



R&D&I in AI and Sustainability to Support Policy Making – Real-World Applications

Dr Erick G. Sperandio Nascimento

Associate Professor (Reader) in AI for Clean Air Systems

Programme Lead of AI and Sustainability



People-Centred AI
UNIVERSITY OF SURREY





PAN - UNIVERSITY INSTITUTE

CORE AI EXPERTISE

CVSSP, CS, Mathematics
Computer Vision, Machine
Perception, Explainable AI,
Sustainable AI

DOMAIN EXPERTISE

Health, Nutrition, Vet. Science, Law,
Business, FinTech, Sociology,
Language, Sustainability, Energy,
Clean Air

CVSSP: Centre for Vision, Speech and Signal Processing

1st

In the UK for
**Computer
Vision**

2nd

In the UK for
**Computer
Vision & AI**

4th

In the UK for
Robotics



SENAI CIMATEC

ECOSYSTEM

Founded in 2002, **SENAI CIMATEC** is one of Brazil's most advanced technology and innovation centers, with a particular focus on researching and developing solutions for various industries

SENAI - National Service for Industrial Training

60 Technology Institutes

26 Innovation Institutes

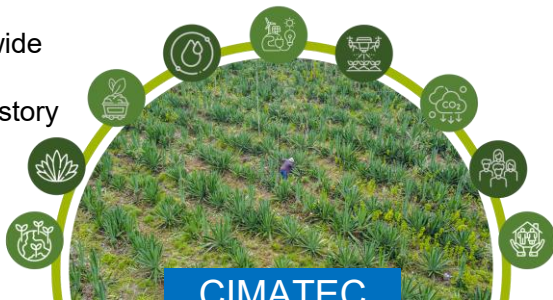
5th professional educational system worldwide

1st in Latin America

+80 Million people trained in 80 years of history



MAIN UNIVERSITY CAMPUS



CIMATEC
SEMIARID



CIMATEC
OCEAN



CIMATEC
PARK



40.000

People trained
in 20 years



More than **110**
ongoing R&D
projects

\$300 Mi



1200

Collaborators



\$ 200

Millions of
investment



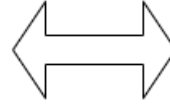
44

Areas of expertise

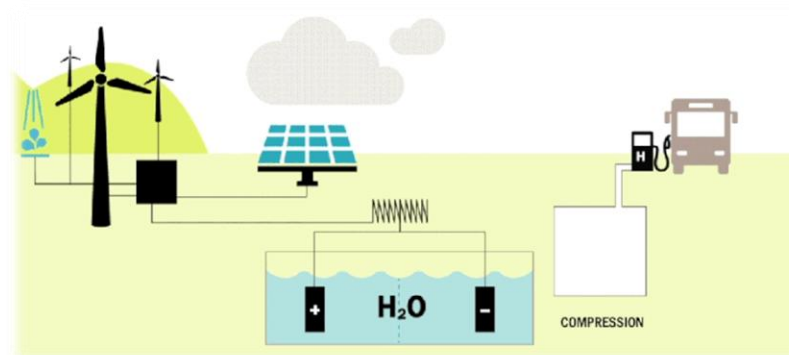
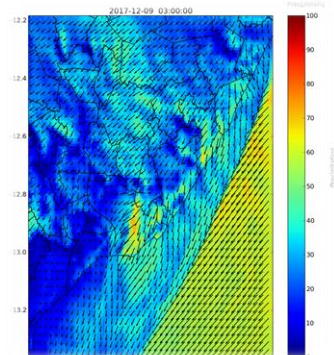
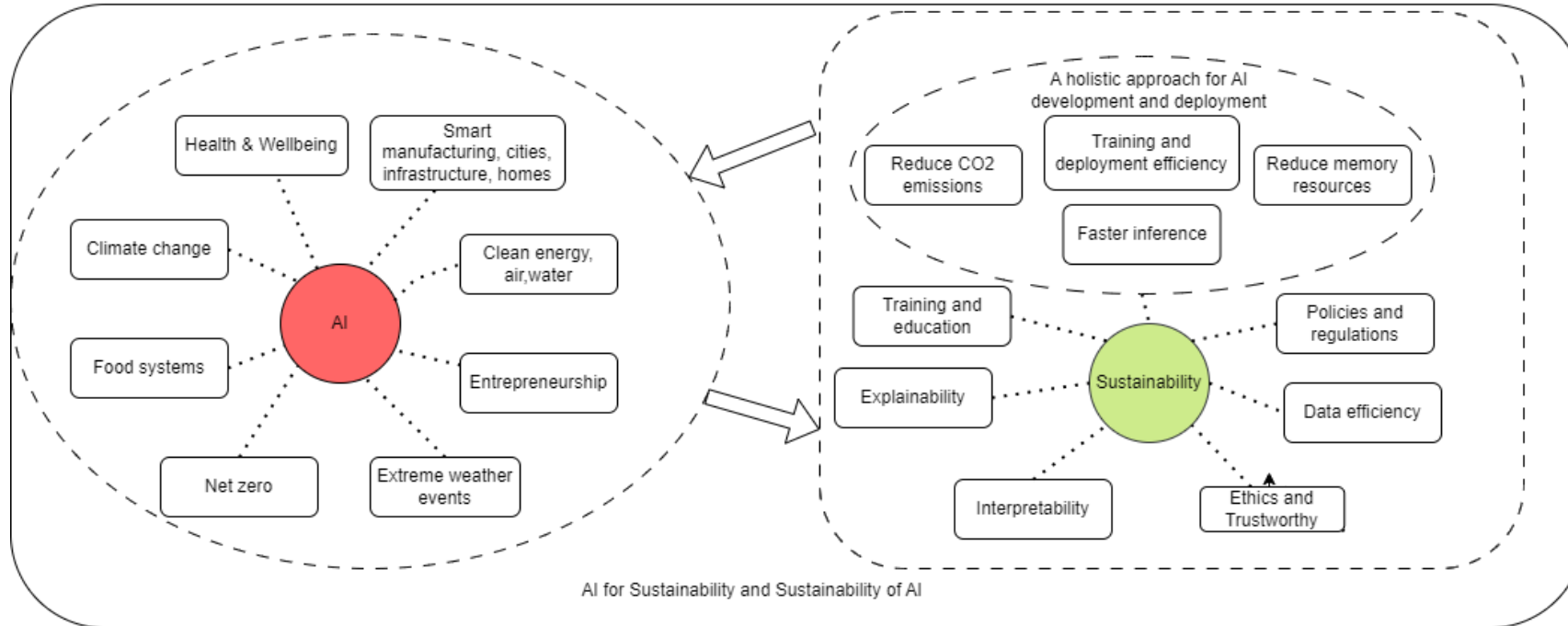
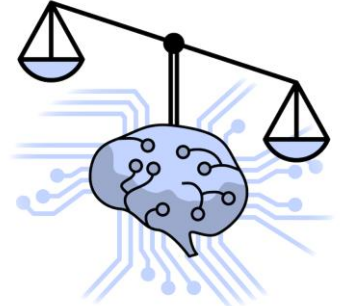
AI AND SUSTAINABILITY

AI and Sustainability Programme

Artificial Intelligence (AI)



Sustainability



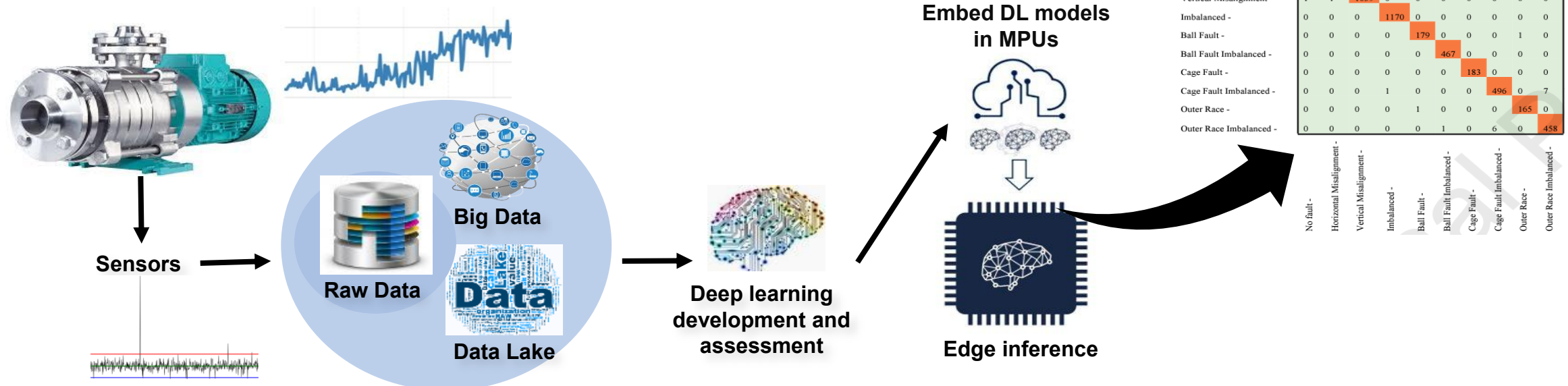
Sustainability of AI

Deep Learning (DL) on the Edge for Operational Predictive Maintenance

- Edge inference using Deep Learning models is a challenge, as it involves processing restrictions, data traffic, security and real-time processing requirements
- They are usually implemented with Internet of Things (IoT) devices that depend on expensive hardware and internet with reliable connections subject to restrictions on bandwidth, power and high latency
- The solution lies in embedding Deep Learning techniques in microprocessors (MPU) that only need basic computing and optimized models
- MPUs preserve information privacy (since no data leaves the device) and provide net-latency-free inference

