

DESCARTES PROGRAM



Physics Aware Digital Twins as reliable, responsible tools to predict and manage disruptions in urban complex systems

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Critical urban systems, Decision-making, Hybrid Artificial Intelligence

BACKGROUND

Cities are complex, entangled, systems of systems. As urban planning grapples with **VUCA** challenges, constant variabilities and uncertainty, it makes it particularly difficult to take decisions based on partial knowledge. In this situation, classic AI, due to several limitations, fails to provide sufficient solutions to allow human-centered optimized decision making.

RESEARCH GAP



Full AI systems can be opaque, hampering error correction.



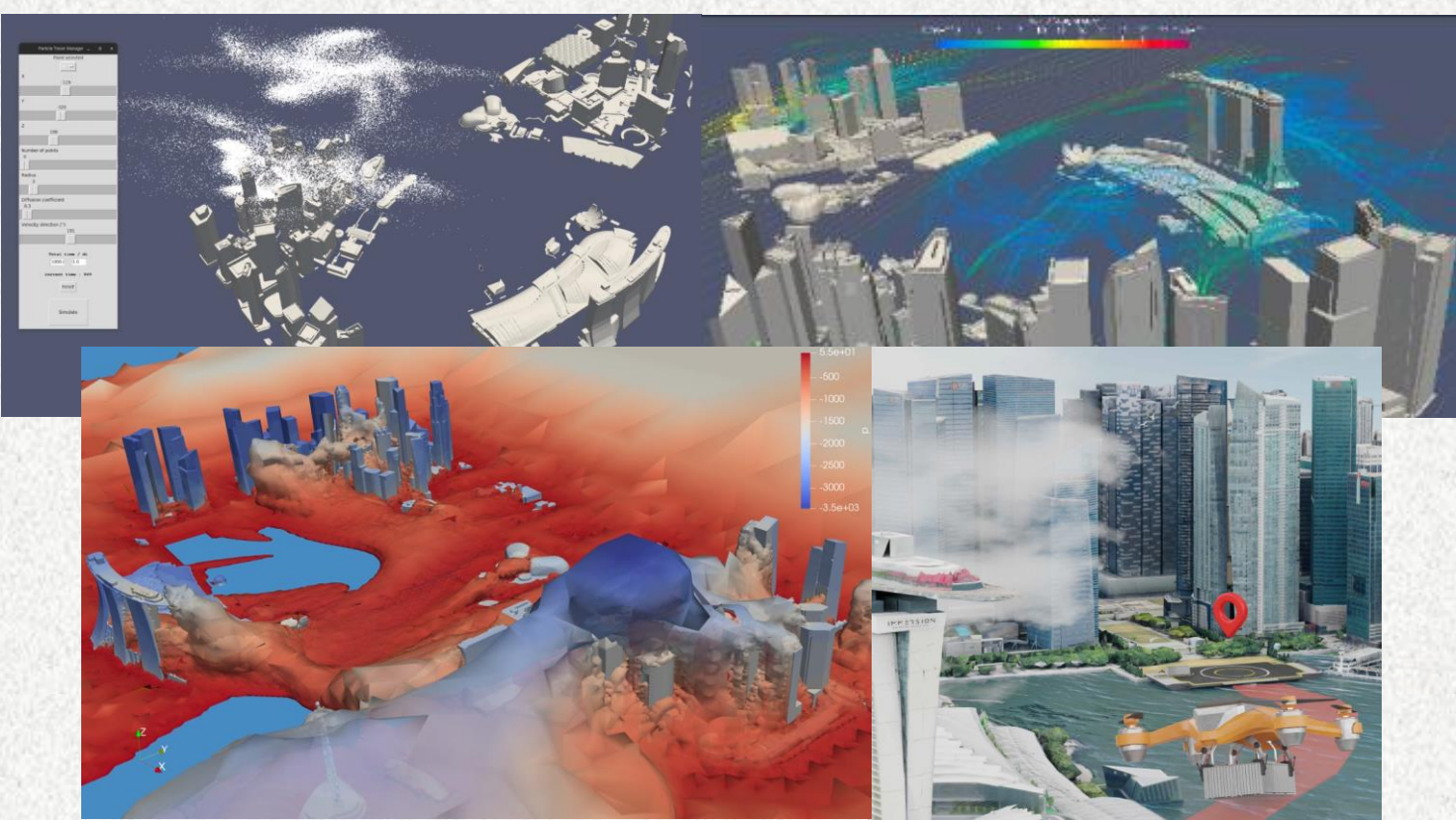
AI can be vulnerable to cyber-attacks, risking breaches.



