Alliance for IoT
and Edge Computing
Innovation

Webinar • 14 March 2023

Presentation of AI for better health

AIOTI

Opening and Welcome

Pietro Dionisio, AIOTI WG Health Chair (Medea)

Agenda

Agenda

15.00 **Opening and Welcome (10 min)**

Pietro Dionisio, AIOTI WG Health Chair

15.10 **Presentation of the paper (20 min)**

Pietro Dionisio, AIOTI WG Health Chair

15.30 **Presentation of the paper uses cases &recommendations (30 min)**

Salvatore Tedesco, Tyndall National Institute

Pietro Dionisio, AIOTI WG Health Chair

16.00 **Questions from the audience (15 min)**

16.15 **Wrap up and end of Webinar (5 min)**

Pietro Dionisio, AIOTI WG Health Chair

About
AIOTI WG Health

Pietro Dionisio, AIOTI WG Health Chair (Medea)

Health

Chair
Pietro Dionisio
Medea

Co-Chair
Roumen Nikolov
Virtech

Vision: To build a dynamic pole for knowledge sharing in the domain while acting as a bridge between initiatives that bring added value to healthy living

Scope: to improve the members' visibility, to support members in assessing and forming consortia for HE and DE calls and in defining, implementing and assessing expected value in terms of networking, know-how sharing and creating market opportunities

Highlights

Relevant facts

67 member organisations

91 participants

Main achievements

1. AI for better health white paper
2. HE calls matchmaking and proposal building
3. Building group vision
4. Finding and sharing various funding opportunities with members
5. Collaboration on paper IoT Improving Healthy Urban Living

Priorities 2023

1. Design and lead health session at IoT Week, IEEE World IoT Forum and IEEE COINS 2023
2. HE/DE Proposals submission: at least 2 proposals submitted by consortia composed by WG Health members
3. Produce a reference white paper collecting the vision and best practices by WG members from the following possible topics:
    - Health data & spaces
    - Role of remote monitoring sensors and home monitoring
    - Nutrition, well being and wearables
    - IoT and edge computing to sustain health systems
    - Crisis management in mental health
    - Chronic disease monitoring and life quality improvement
    - How IoT and other technologies (edge, AI etc.) can be accepted by users

Presentation of the Paper

Pietro Dionisio, AIOTI WG Health Chair (Medea)

White Paper
AI for better health (AIOTI WG Health-2022)

- Multidisciplinary was the key → outstanding value with WG Health ….and not only….

Main contributors

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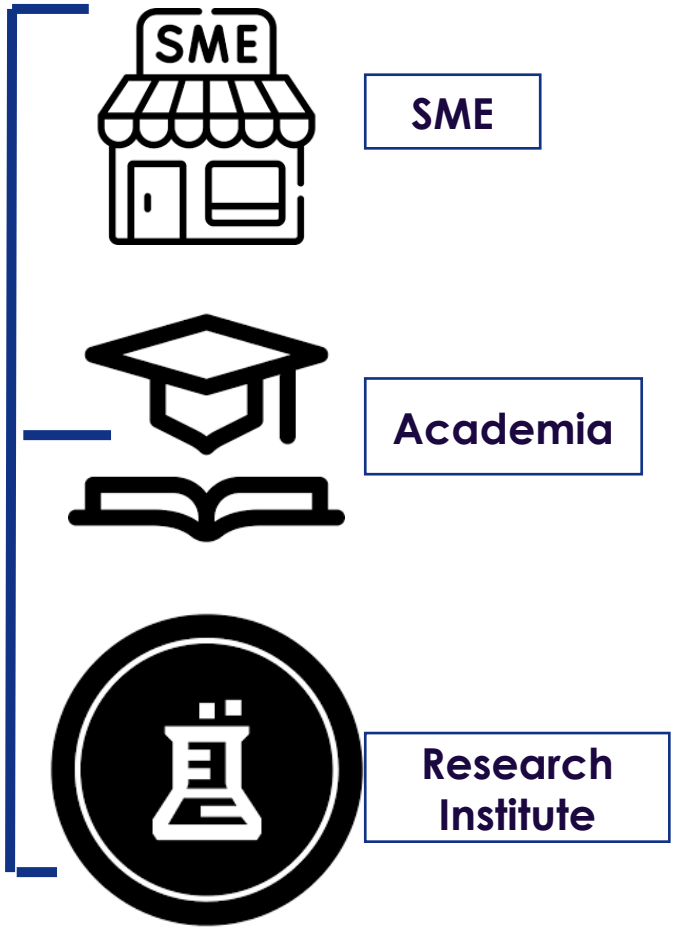

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White Paper
AI for better health (AIOTI WG Health-2022)

White paper objective:

Based on WG Health's members best practices, to share the main perspective, experiences and know-how on specific key issues, opportunities and open points hindering (or supporting) the **AI's wider implementation** in the healthcare domain.

The rationale:

WGs' members are bearers of **needs**, **experiences**, concrete realities belonging to the **real world**

AI for health sustainability

AI in Health

better health monitoring, better diagnoses and more personalized treatments, as well as live a healthier and more independent life

To address....