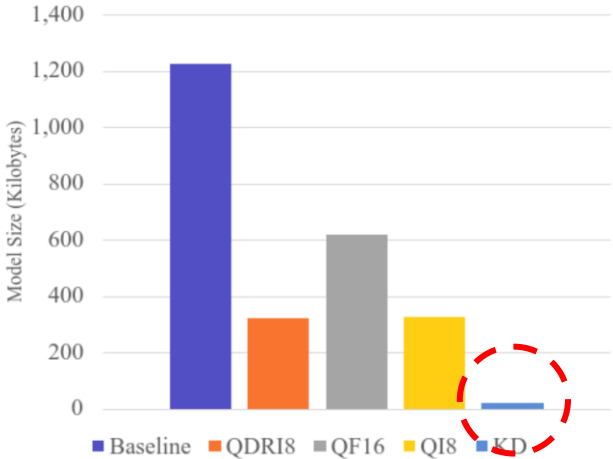
Microprocessors (MPU) for DL on the edge

- Arduino Nano
- SparkFun Edge
- STM 32
- Raspberry Pi
- NVIDIA Jetson Nano
- NVIDIA Orin Nano



Sustainability of AI

Sustainable Deep Learning for Fault Diagnosis: A Comparative Study of Different Compression Techniques in Embedded Platforms



QDRI8: 8-bit integer dynamic range quantization

QF16: 16-big floating point quantization

QI8: 8-bit integer quantization

KD: knowledge distillation

Histogram plot presenting the size of the PdMCNN model for each compression technique, highlighting our proposed Distilled PdMCNN model

Devices	Baseline	QDRI8	QF16	QI8	KD
Desktop	14.69	17.33 ↑ (18.00%)	15.13 ↑ (3.02%)	7.99 ↓ (45.61%)	0.39 ↓ (97.31%)
Laptop	7.77	10.98 ↑ (41.41%)	7.60 ↓ (2.11%)	5.81 ↓ (25.21%)	0.34 ↓ (95.60%)
HPC-CPU	7.34	12.44 ↑ (69.49%)	7.38 ↑ (0.56%)	7.47 ↑ (1.68%)	0.39 ↓ (94.67%)
STM32	784.95	499.38 ↓ (36.38%)	772.23 ↑ (1.62%)	393.08 ↓ (49.92%)	22.86 ↓ (97.09%)
Raspberry	81.77	57.22 ↓ (30.03%)	83.68 ↑ (2.33%)	54.97 ↓ (32.77%)	3.32 ↓ (95.94%)
Jetson nano	148.52	98.55 ↓ (33.64%)	150.65 ↑ (1.44%)	93.05 ↓ (37.35%)	5.13 ↓ (96.54%)

↑ Percentage Growth ↓ Percentage Reduction

Average inference time (ms) for each device of the PdMCNN model compressed by different techniques, highlighting the results of our proposed Distilled PdMCNN model

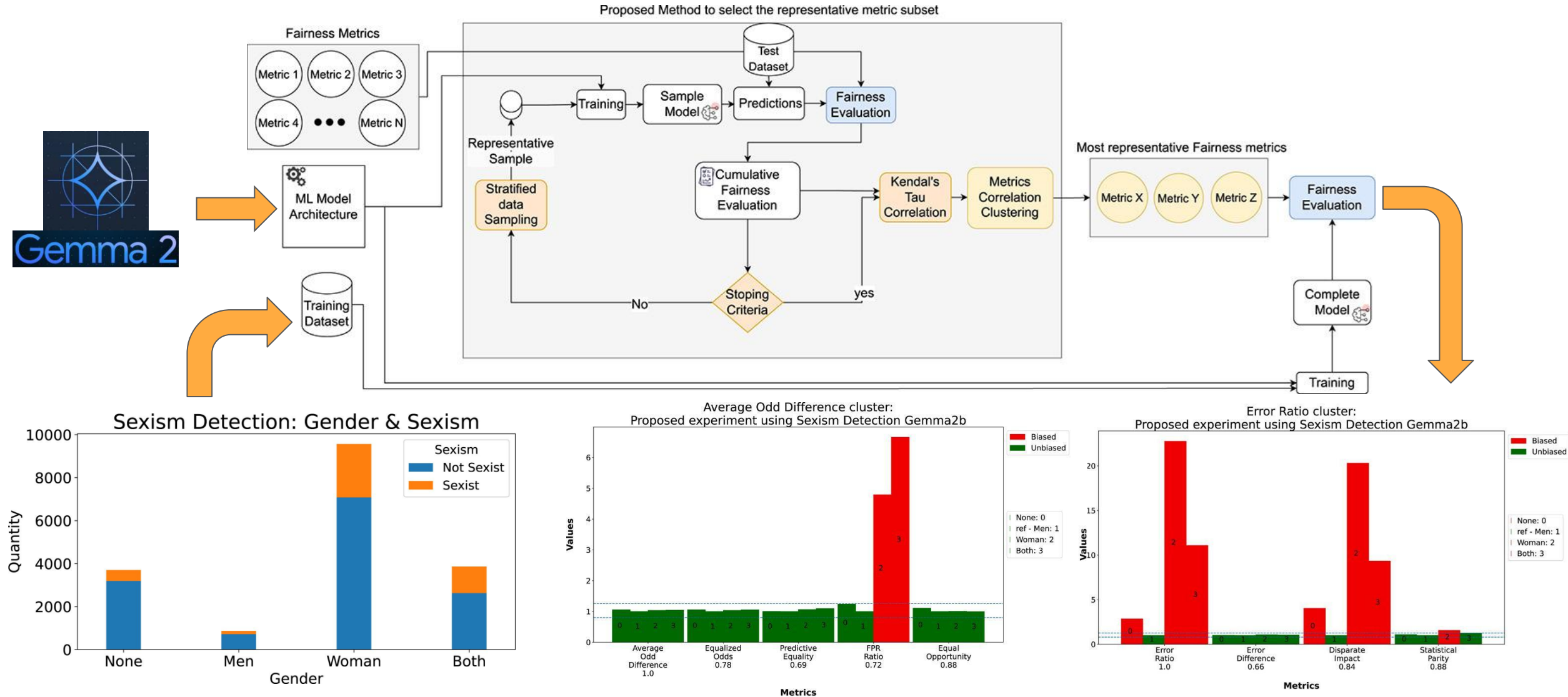
Device	Compression Technique	F1	ROC AUC	PRC AUC	Precision	Recall	Specificity	Accuracy
Desktop	Baseline	0.9481	0.9647	0.9089	0.9590	0.9391	0.9903	0.9852
Desktop	QDRI8	0.9485 ↑ (0.042%)	0.9655 ↑ (0.083%)	0.9094 ↑ (0.055%)	0.9577 ↓ (0.135%)	0.9406 ↑ (0.159%)	0.9903	0.9852
Desktop	QF16	0.9481	0.9647	0.9089	0.9590	0.9391	0.9903	0.9852
Desktop	QI8	0.9495 ↑ (0.147%)	0.9653 ↑ (0.062%)	0.9115 ↑ (0.286%)	0.9612 ↑ (0.229%)	0.9401 ↑ (0.106%)	0.9906 ↑ (0.030%)	0.9856 ↑ (0.040%)
Desktop	KD	0.9291 ↓ (2.004%)	0.9601 ↓ (0.476%)	0.8790 ↓ (3.289%)	0.9273 ↓ (3.305%)	0.9352 ↓ (0.415%)	0.9850 ↓ (0.535%)	0.9757 ↓ (0.964%)
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↑ Percentage Growth ↓ Percentage Reduction

Evaluation metrics for each device under the different compression techniques. Results of the proposed model is highlighted.

