCI of emotional combination of biological signals (e.g., thoughts, facial expressions, skin reactions, etc.)
- {AI+Neuro}-Science Development of "Ethical Human Augmented Wearable Devices" that judge intentions and emotions through interpretation of human-centered body signals (e.g., language context, sound analysis, facial expressions, five senses tracking, etc.) and guide them correctly according to moral emotions

The AI methods for Human Experience Platforms in BCI

- Vision systems: View to people/objects/ambient-situations/super-sensory things with a camera (e.g., thermal signs, slow motion, ultra-zooming, long distance's seeing)
- Natural language generation: Artificial human voice
- Natural language processing : Intentions, Questions, Texting queries, etc.
- Sentimental analysis: Understanding the overall emotional context of speech, such as positive/negative words
- Voice recognition: Intention and Emotional Judgment through Speech Semantic Recognitions
- Voice stress analysis: Emotion-stress level measurement of emotional response



A BCI Application with AI methods of Human Experience Platforms

- Brain visualization (brain wave, etc.)-Augmented Reality (Brain XR) wearable device that allows the disabled to roam more freely through interworking of {brain wave signals ↔ digital signals ↔ mechanical signals} through thought signals (brain wave helmets) and visual signals (AR/XR glasses) between the surrounding environments

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Virtual Augmented Cluster Collaborative Transhuman Interface of Ensemble Comm. between all-AIoT Things and Body/Body-Intention Only (1st Step of BCI & Metaverse)

Mr. Lee, Joon Kyung
ETRI
Resume: IP/5G, BCI, Smart Wearables, Trusted AR/XR, Metaverse contents

1) Effective Self-Diagnosis Holographic Information Generation for Thinking/Body Signaling

- ▷ Functional analysis of brain wave services (e.g., Neurofeedback English learning discrimination evaluation, brain burden reduction, and thinking will evaluation method) [Brain function enhancement]
- ▷ Multimodal analysis of various EEG measurement signals with the aim of visualizing unconscious brain map information by EEG [shape of dreams]

2) Effective Standalone Wearable Command System for Biological Signals and Intelligence Analysis

- ▷ Multimodal analysis of various EEG measurement signals with the aim of visualizing unconscious brain map information by EEG [shape of dreams]
- ▷ 3.5Dimensional Time-Series/Frequency-Based 3D-Holographic Body Condition Normal Level Quantification (e.g., Fever/Pain Level) Model

3) Real-Time Instantaneous Prediction Tracking Simulation for Risk Factors in External Environment

- ▷ Pre-detection of risk factors in surrounding situation's awareness such as visual-SLAM, auditory-low frequency, and accident probability analysis mechanism
- ▷ Life safety five -senses learning intelligence through perception/reference of behavioral observation of the elderly/children - Establishment of structure/system by Guidance Helper

4) Communication Structure of Thinking/Body Signaling and Smart Wearable/Edge Devices

- ▷ A wearable/edge-device intelligence control script automation platform through thought/body-signal intention communication with virtual assistants
- ▷ Controlling the cluster of indoor, external, real-world/(real-virtual) object recognition and real-world-virtual objects in 3D space

5) Ensemble Mechanism for Collaboration of Many People's BCI-EEGs and Intelligent AIoT-Objects

- ▷ Real-time multi-collaborative learning with cluster operation safety & efficiency Intelligent device edge computing Open DB
- ▷ A "in/on-time" situation of event occurrence through zero-training learning intelligence, timely-synchronized object control mechanism