Ageing population and chronic diseases

Lack of health personnel

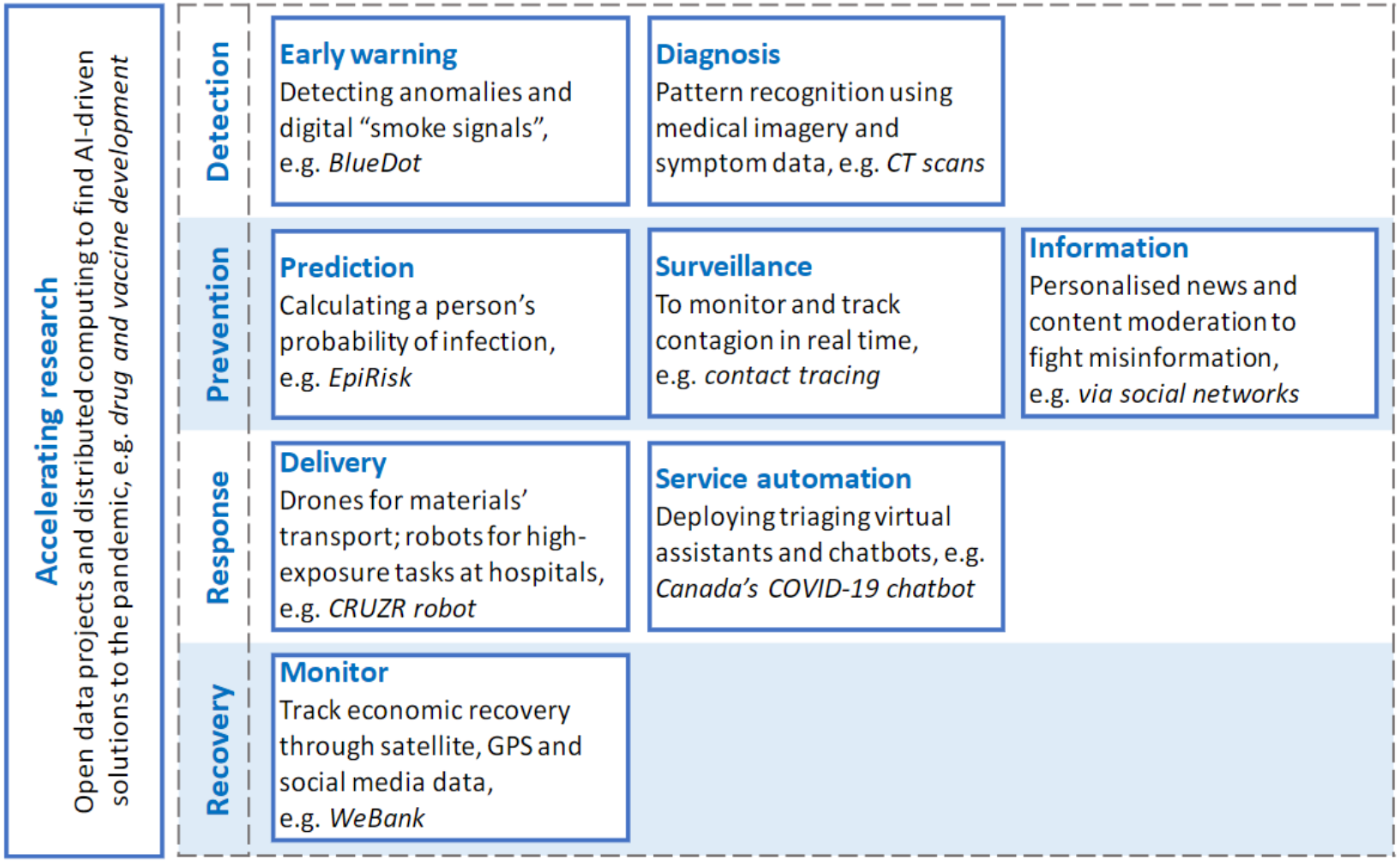
Sustainability

Inefficiency of healthcare systems

Healthcare inequities

COVID-19's impact and the push towards AI implementation strategies

AI tools and technologies are employed to support efforts of policy makers, the medical community, and society at large to manage every stage of the crisis and its aftermath: **detection**, **prevention**, response **recovery** and to accelerate **research**.



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AI adoption into the healthcare domain

AI algorithms errors due to exs: data shift between AI training data and real-world data, unexpected variations in clinical contexts and environments

Risks…

…

Lack of transparency and trust: lack of understanding and trust in AI

there are no policies within those strategies targeting healthcare in particular.

BUT

AND

…

EU **Member States have developed AI strategies** that identify healthcare as a priority sector

Privacy and security issue: risk of data being exposed, shared without any consent, re-purposing, etc.

The **lack of trust in AI-driven decision support** is hindering the wider adoption, while issues around integrating new technologies into current practice are also prominent challenges identified by relevant stakeholders in EU MS

Obstacles to implementation in real-world healthcare: limited data quality, lack of clinical & technical integration and interoperability of AI with existing clinical workflows

Misuse of medical AI tools: lack of training, lack of digital literacy among patients….

Gaps in AI accountability: Legal gaps in current regulations, lack of ethical and legal governance for AI

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AI, limitation and the vision for a future better health

Opportunities:

- To study, **analyze and model the use of health resources and processes** in order to propose improvements that allow their efficient use. In hospitals, healthcare centers,
- Study of the **incidence and the factors** that most influence a disease for prevention purposes
- To study the **characteristics of chronic** and elderly patients to define patterns for improving care
- **Management and consumption of medical material** in order to propose optimization strategies
- **To analyze the medical treatments** that are being applied in the different health areas

Challenges:

- **Explainable AI:** difficult to explain its decision to the physicians. This aspect is critical to increase the confidence in these technologies.
- **Unbiased decisions:** AI bias is an important limitation in order to use AI systems in health. This bias limits the applicability of these systems in different contexts.
- **Frugality:** the performance of AI systems depends strongly on the quality and quantity of data used to train them. There are many health applications where it is not possible to work with all the necessary data.

AI and Ethics

The healthcare domain is a really complex ecosystem ….

- Data management for sensible data and other regulations that will affect the data usage of the health data (e.g., Data Act)
- Cybersecurity requirements,
- HIS systems integration requirements (See IEC 80001-1:2021

Some/Few specific challenges

Aware patient: they decide of their own health data and how information can be shared

Physicians's digital literacy: they have to understand the new tools they are going to use.

Auditory principle: With the AI and the explainability "restrictions", a challenge may arise with this situation.

AI Data analysis, privacy, data ownership and data access

Data Protection Impact Assessment (DPIA)

Definition of Data Governance model where controllers are responsible of making decisions about collecting, storing or processing personal data.

Data security

Data ownership

Informed consent

De-identification methods: Pseudo-anonymization, anonymization….

AI standardization

International standards – the technical specifications and requirements needed for AI and other technologies to perform well – can help address real and perceived risks by setting clear boundaries and making machine learning (ML) predictable, reliable and efficient.