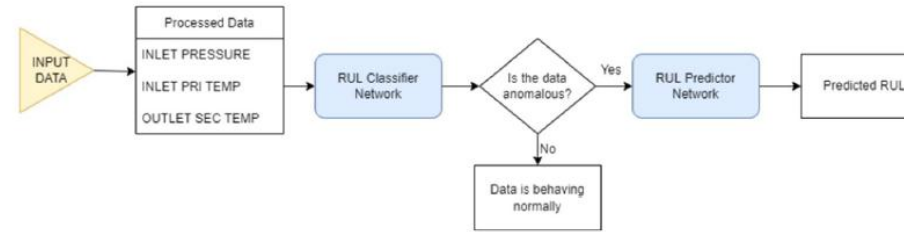
Trustworthy AI – Tackling Bias and Unfairness in ML

Correlation-based methods for representative fairness metric selection: An empirical



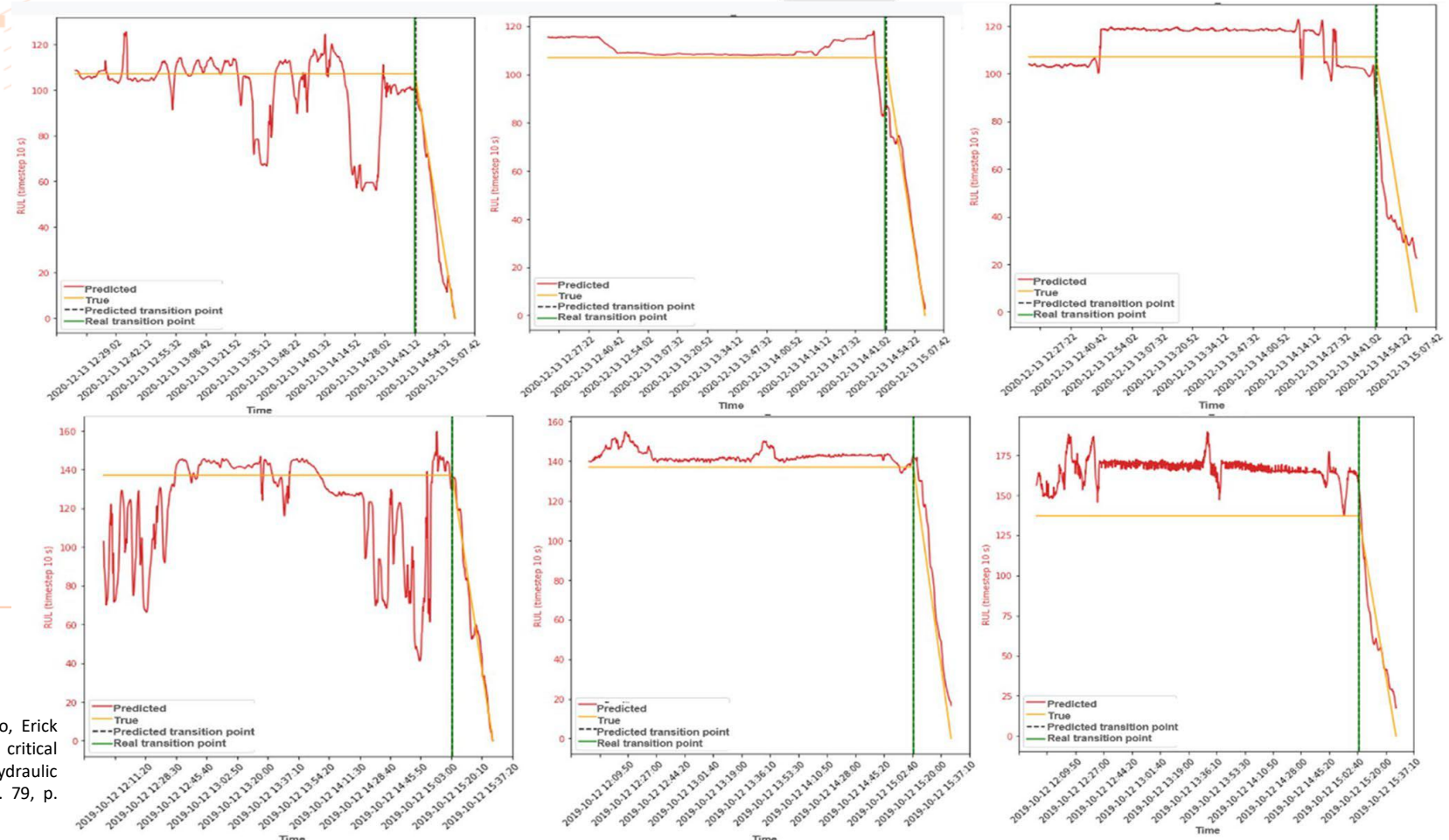
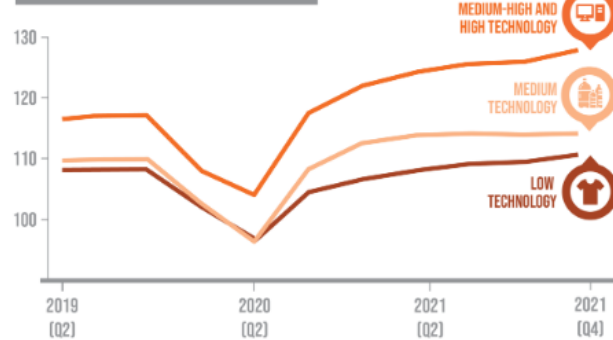
Making HPC centres more sustainable for AI workloads

Predictive maintenance applied to mission critical supercomputing environments: remaining useful life estimation of a hydraulic cooling system using deep learning



HIGHER-TECHNOLOGY INDUSTRIES ARE FAR MORE RESILIENT IN CRISES THAN THEIR LOWER-TECH COUNTERPARTS

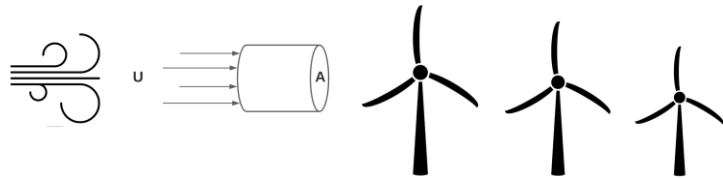
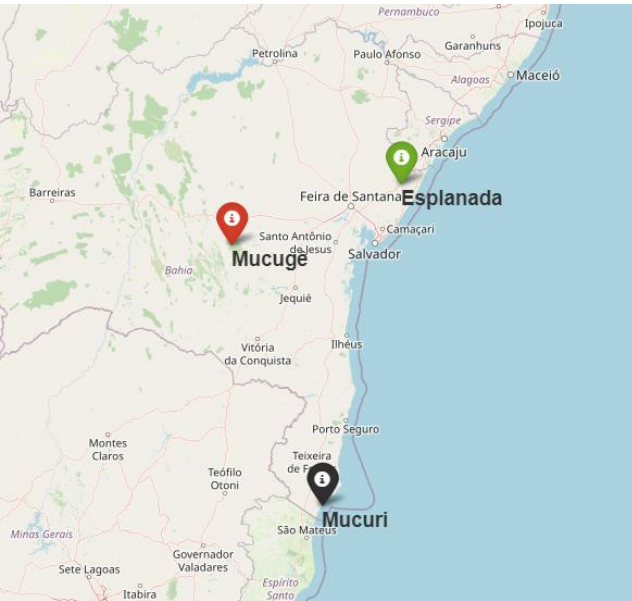
MANUFACTURING PRODUCTION INDEX



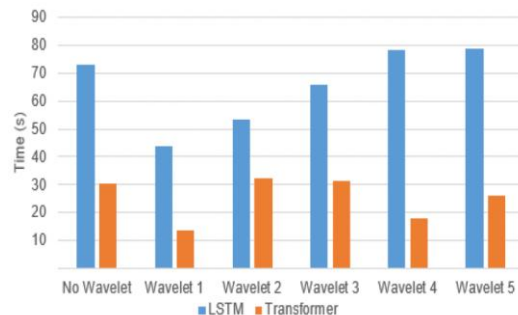
LIMA, ANDRÉ LUIS DA CUNHA DANTAS ; ARANHA, VÍTOR MORAES ; Nascimento, Erick Giovanni Sperandio . Predictive maintenance applied to mission critical supercomputing environments: remaining useful life estimation of a hydraulic cooling system using deep learning. JOURNAL OF SUPERCOMPUTING, v. 79, p. 4660-4684, 2022. DOI: <http://dx.doi.org/10.1007/s11227-022-04833-5>

AI and Energy

A transformer-based deep neural network with wavelet transform for forecasting wind speed and wind energy