AI can pose ethical issues in decisions affecting humans.

OUTCOMES

Real-Time Hybrid Twins



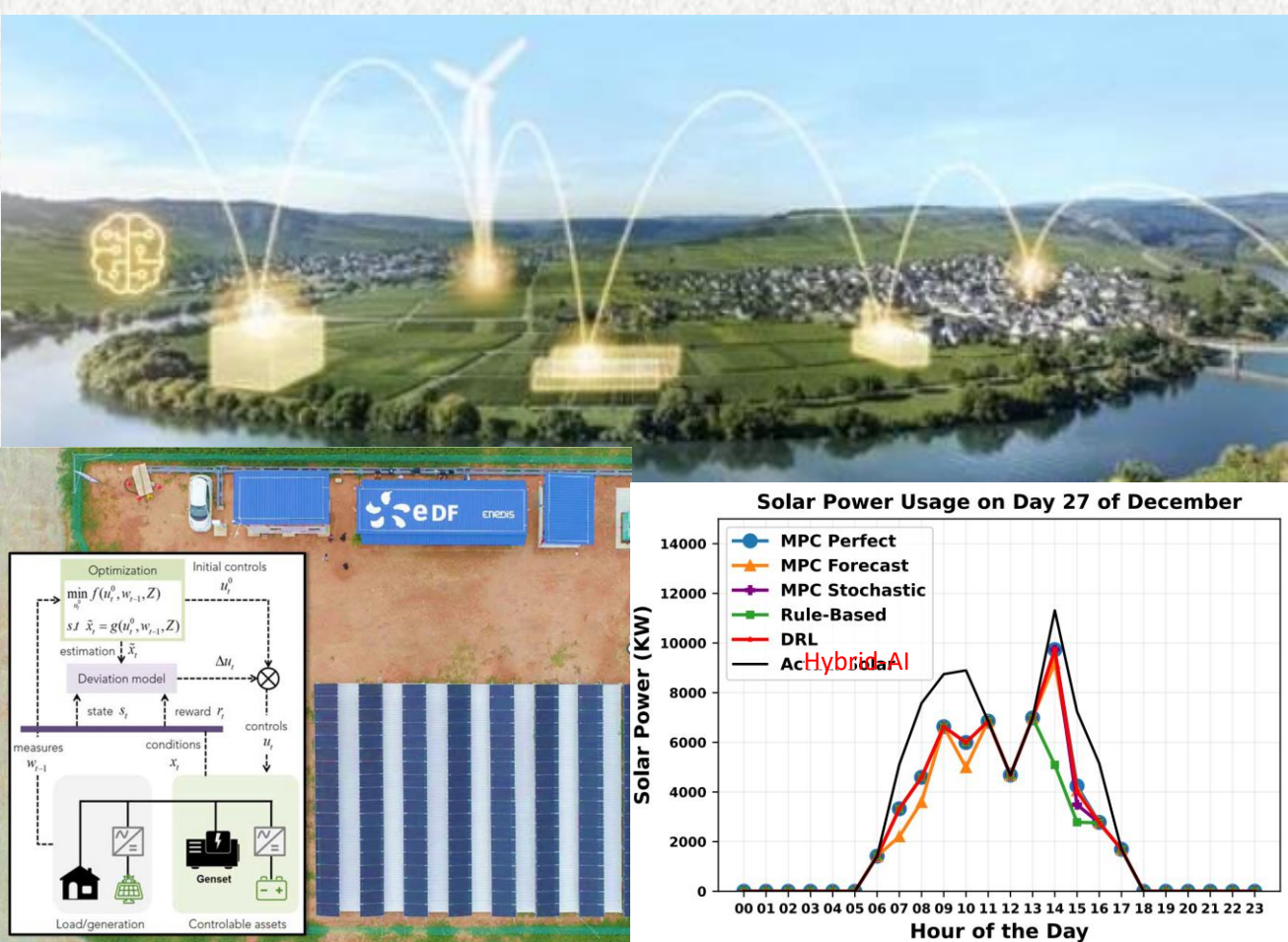
Real-Time Urban Maps

Hybrid AI offers >1,000x speed-up of usual physics-based models (Navier Stokes, Thermodynamics...), enabling urban maps for wind, temperature, air quality, pollution dispersion, drone no-fly zone etc., evaluated in real time to optimize decisions for constantly changing conditions (e.g., flight paths, weather forecasts).