ITU/WHO Focus Group on artificial intelligence for health (FG-AI4H)

ISO:

- **ISO SC42 Artificial Intelligence**
- **JTC 1/SC 42 | ISO/IEC AWI 5392 Information technology**
- **JTC 1/SC 42 | ISO/IEC AWI 5339 Information Technology**

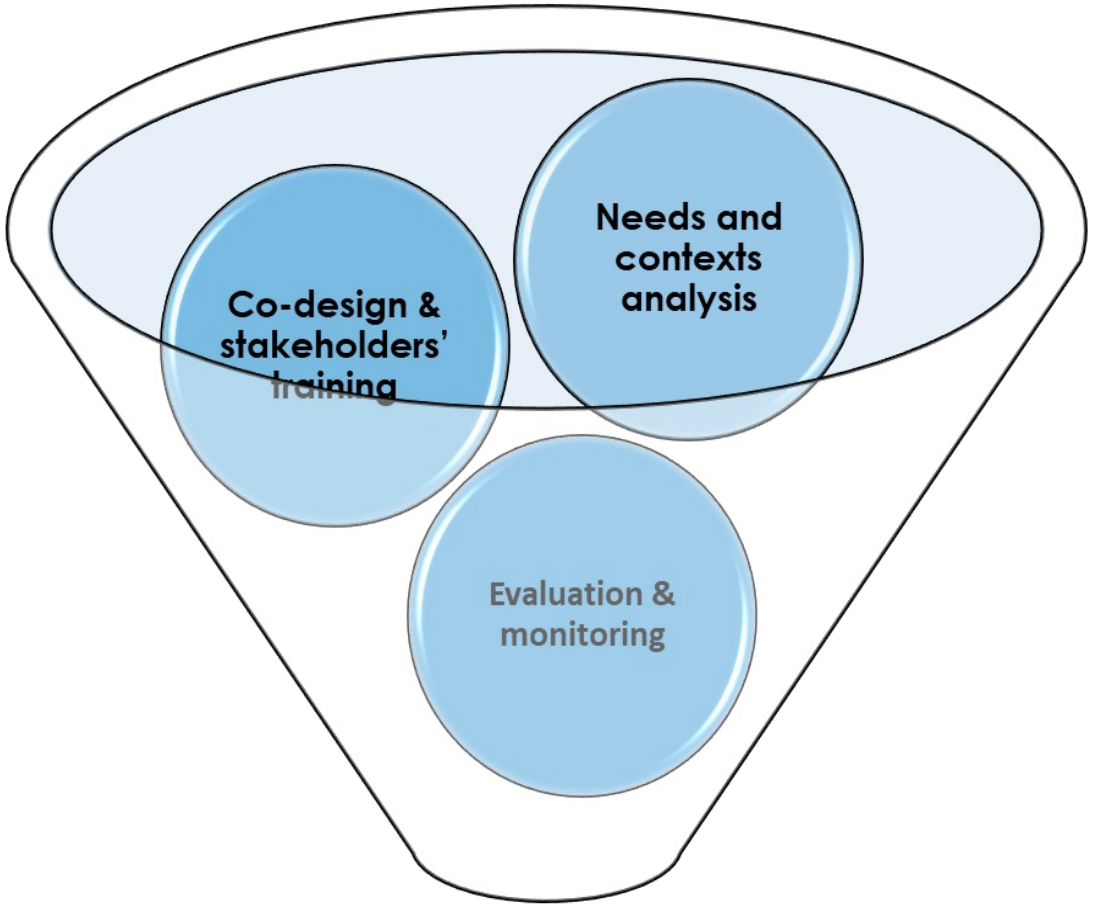
ETSI SmartM2M SAREF4EHAW for eHealth/Ageing-well

W3C Semantic Web in Health care and Life Sciences Community (HCLS)

AI impact assurance for sustainability

As aforementioned, the wider adoption of AI is hindered by some associated risks preventing the full trust by its users.

1. **Needs and contexts analysis**
2. **Co-design and stakeholders' training**
3. **Evaluation and monitoring**

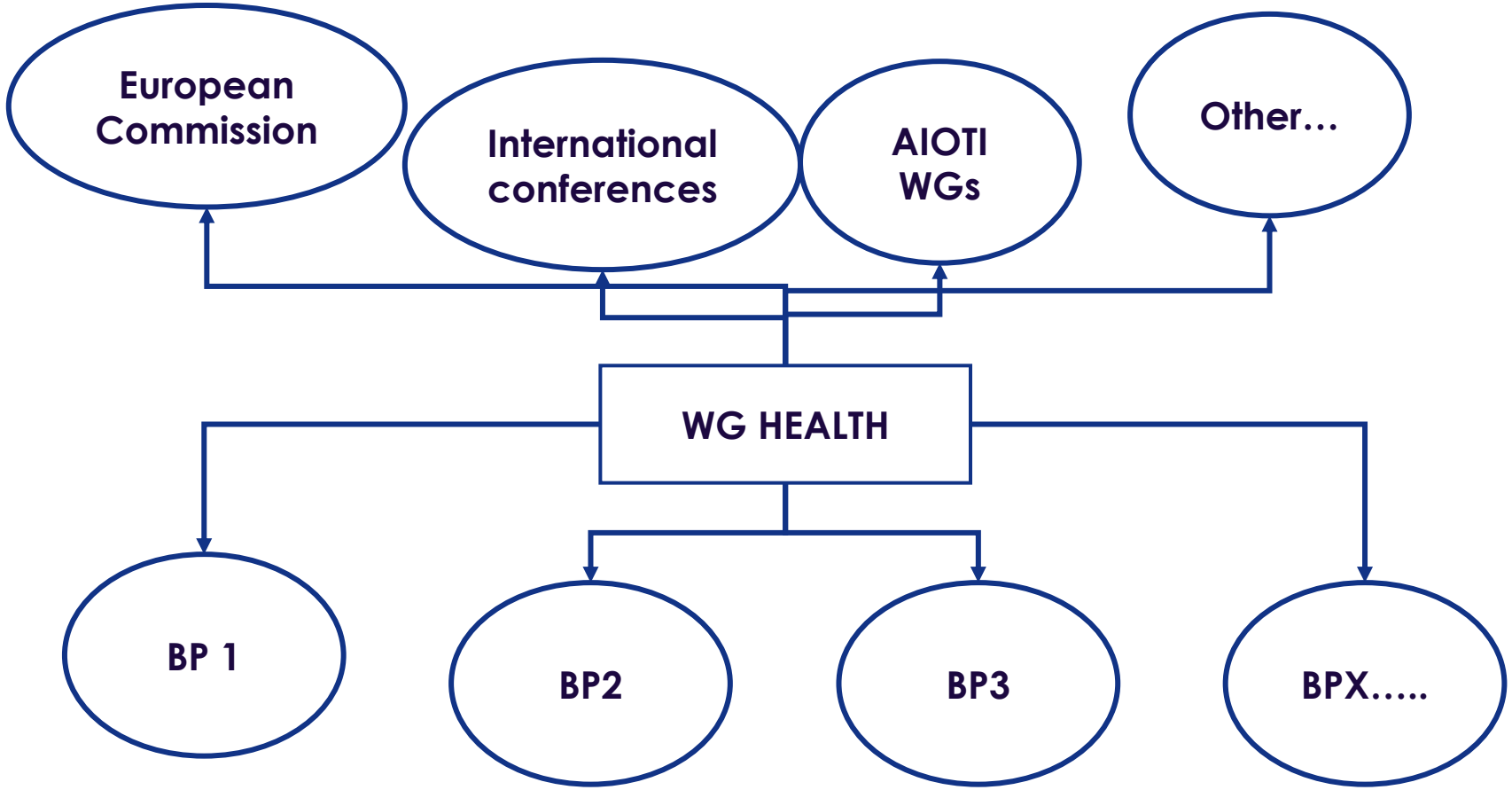


Presentation of the use cases and recommendations

Salvatore Tedesco, Tyndall National Institute

Pietro Dionisio, AIOTI WG Health Chair (Medea)