Training Time - Esplanada at 120m

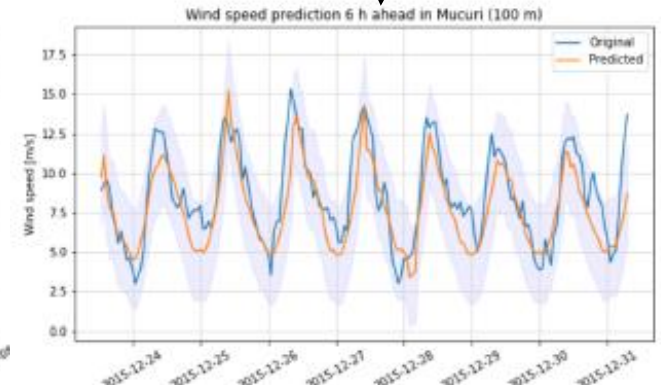
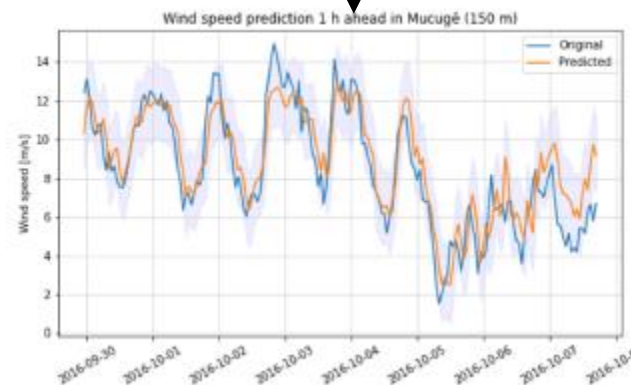
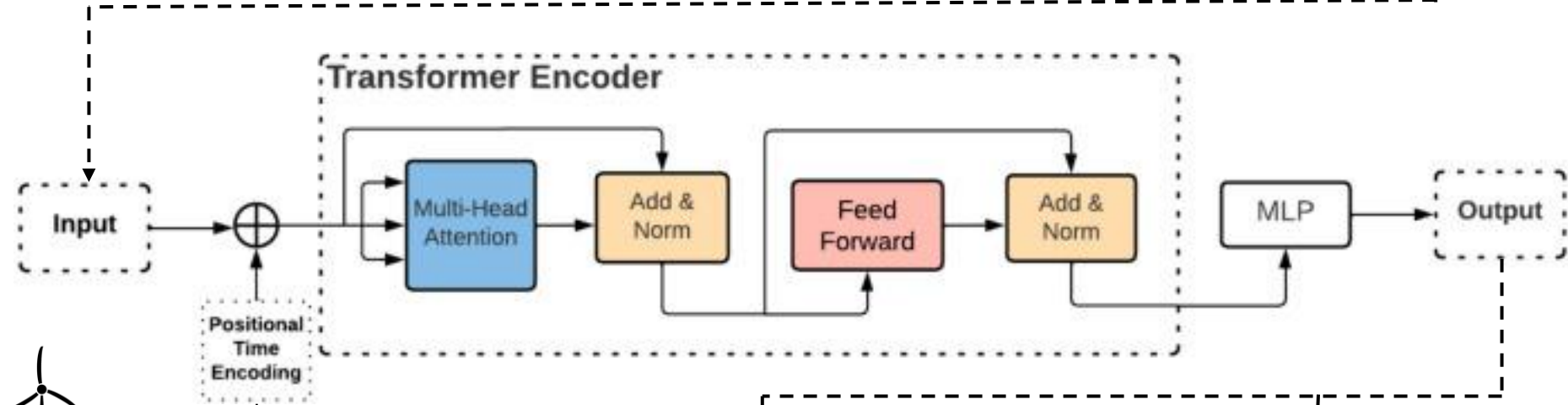


$$\sin(t_a, f) = \sin\left(\frac{2\pi t_a}{f}\right)$$

$$\cos(t_a, f) = \cos\left(\frac{2\pi t_a}{f}\right)$$

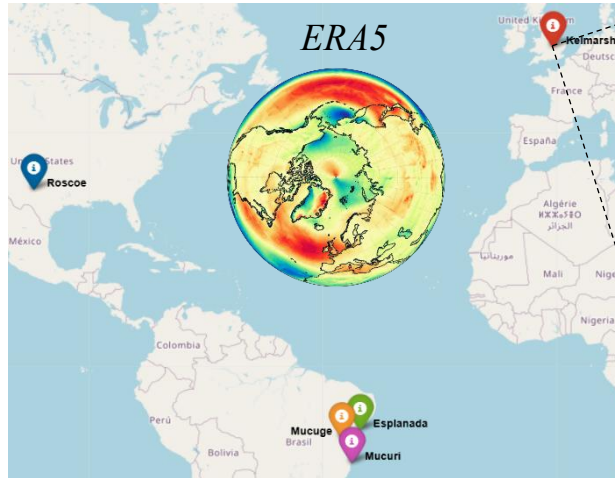
Anemometric data – wind speed and direction, air pressure, temperature and humidity

Discrete Wavelet decomposition and selection

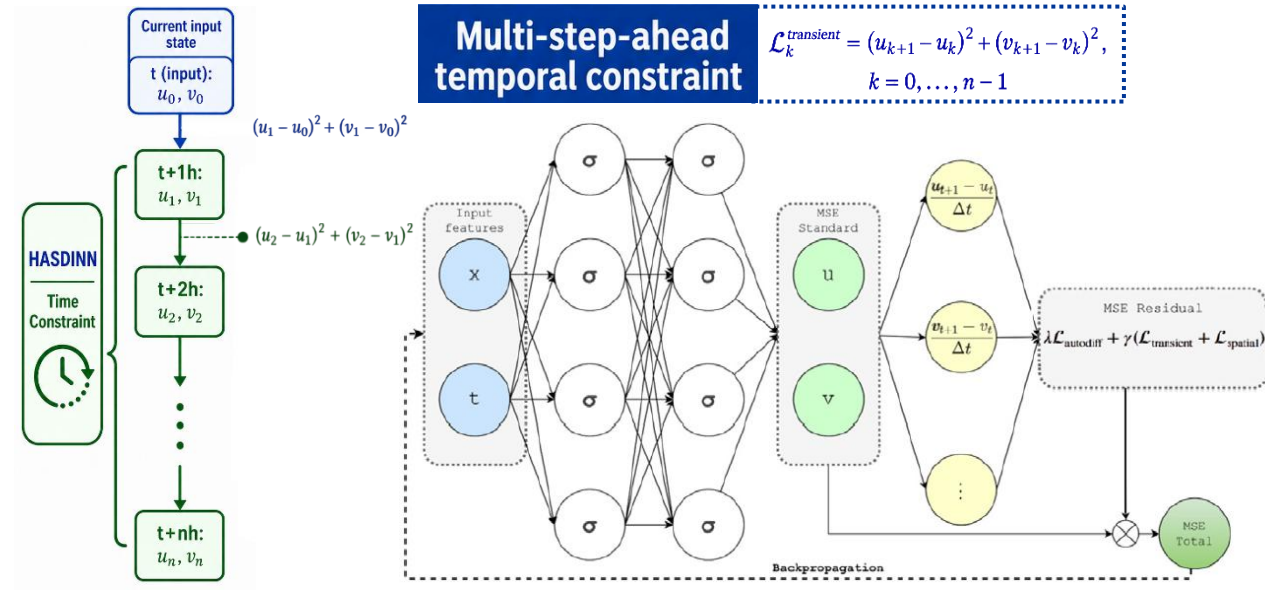
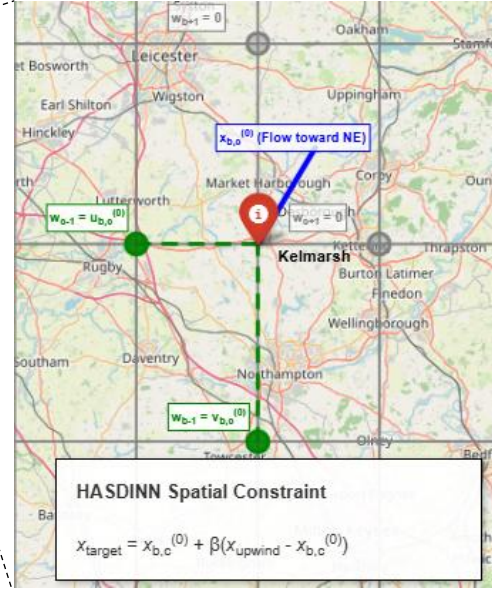


AI and Energy

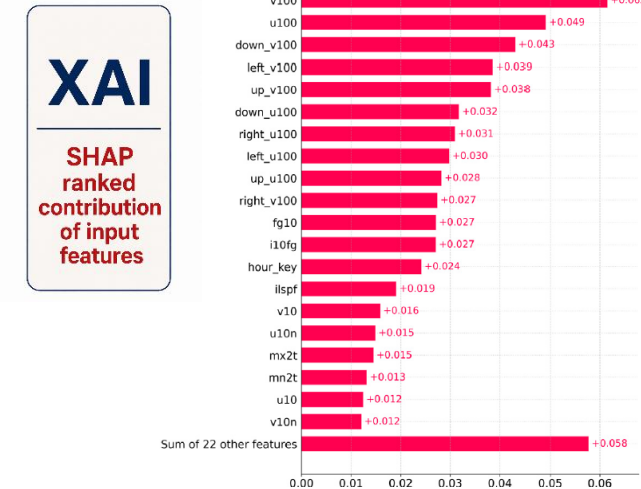
Multi-site short-term wind-component forecasting with hybrid adaptive spatiotemporal **domain-informed** neural network



Download and preprocess six years of meteorological grid data of five sites.