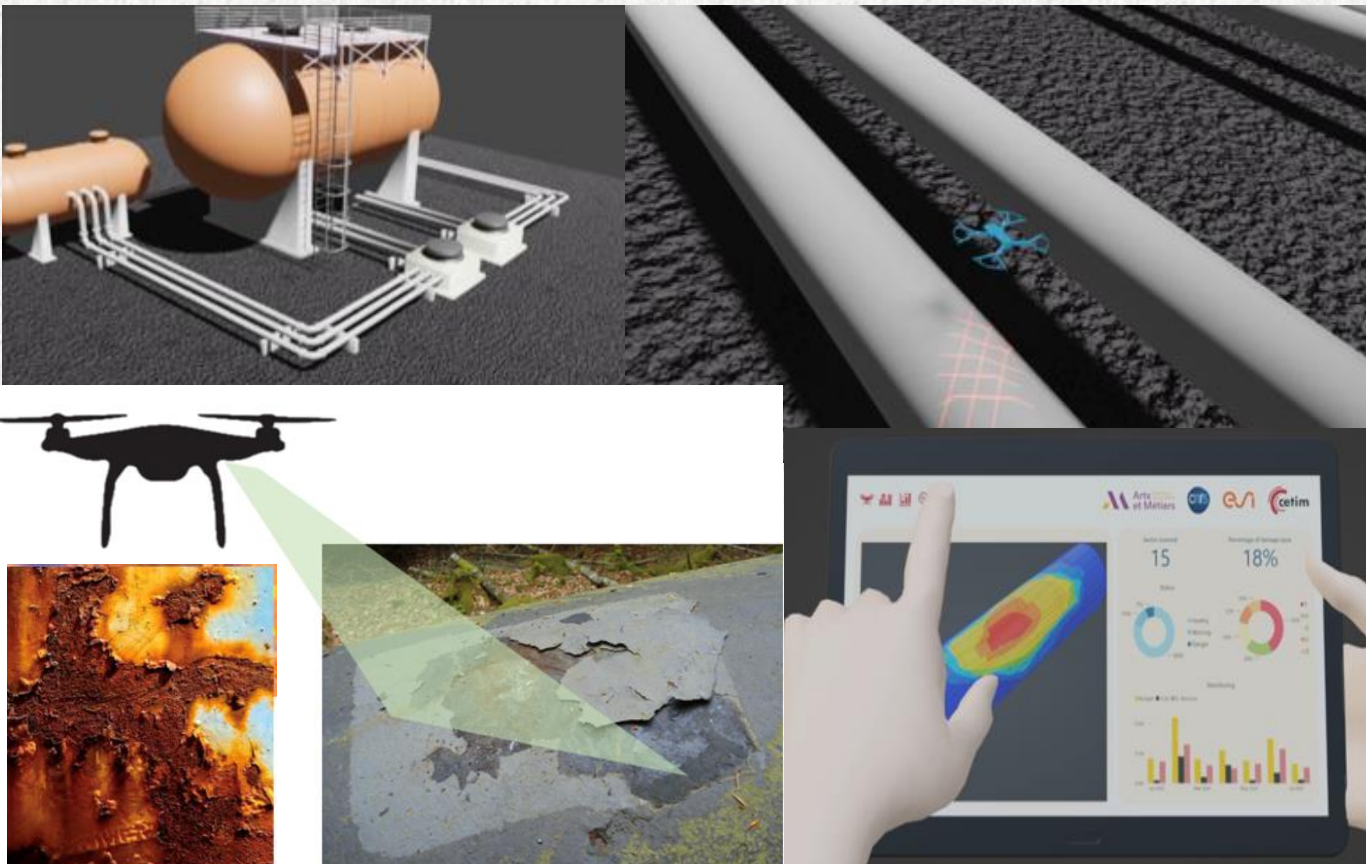
Urban Crisis management

Plans optimized trajectories (evacuation routes, emergency response paths), by intelligently modelling the evolving risk in degrading situations. It enables optimized real-time decision-making to manage the aftermath of a crisis.



Digital Energy Management

Allows accountable decision-making for energy distribution, reducing fuel usage/cost by 6% in the uncertain weather of S.E.A; calculation of the frequency drift ~1,000 time faster to ensure resiliency.