Best practices for better health deployed by AIOTI members



AI-based Smart Wearable Systems for Health and Wellness in Sports, Ageing, Rehabilitation, and Industry

14/03/2023

Dr. Salvatore Tedesco, PhD
Senior Researcher – Team Leader
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Introduction – Dr. Salvatore Tedesco

2012-present: Tyndall National Institute, University College Cork, Ireland

- Senior Researcher – Team Leader of Wearable-AI Lab (2019-present)
- Research Engineer (2012 – 2019)
- Assistant (2012)

2017-2022: University College Cork, Ireland

- PhD in EE Engineering

2008-2011: University of Salento, Lecce, Italy

- MSc in Telecommunications Engineering

2005-2008: University of Salento, Lecce, Italy

- BSc in ICT Engineering

Research Experience

- Background in wearable technology integrating ML/AI for healthcare and well-being applications
- Responsible for leading a research team in Wearable-AI with postdoctoral researchers, junior researchers, research staff, and students

- Working on basic and applied research in >20 industrial and research-oriented projects, leading to > € 1.1 million in grant funding as PI and co-PI

- Responsible for building the Human Motion Lab at the Tyndall National Institute, with equipment worth > € 100k

- >80 peer-reviewed scientific publications cited >1,000 times, h-index 15 (Google Scholar)

Equipment available at the created Human Motion Lab in Tyndall

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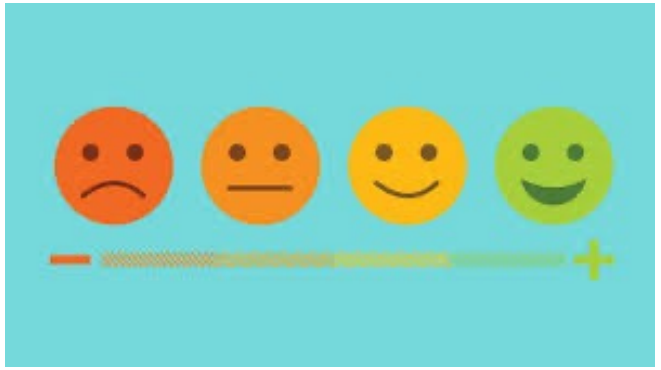
The Wearable-AI Team

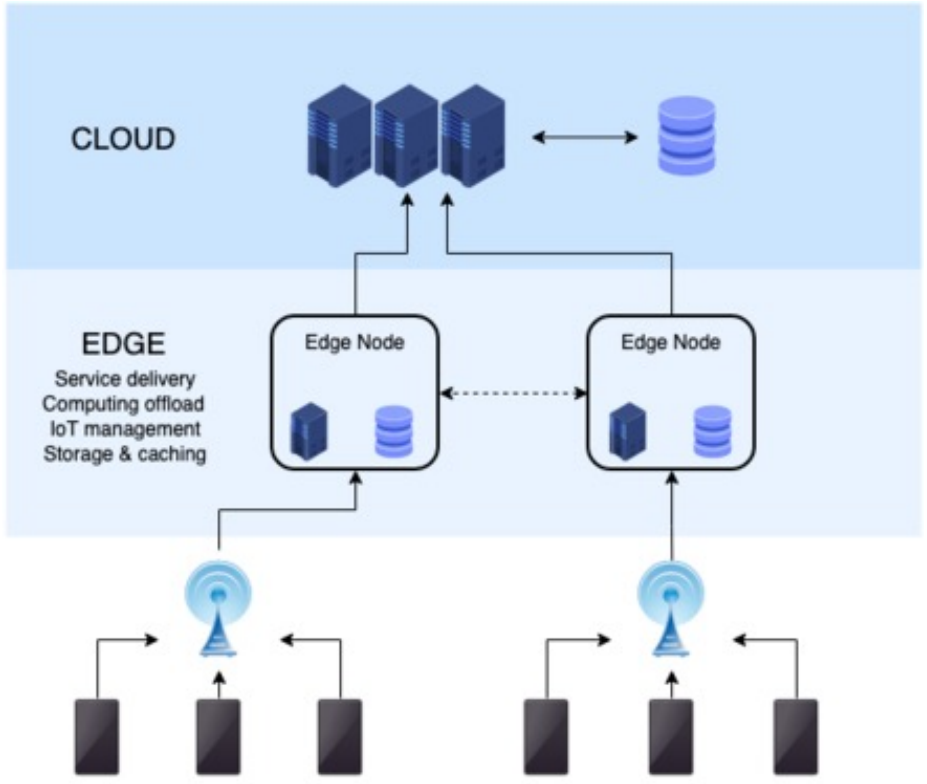
AI-powered, on-body wearable technology from fundamental to industry-oriented research

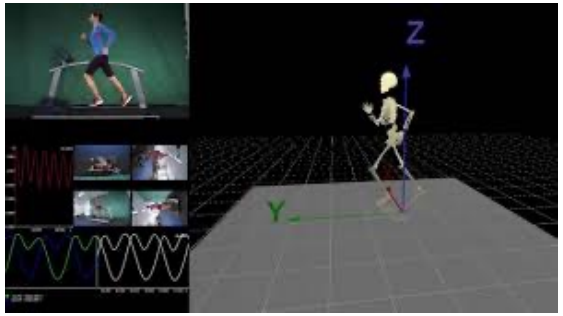
Digital Health – Chronic Disease Management and Rehabilitation