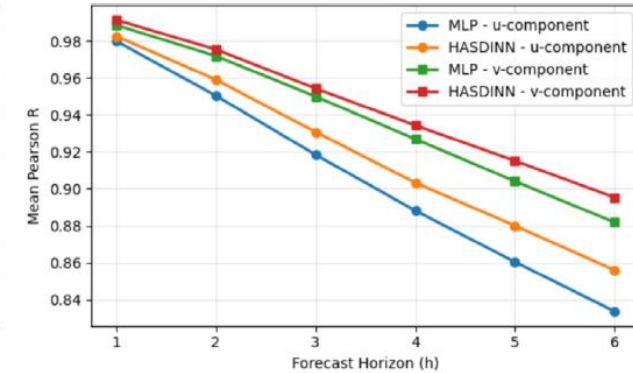
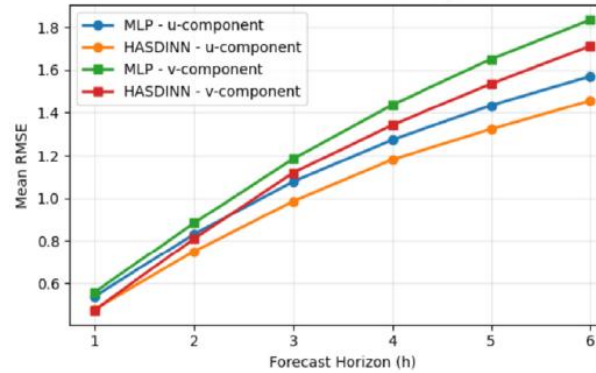
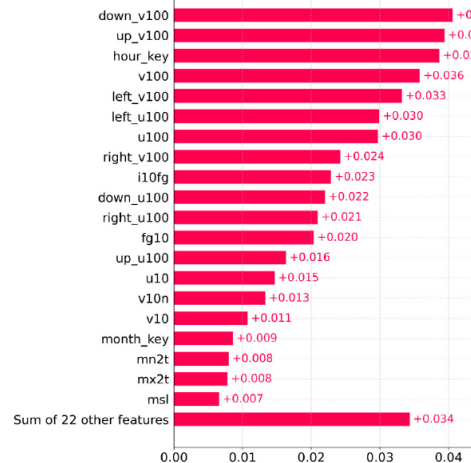


MLP



Hybrid adaptive spatiotemporal domain-informed neural network (HASDINN).

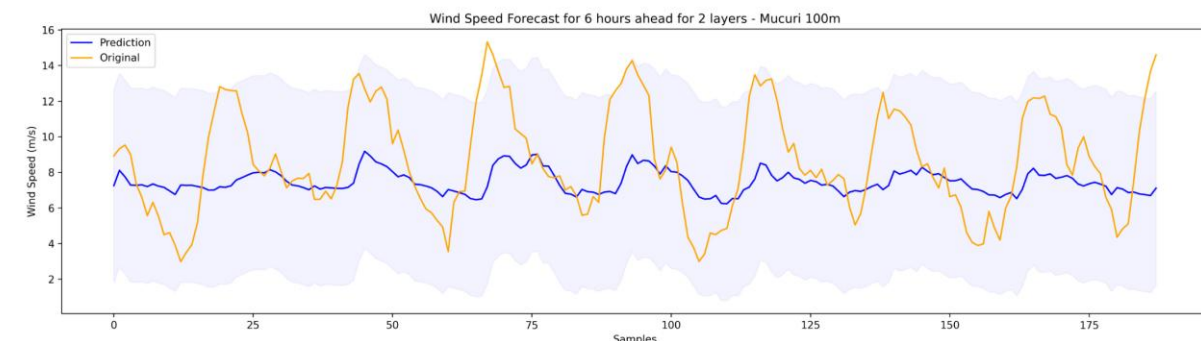
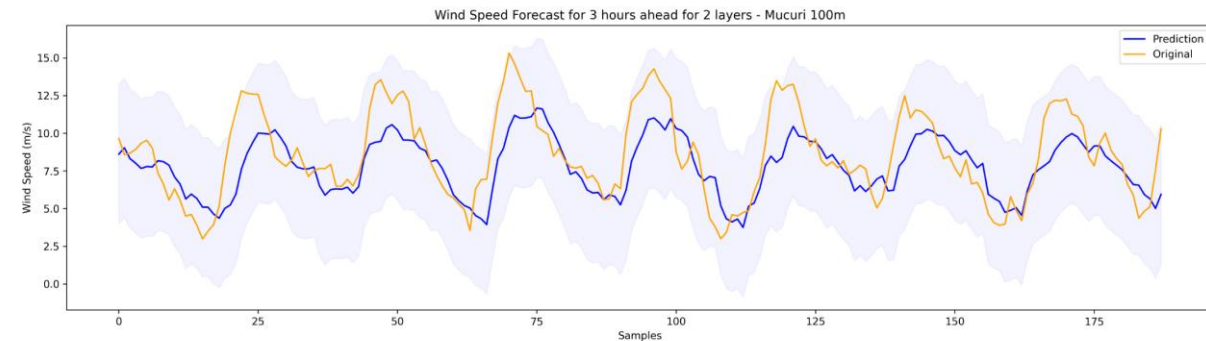
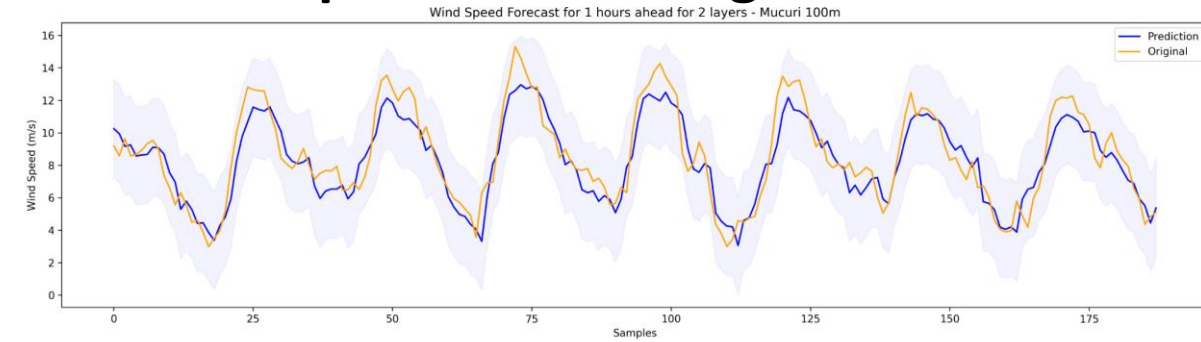
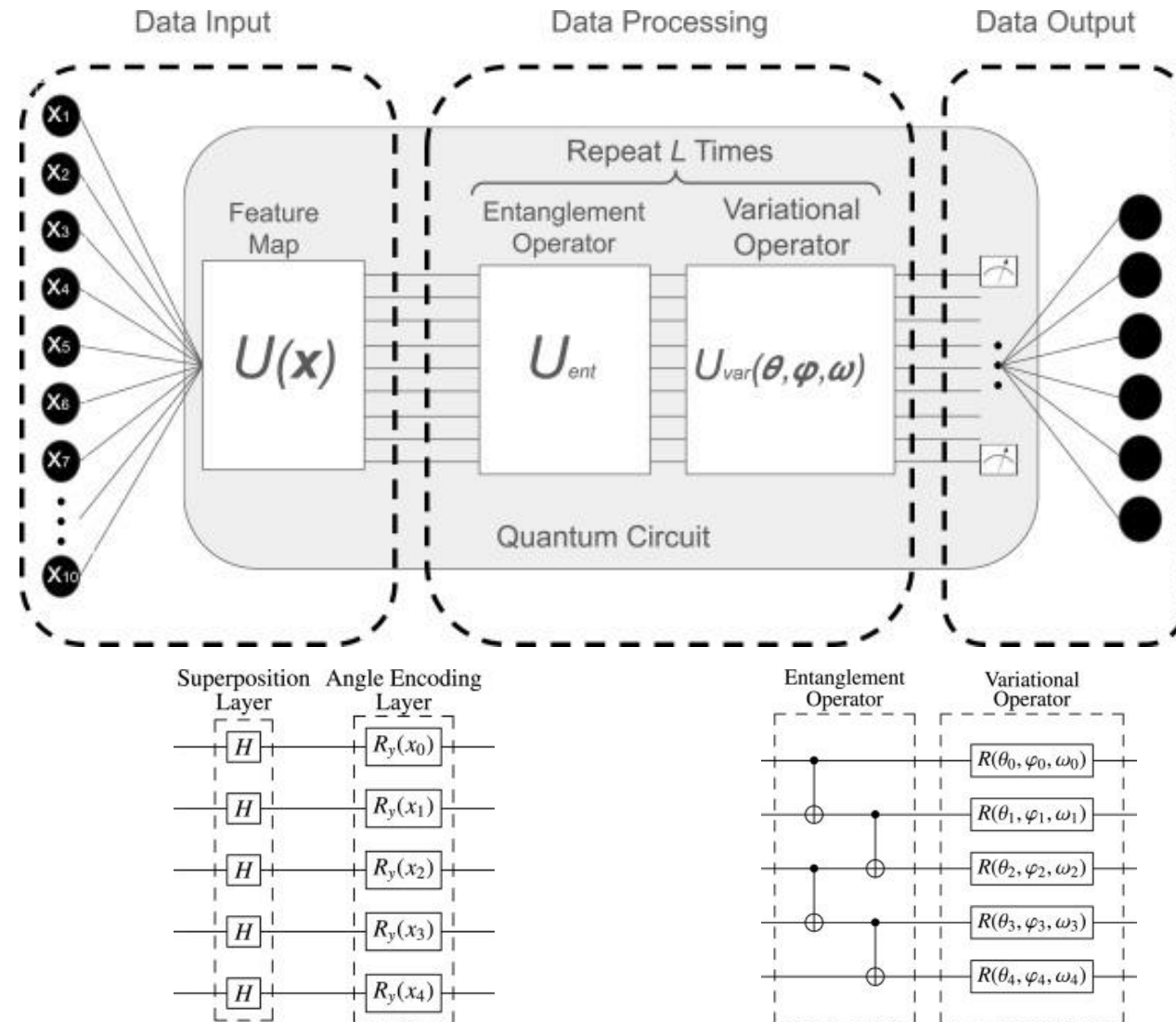
HASDINN