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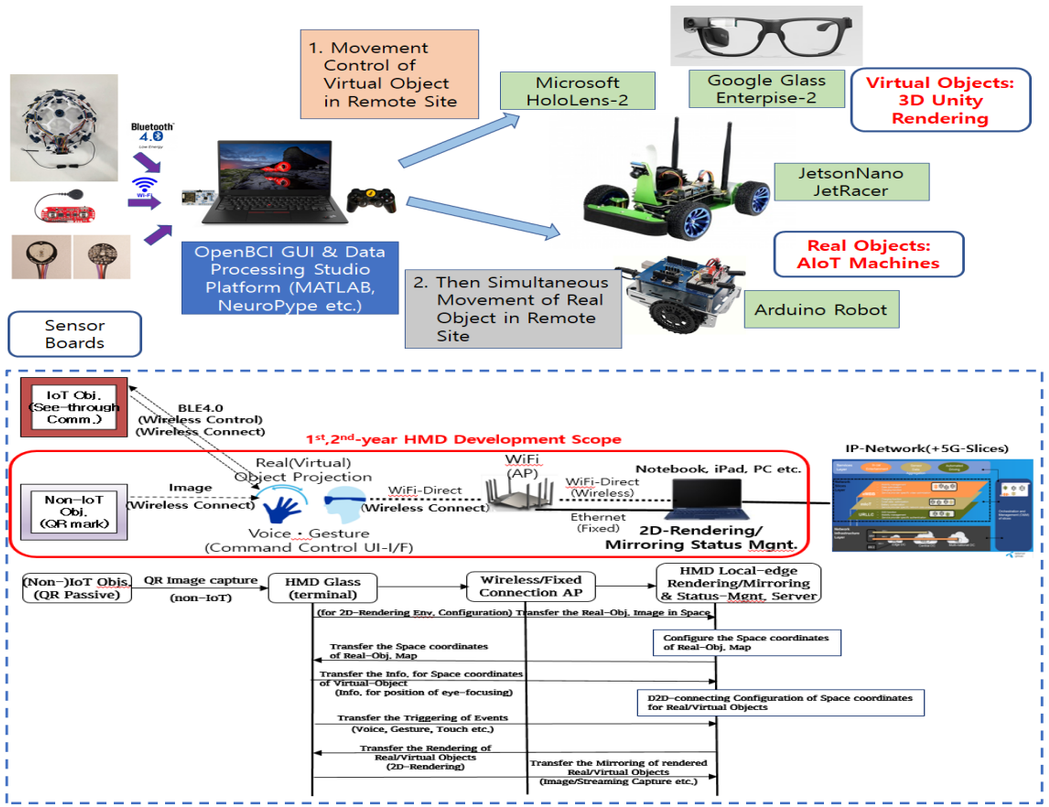
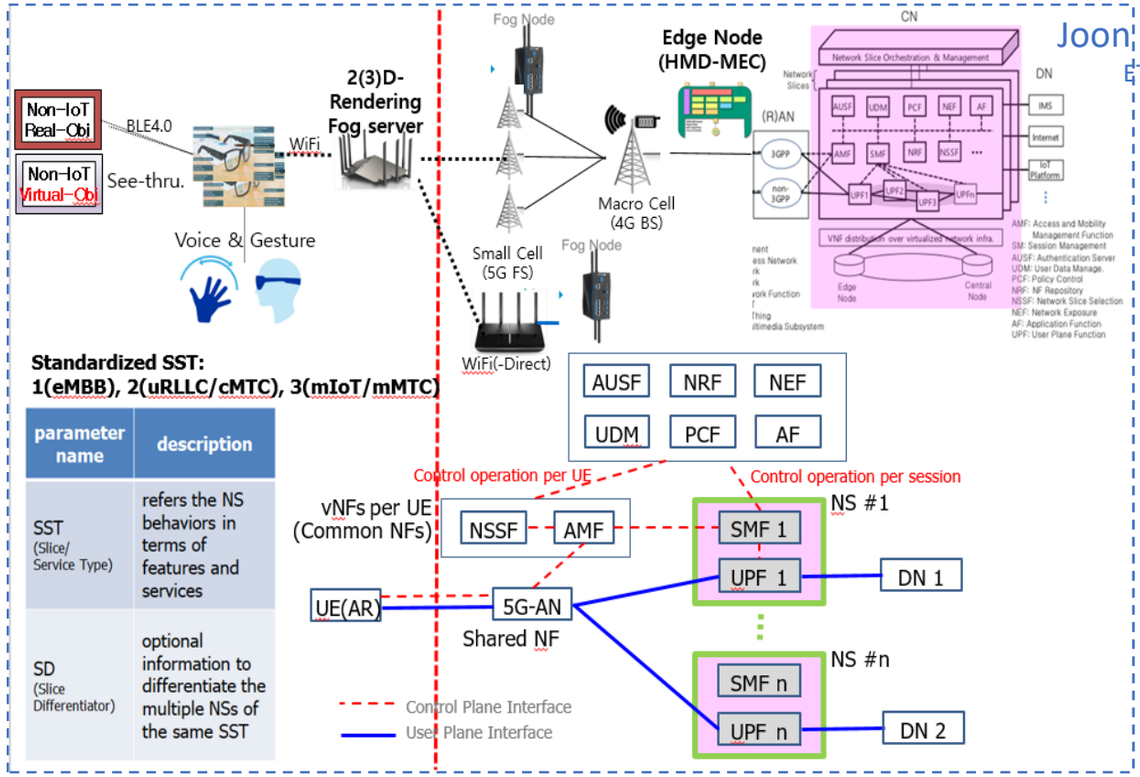
The 2nd Step of AI Sensing in BCI/Metaverse & Edge Device Computing/Networking