Health Markers

Applied Machine Learning





Biomechanical Motion Analysis, Ergonomics and Gait Analysis

Sports Analytics

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Research Example

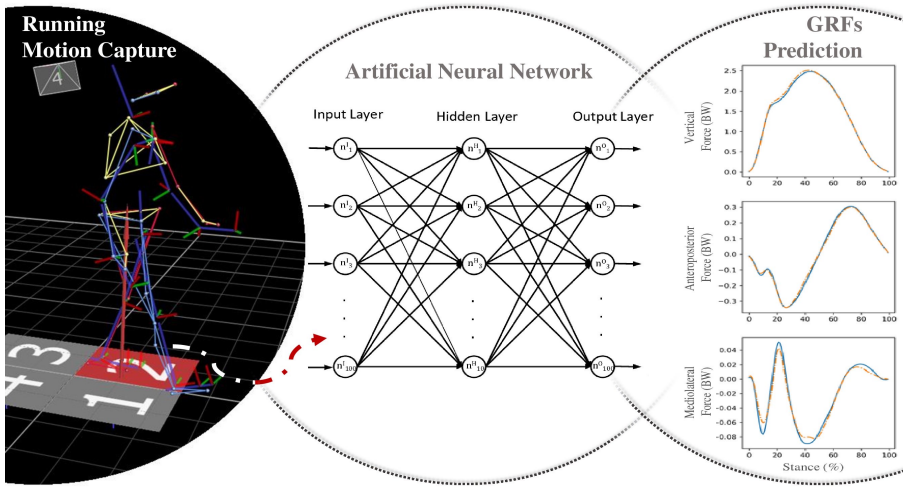
Estimation of Ground Reaction Forces (GRF) in Athletes

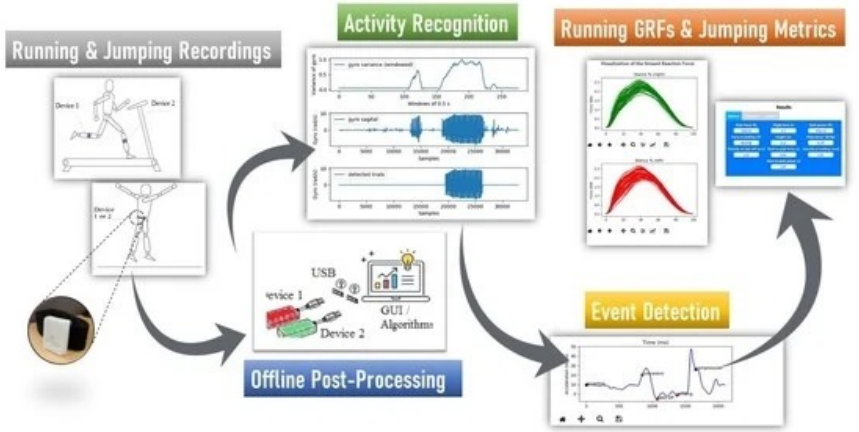
Research Challenge

- Running-related injuries can be connected to GRFs
- Wearables can provide insights into the kinetics potentially responsible for injurious tissue loads

Novel Approach

- It was proved that ANNs can predict all three GRF components in running conditions from kinematic input
- ANN results are more promising compared to state-of-the-art biomechanical models
- Developed a wearable IMU-based solution worn on shanks and/or lower-back to automatically detect individual jumps as well as each running stride, provide running performance metrics, GRF waveforms for each stride, and jumping metrics effectively visualized on a GUI





Research Example

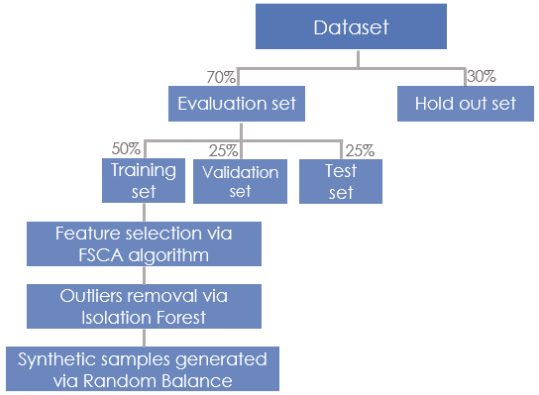
SENDoc – Mortality Prediction in Older Adults

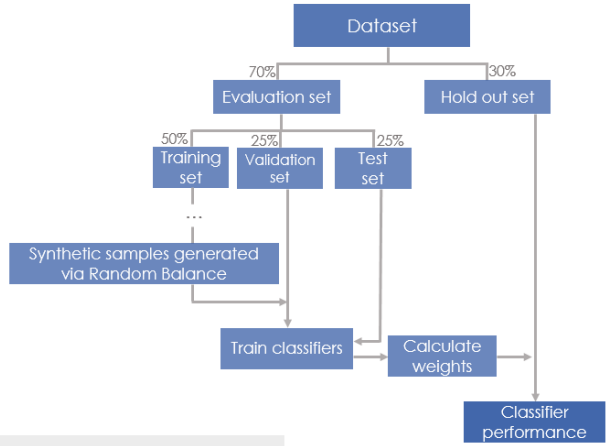
Research Challenge

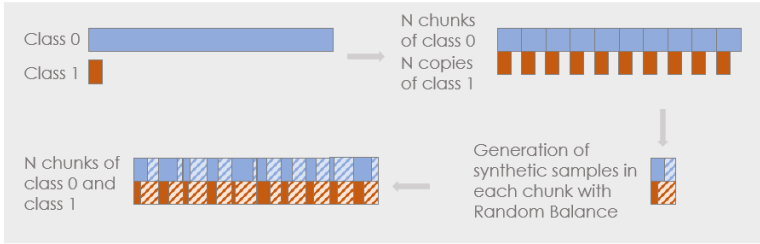
- Mortality prediction is essential for individualized disease management and for effective health resource allocation
- Standard indexes are used in clinical practice but do not take into account changes in population over the years
- Machine learning has the potential to solve this problem