Comparison of mean RMSE and Pearson's R for the wind-components across forecast horizons for the MLP and HASDINN models averaged over all sites.

Quantum AI and Energy

A quantum neural network model for wind speed forecasting



Otto Pires, Erick Sperandio Nascimento & Marcelo Moret. A quantum neural network model for short term wind speed forecasting using weather data. Energy and AI, 2025.

<https://www.sciencedirect.com/science/article/pii/S266654682500120X>

Multi-Agent AI System for Supporting Anaerobic Digestion Plant Operators

Why?

Waste Management and Water Pollution

Diverts organic waste from landfills. Reduces groundwater contamination from decomposing organic matter

Greenhouse Gas Emissions and Energy Dependency

AD prevents methane from being released uncontrolled into the atmosphere. It can be used to generate energy.

Generic data models struggle to optimize AD safely or effectively

Identifying process decline early can save £100k+ in downtime.

Highly Complex AD Plant Operations and Poor Interpretation

Operators struggle to interpret outputs from the complex hybrid physics-based optimisation models.

What?

Anaerobic Digestion Plant Operation

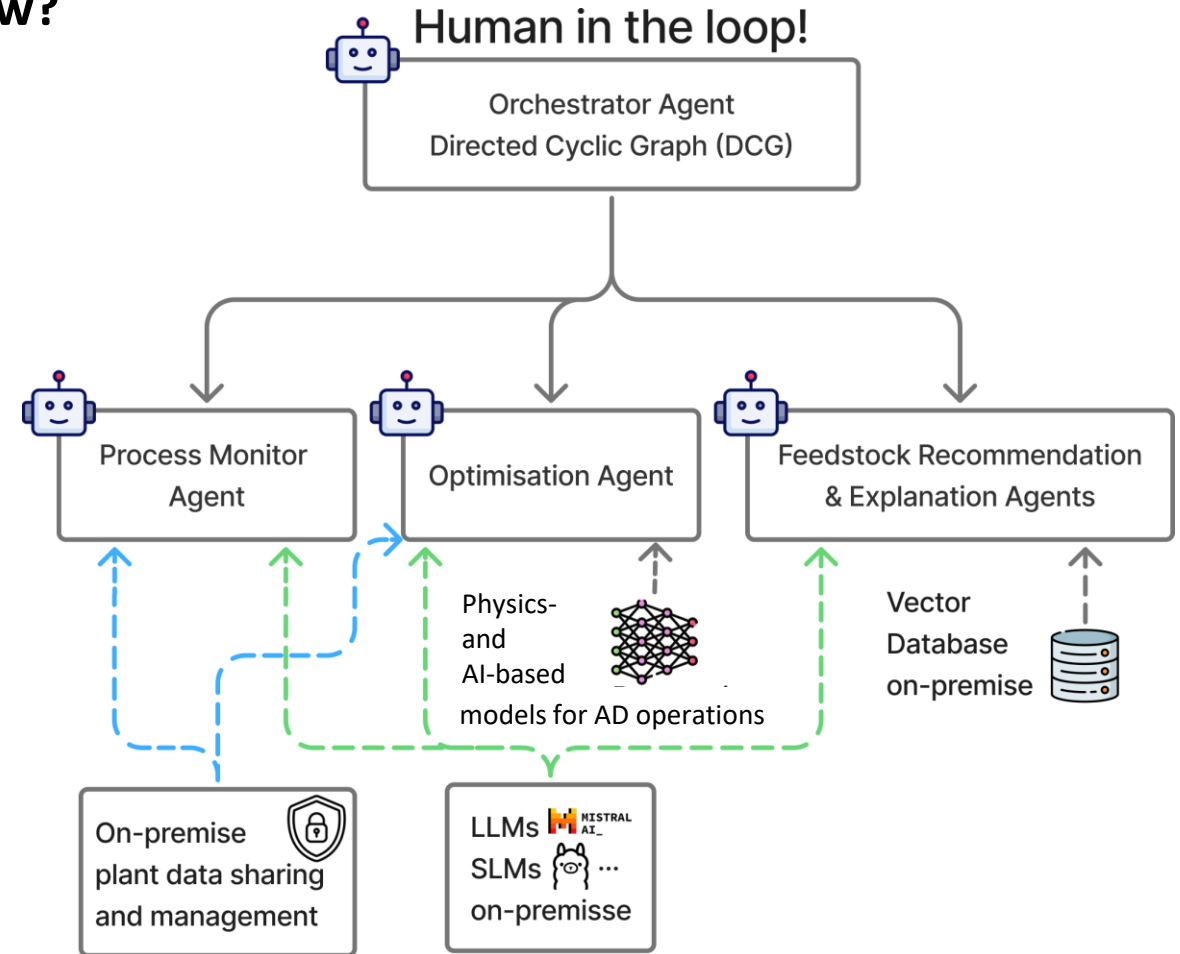
where biological, mechanical, and thermodynamic processes are tightly interdependent

High Performance in AD Early Problem Detection

Multi-agent LLM System Assistant

Natural language for enhanced and human-centred decision support

How?



BiofuelAi



People-Centred AI
UNIVERSITY OF SURREY



What?

Environmental forecasting

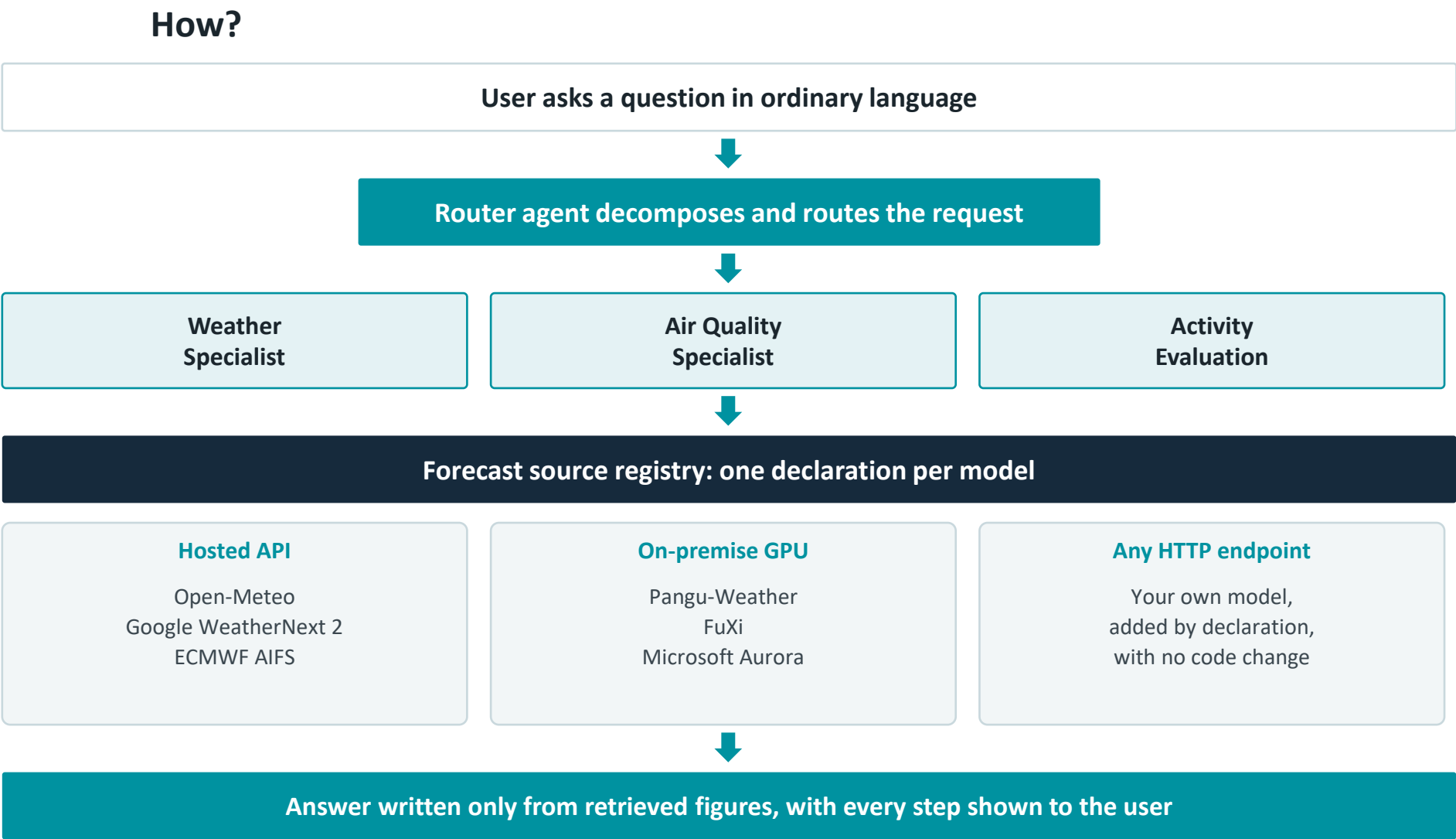
where weather, air quality and activity interact