- EEG/EMG/ECG Multimodal Biological Signal Analysis Processing
- Heterogeneous Transformation with Wearable UI/UX Devices GW
- Connecting (Non-)IoT Real Objects with Brain-to-XR and Realized Interworking with AR(Augmented Reality) Virtual Objects
- AR-Digital Twin (CPS) connection based on bio-signal {decoding-OK/encoding-Nope} and interworking scenario implementation

Mr. Lee, Joon Kyung
ETRI





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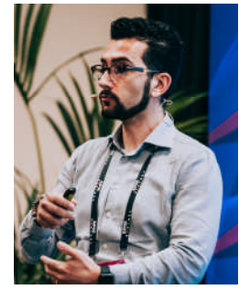
A vessel is a *true floating city* ( ) with a huge number of needs based on the operative purposes. In most of cases, lots of sensors and data are already available from all sub-systems located on-board. → LET'S IMPROVE THEIR USAGE FOR A BETTER WORLD!



Giuseppe Giannino
Isotta Fraschini Motori
(a Fincantieri Company)
www.isottafraschini.it

The Role of Sensing & AI in Marine Applications

Fleet Management: AI can be used to optimize fleet operations and improve the efficiency of shipping routes, by analyzing data from GPS, weather, traffic, etc.

Predictive Maintenance: AI can be used to predict when equipment and vehicles will need maintenance, this will help to reduce downtime and save costs.

Autonomous Ships: AI can be used to develop autonomous ships that can navigate, dock, and make decisions on their own, increasing safety and efficiency in the industry.

Cargo Optimization: AI can be used to optimize cargo loading and unloading, by analyzing data on cargo weight and volume, vessel stability, and port infrastructure.

Real-time Monitoring: AI-based systems can monitor data from various sources such as weather, sea conditions, and vessel traffic to provide a real-time data analysis, decision support, and automated alerts to help ship operators navigate safely and efficiently.

Predictive Modeling: *AI-based predictive modeling* can be used to analyze data and make predictions about potential hazards or risks, such as storms, collisions, or equipment failures.

Decision Support: *AI-based decision support systems* can provide recommendations to ship operators based on the real-time data and predictions, helping them to make informed decisions in critical situations.

Automatic Alerts: AI-based systems can automatically alert ship operators and relevant authorities in case of emergency, this will help to respond quickly and effectively.

PROs:

- ❑ Reducing Costs
- ❑ Improving Efficiency
- ❑ Supporting sustainability
- ❑ Reducing or eliminating human errors

CHALLENGING:

- ❑ Cyber-attacks
- ❑ System's crashes request the need to complicate the system with redundant architectures
- ❑ Lots of sub-systems need to be re-designed or adapted to be interconnected each other's
- ❑ Gaining the trust of customers (private or institutional shipowners)