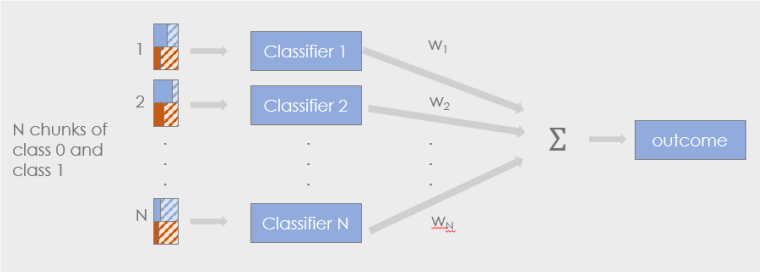
Novel Approach

- A novel ensemble approach has been developed to tackle the problem of a highly imbalanced dataset
- All-cause mortality prediction in data collected from older adults in Sweden shown an AUC-ROC of 0.88, with 2-7 years' notice
- Cancer-related mortality in the same cohort showed similar results and highlighted that a subset of variables only including wearable and self-reported data could provide similar performance









	AUC-ROC
Test	0.880 (0.873 - 0.887)
Train	0.884 (0.881 - 0.887)

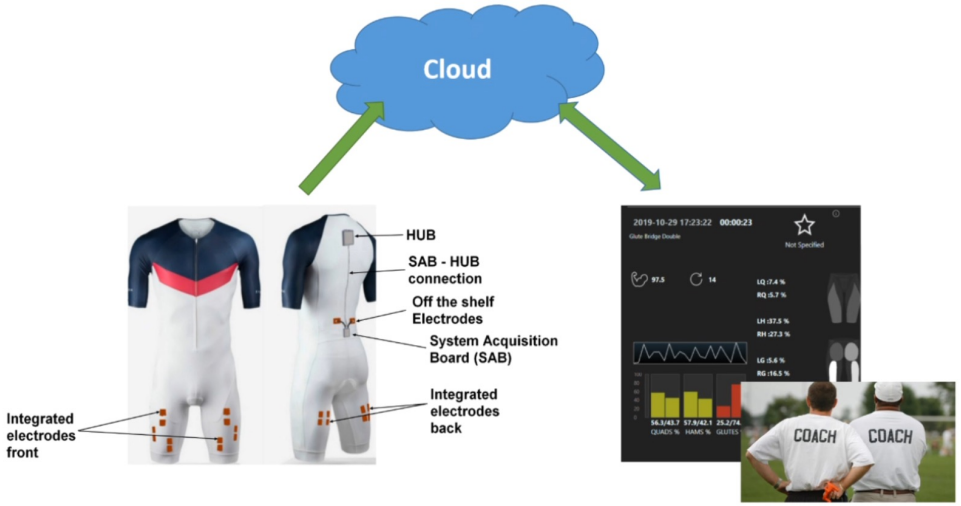
	All features	Demo./ Anthrop.+ Quest.	Demo./ Anthrop.+ Quest.+ Wearable	Demo./ Anthrop.+ Quest + Wearable + Lab tests	Demo./ Anthrop.+ Quest.+Wearable + Others
	AUC-ROC	AUC-ROC	AUC-ROC	AUC-ROC	AUC-ROC
Test	0.882 (0.870 - 0.896)	0.533 (0.505 - 0.567)	0.857 (0.814 - 0.887)	0.670 (0.632 - 0.713)	0.875 (0.864 - 0.887)
Train	0.886 (0.881 - 0.887)	0.602 (0.504 - 0.564)	0.878 (0.741 - 0.873)	0.751 (0.259 - 0.270)	0.886 (0.771 - 0.784)

Research Example

Holistic Human Sensing for Health and Wellness

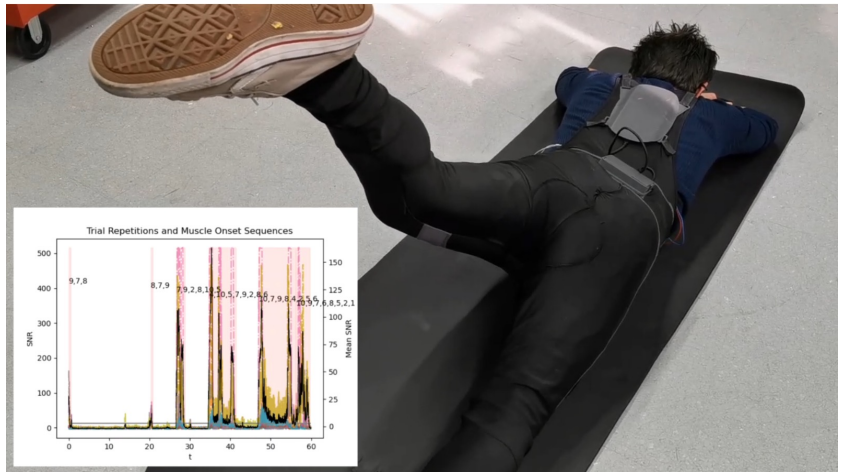
Research Challenge

- Injury prevention is one of the main priorities in sports due the associated high physical, mental, and economical burden on the athletes, coaches, and clubs
- 30 billion dollars are spent globally every year for injury treatments in soccer
- In a single season, English Premier League clubs lose between 19 and 26 M$ in players' wages due to injuries
- AI could play a hugely important role in this field
- EMG-based muscle recruitment pattern might be linked to hamstring injuries



Novel Approach

- Develop a wearable sensing prototype for the collection, processing, transmission of sensor-driven data measurements in lab- and field-settings to provide performance-related metrics
- Develop a cloud-based platform capable of retrieving and analysing the sensing data collected to provide and visualise indications on wearers' hamstring injury risk



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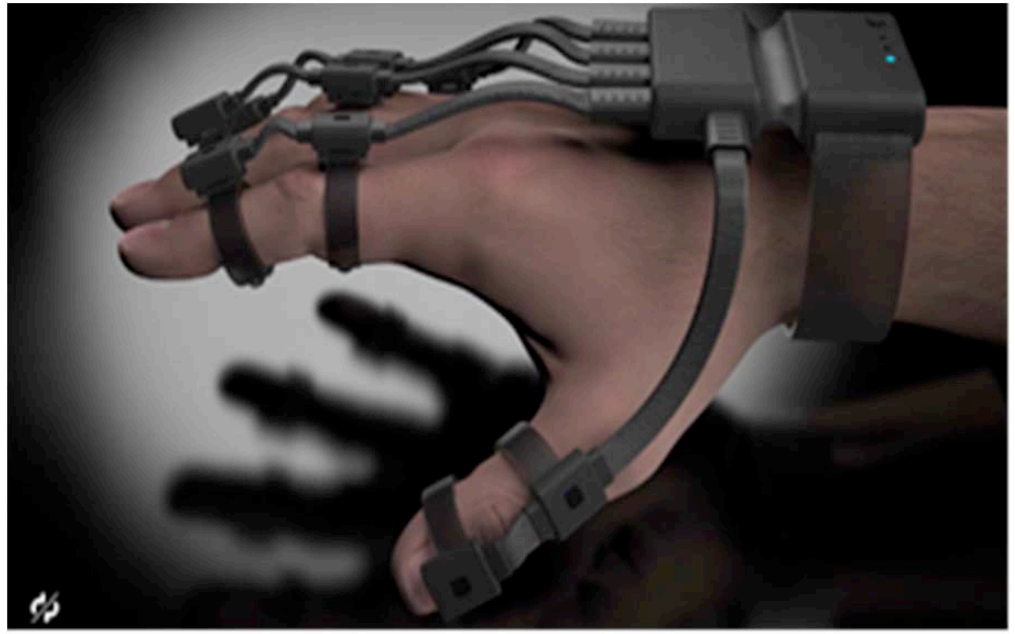
Research Example
Smart Glove for Industry X.0