State-of-the-art AI models

Pangu-Weather, FuXi, Aurora, WeatherNext 2, ECMWF AIFS

Multi-agent AI platform

Natural-language access.
We are here!





AI and Clean Air

Multimodal and multi-source



Reanalysis

e.g. CAMS, ERA5, MERRA-2



Remote Sensing

e.g. TROPOMI, Sentinel-2



In-Situ Networks

e.g. DEFRA, AURN



Geospatial

e.g. DEM, CLC, GHS

Modular
Input
Encoding

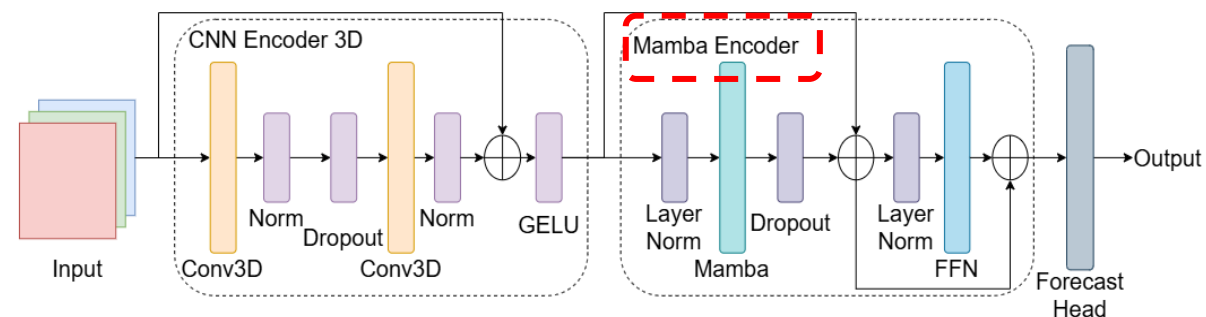
New data slots in with ease



Emission Inventories

e.g. EDGAR, NAEI

Novel AI methods

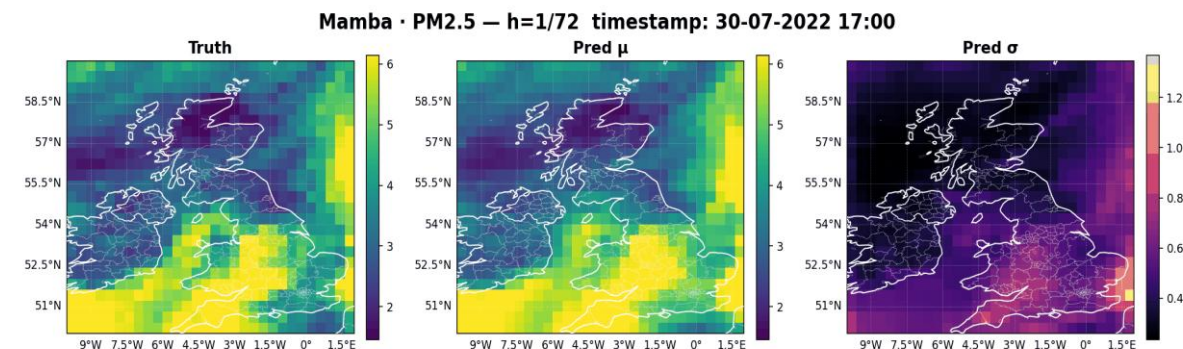


Physics-informed AI

$$\mathcal{L}_{\text{total}} = \mathcal{L}_{\text{data}} + \lambda \mathcal{L}_{\text{PDE}}$$

$$\mathcal{L}_{\text{PDE}} = \left\| \frac{\partial \hat{C}}{\partial t} + \underbrace{\mathbf{v} \cdot \nabla \hat{C}}_{\text{Advection}} - \underbrace{K \nabla^2 \hat{C}}_{\text{Diffusion}} - \underbrace{\left(E - \theta_{\text{chem}} \hat{C} \right)}_{\text{Source / Sink}} \right\|^2$$

Actionable spatiotemporal forecasting



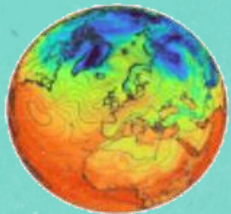
72h lead time forecasting in less than 1s for the whole UK!
@ NVIDIA RTX 6000 Ada GPU

PILLAR 2

MULTIMODAL MONITORING & USER-CENTERED INFORMATION

MULTIMODAL DATA

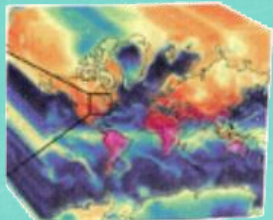
Meteorological & Climate



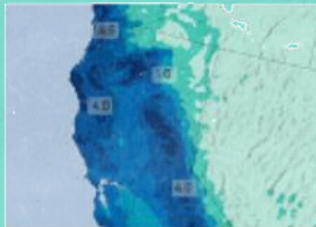
Oceanic & Cryosphere



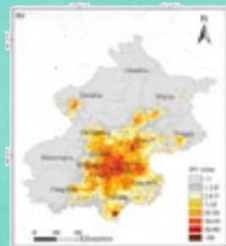
Remote Sensing & Satellite



Climate & Weather



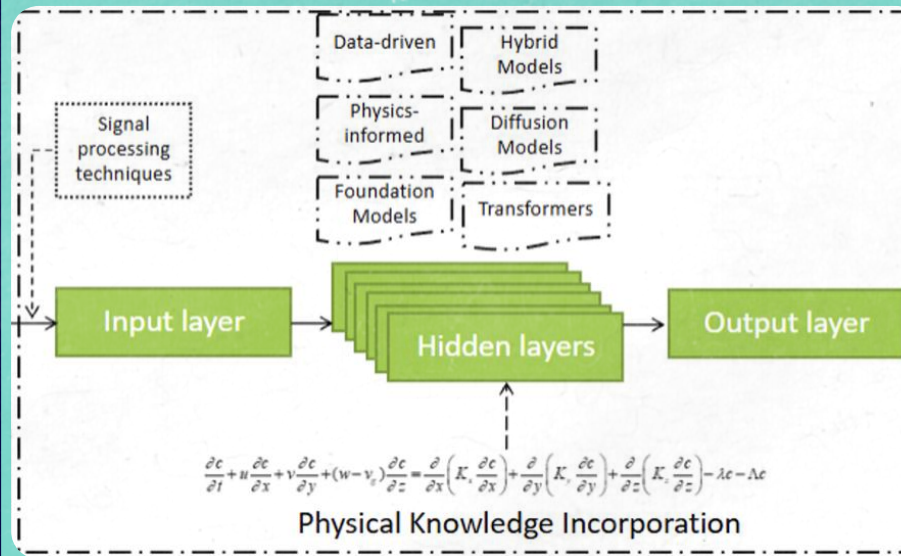
Socioeconomic & Human Activity



Air Quality & Pollution



AI TRAINING AND VALIDATION



TASKS

HIGH RESOLUTION
ATMOSPHERIC
SIMULATION

DISASTER RISK
MANAGEMENT

CROWD
SIMULATION

Multimodal Domain-Informed Foundation Models for Predictive and Prescriptive Maintenance

Why?