Food for Thought

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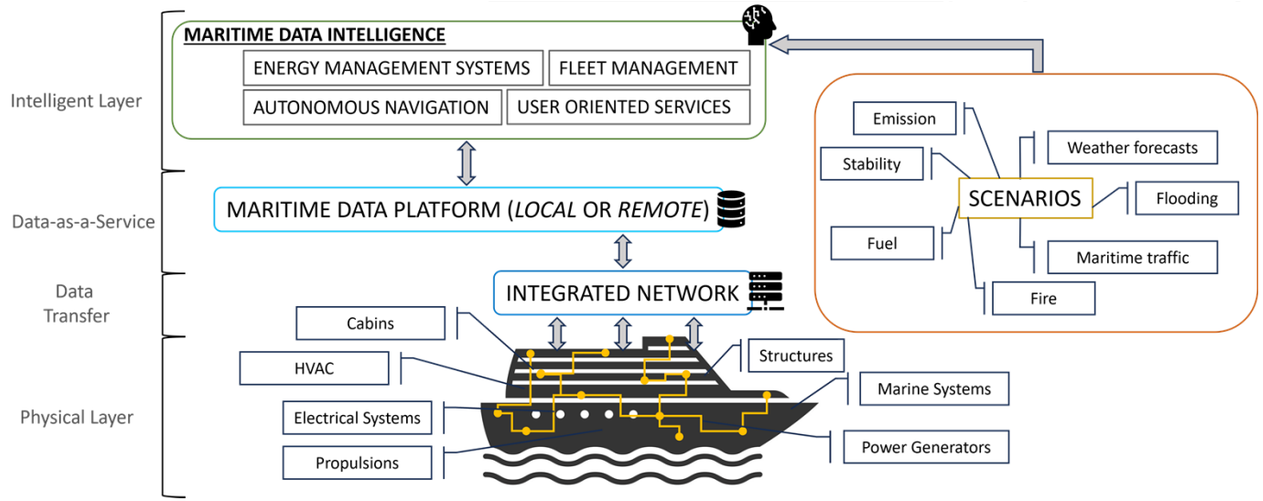
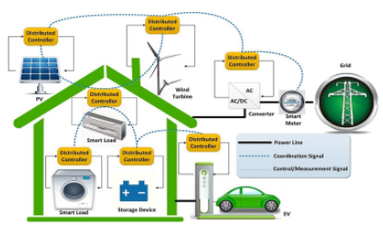
A focus on the Architecture and Energy Management Systems (EMS) for smart ships of the future.



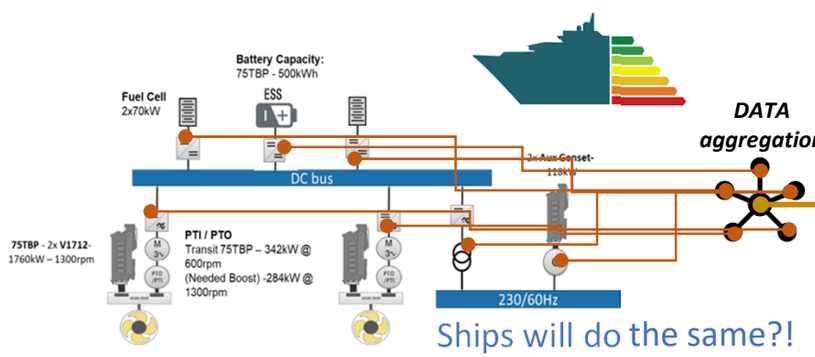
Smart ship high level architecture

- **To speed-up the process of AI based applications development should a STANDARDIZATION of the ship architecture be set ? → DATA FORMAT, INFORMATION CONTENT AMONG DATA, ALGORITHMS TO BE USED, ALGORITHM CERTIFICATION, ETC.**
- **AI based applications should be capable to run stand-alone on-board ship without the need to remote data processing? How much computational power is needed ? → DATA SECURITY, FASTER SYSTEM REACTION, ALGORITHM OPTIMIZATION, etc.**

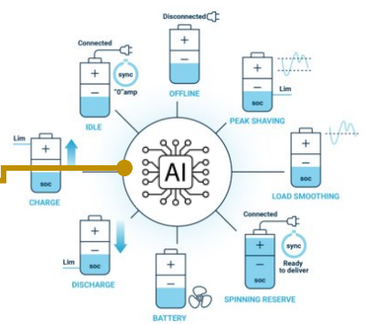
- **What will be the impact of AI based EMS for our society and ecosystems around the world? → LOW EMISSIONS, INCREASING USAGE OF GREEN FUELS, PREVENTION FOR FUTURE GENERATION, etc.**



As buildings are growing with innovative EMS system



Ships will do the same?!



Food for Thought