Research Challenge

- Smart gloves are a promising tool for human-computer interface in a number of context, from health domain to industry X.0 and AR/VR
- Our Tyndall-based smart glove has resulted from a decade of research in the space and is leveraged as a platform for further research



Novel Approach

- Used of the Tyndall glove for human-robot interaction and implementation of collaborative robotics in industrial settings
- Implementation of on-the-fly low-complexity machine learning for model personalization on the users on-the go

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Ongoing Research

Predictive Analytics (Dementia, Migraine, Carer's Health)
Continuous Cuff-less Blood Pressure Monitoring

Research Challenge

- Predictive analytics consist of a series of statistical and ML techniques with the goal to exploit patterns in transactional and historical data to forecast the probability of future events and risks.
- Predictive analytics can be applied in several contexts, e.g.,
  - the development of AI models for the prediction of dementia in the ageing population even years before symptoms occur;
  - the adoption of machine learning models for health status prediction in carers;
  - the adoption of wearable sensors and AI for the management of chronic migraine.
- Cuff-based devices are the standard method but are not comfortable and are not suitable for long-term BP monitoring
- Ongoing research is carried out in estimating cuff-less BP in different contexts (following physical activities, or during cognitive tasks) over several datasets to create a truly generalizable model.

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AI-based Biomedical Systems – Today

Evolution until today:

- Biomedical systems and AI moved from labs to the real-world
- New solutions & architectures have been developed and currently state-of-the-art results are based on these techniques
- Biomedical systems and AI are nowadays adopted to a broad range of applications

Healthcare, computer vision and many other applications were all revolutionised by AI

What are the current challenges?

- **Energy and power-hungry requirements (especially for low-power applications)**
- **Dealing with small data is still a challenge in several scenarios**
- **Models not meeting challenging requirements in targeted scenarios**
- **Emerging applications due to society transformations**

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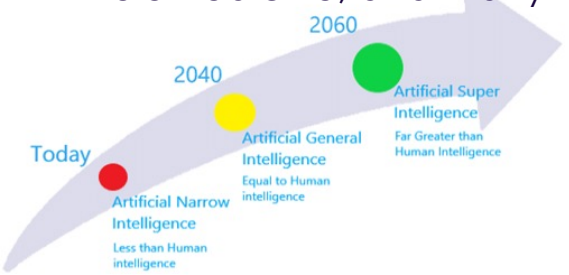
AI-based Biomedical Systems– The Future

What do we need to change to overcome those challenges?

- **Power efficiency and online learning**, through next-generation hardware and algorithms capable to continuously learn in systems constantly delivering a stream of sensor data
- **Data-centric AI**, through meaningful learning with limited datasets
- **Advanced model-centric AI**, through the development of more advanced models targeted for specific applications

Future AI will enable new breakthroughs in applications healthcare applications such as telemedicine, and many more



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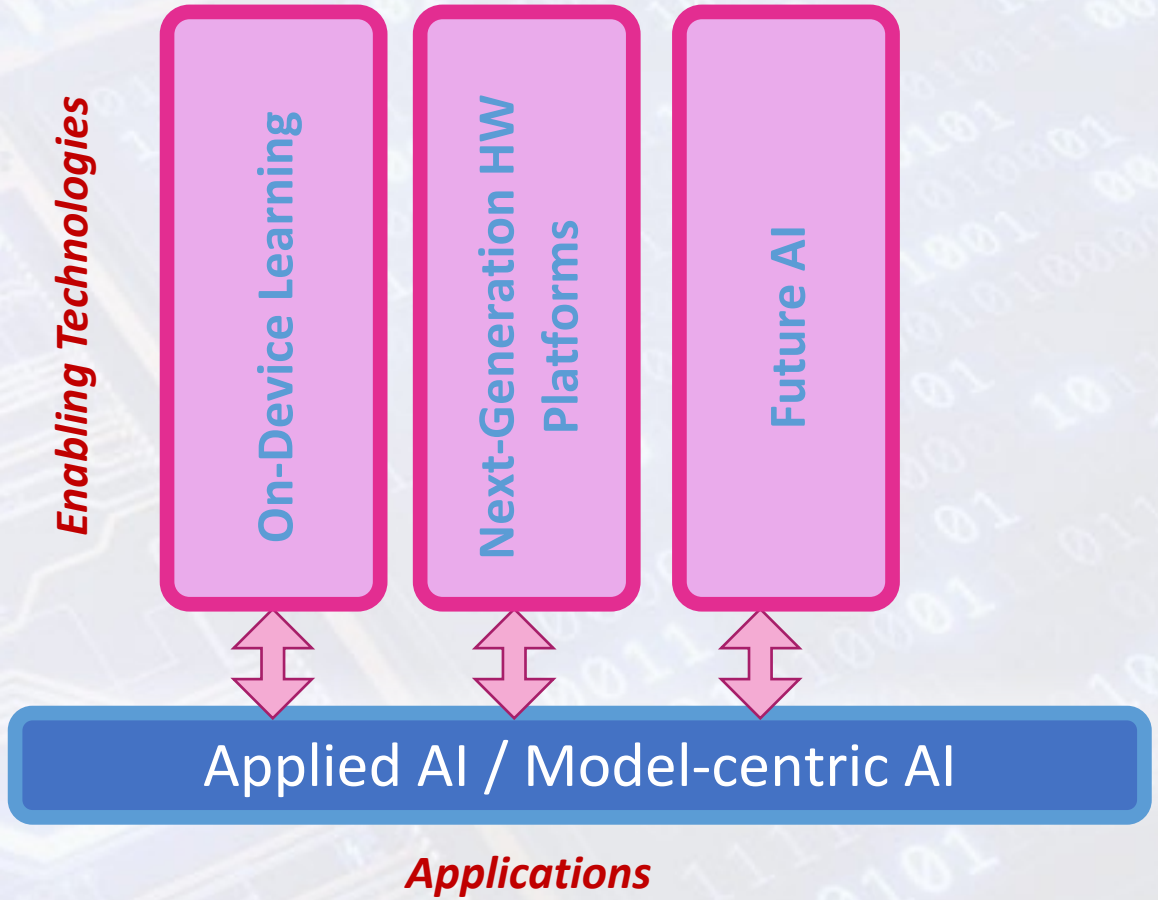
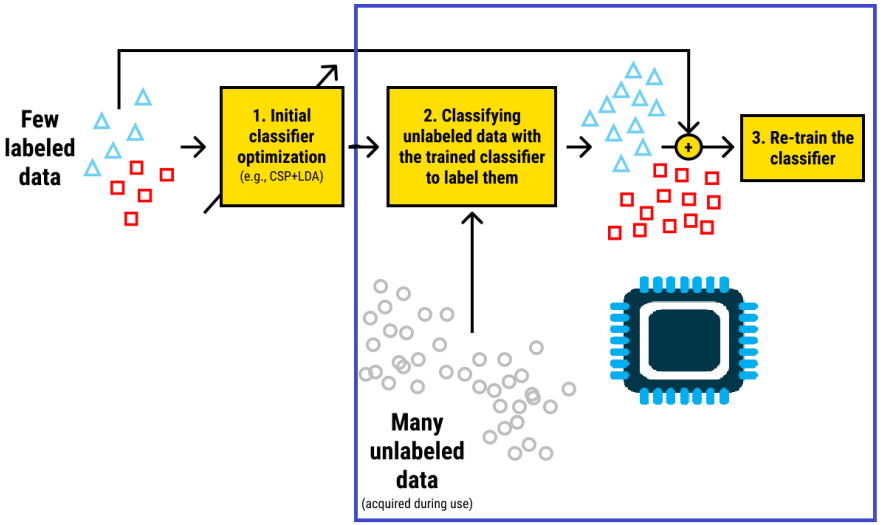
Tyndall AI Research Vision