Offshore Oil Well¹



5% production loss

\$500K/day

maritime probe maintenance

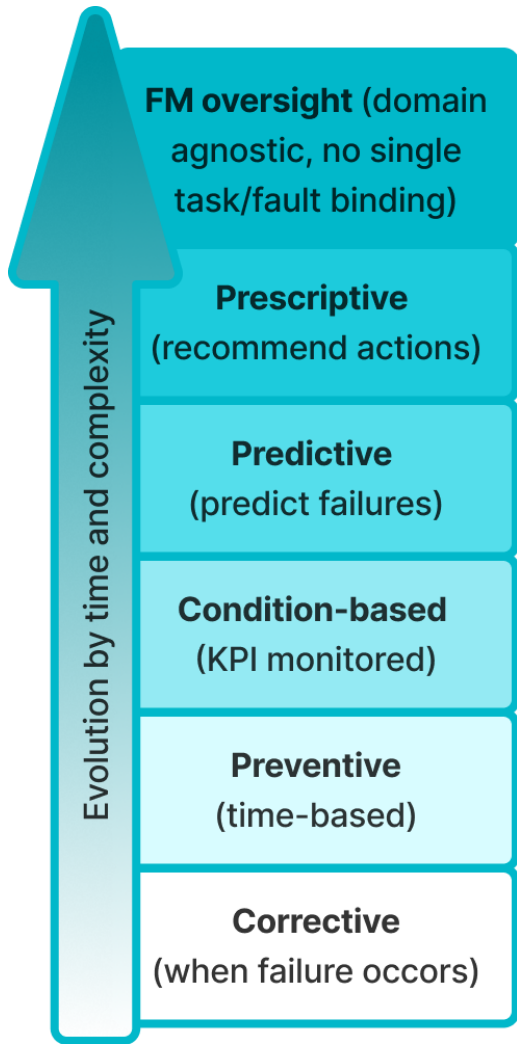
Macondo Prospect



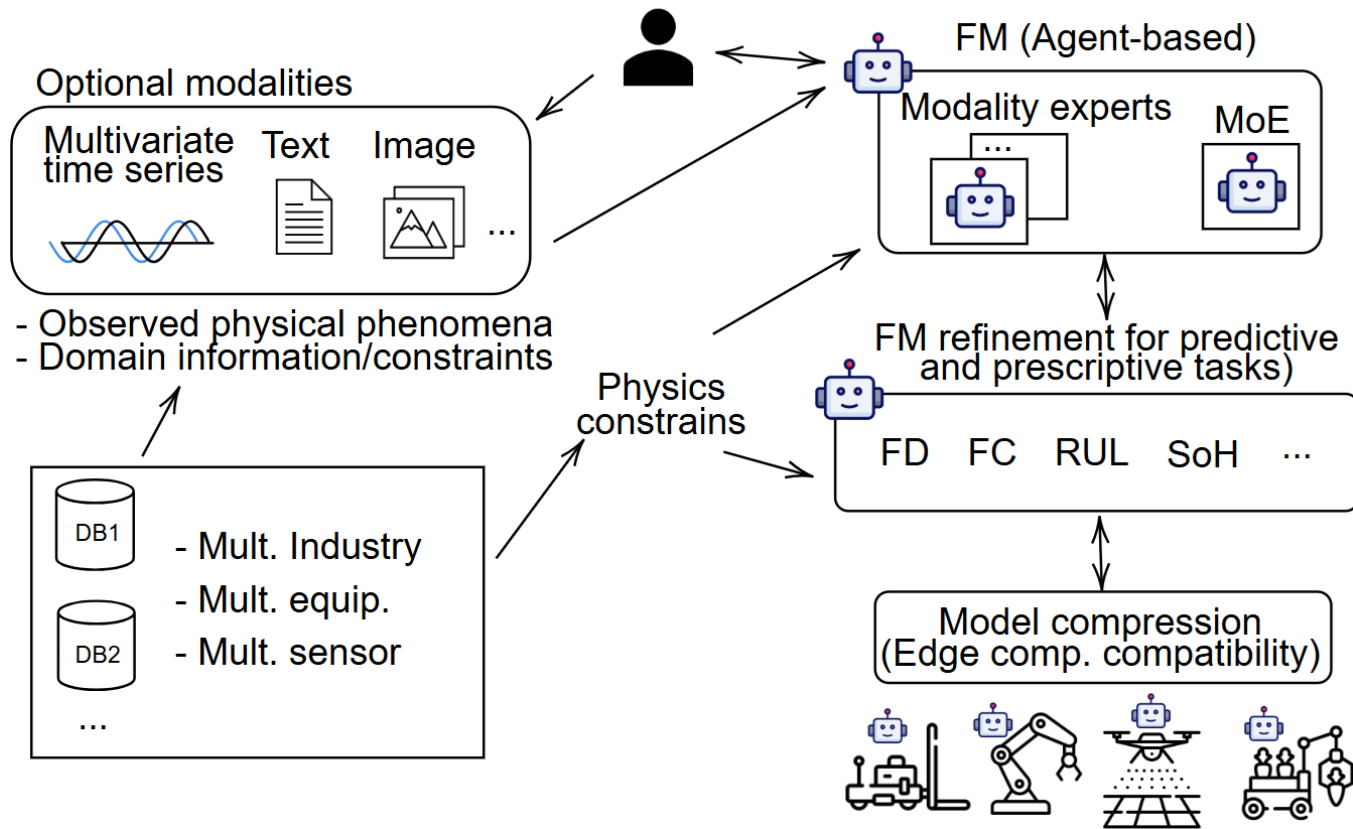
11 workers died²

Oil leakage for 87 days

What?

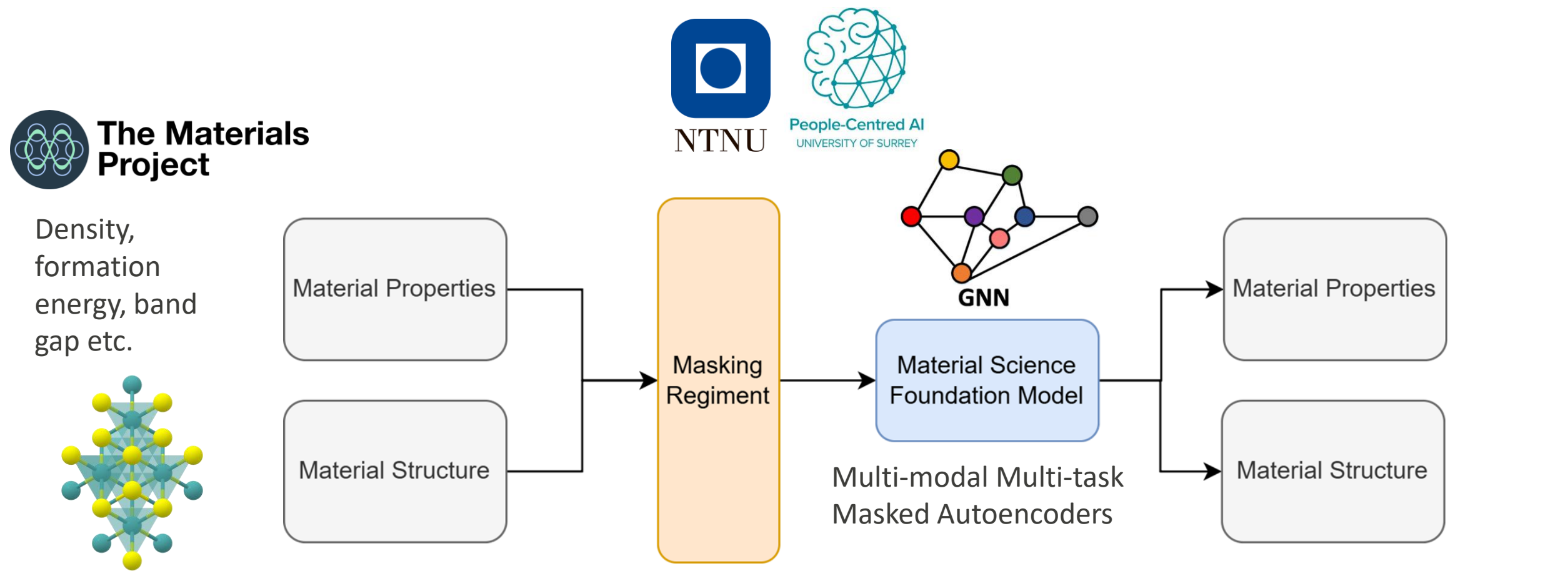


How?



1 - Vargas et. al(2019) <https://github.com/petrobras/3W>
2 - <https://www.csb.gov/macondo-blowout-and-explosion/>

Sustainable Multimodal Multi-task Foundation Model for Material Sciences



- **Structure-from-Properties:** Generate new material structures using only property data.
- **Properties-from-Structure:** Predict material properties using only structural data.
- **Downstream Adaptation:** fine-tuning for multiple material science downstream tasks.
- **Focus on battery design:** Fine-tuning for predicting the conductivity of a material.



Thank you!



People-Centred AI
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