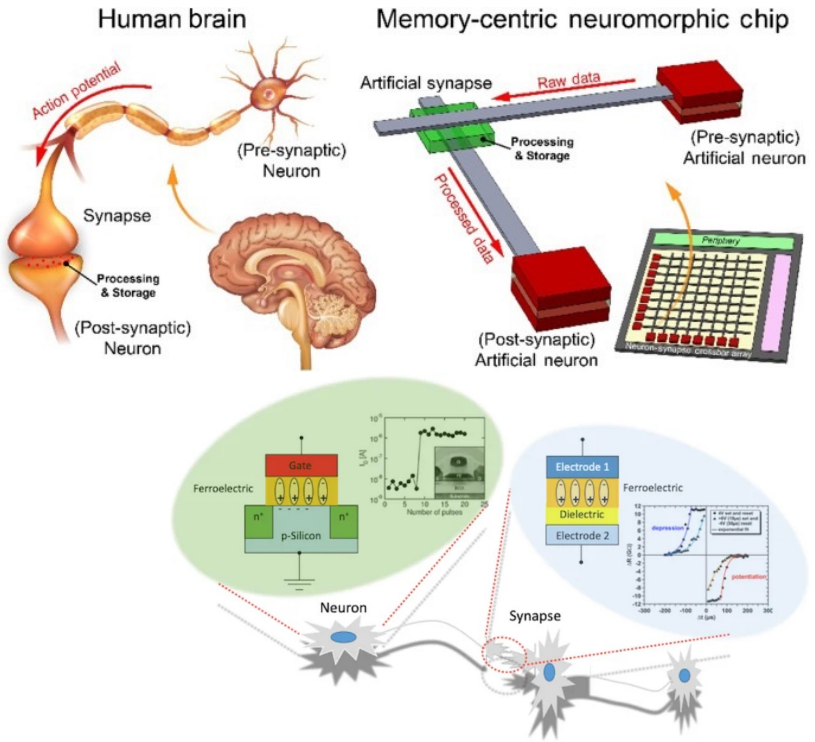
Enable Deep Tech innovation and impact through efficient ubiquitous AI



New Directions at Institute-Level

- Continuous learning to address the challenges of unlabelled data training allowing AI models to adjust over time
- Low-complexity on-device learning to increase the efficiency of adaption of AI models on low-power devices
- Next-generation AI application-specific ASICs
- Brain-inspired non Von Neumann dedicated hardware, architectures (neuromorphic computing) and brain-inspired algorithms (spiking neural networks)
- "Universal learners" through the combination of neural networks with genetic evolution algorithms to create novel ML/AI structures to overcome the limitation of both approaches
- Risk profiling & prediction of mental health conditions in targeted populations of interest, such as pregnant women (at risk of post-partum depression), lonely older adults, medical operators, people in the autism spectrum, etc.





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Summary

Current Overview of AI

- Market growth, vast datasets, and novel algorithm advances are enabling AI penetration of the wearable domain creating "true" smart and adaptive wearable devices;
- Emerging techniques and solutions currently in their infancy (e.g. edge & predictive analytics, etc.) will further enhance the wearable-AI research field enabling breakthroughs across a range of applications;
- Wearable-AI offers a compelling solution and is shifting engineering paradigms in a wide range of new applications by solving real-world challenges;

Current Context of Wearable-AI at Tyndall describes how

- The wearable-AI Team have focused on AI-powered, on-body, wearable technology from fundamental to industry-oriented research in multiple application domains (i.e., healthcare, geriatric care, rehabilitation, sport and fitness).
- Our AI work has enhanced the practical applications of wearable technology and illustrates the potential for its ubiquitous adoption into healthcare and fitness wearables and thus into society more generally;

Current Challenges

- Open access data is still limited, especially in the healthcare domain
- Reproducibility crisis

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Questions from the Audience

Moderated by:
Pietro Dionisio, AIOTI WG Health Chair (Medea)

Wrap up and end of the Workshop

Pietro Dionisio, AIOTI WG Health Chair (Medea)

Thank you for listening

Any questions?

You can find us at @AIOTI_EU or email sg@aioti.eu

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