Infrastructures monitoring and predictive maintenance

Reconstructs the hidden structural integrity of the infrastructure from very few input data, to enable predictive and regular maintenance of large civil and industrial buildings, allowing to totally bypass the deployment of expansive internal sensors.

AIM

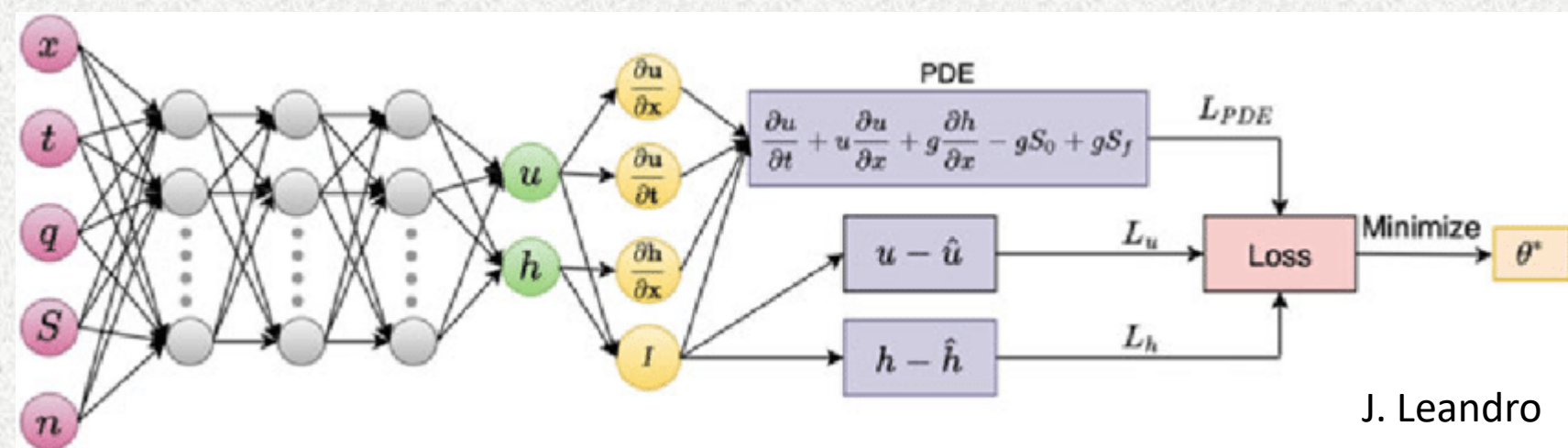
In order to better **predict, anticipate** and **control in real time critical urban systems** (characterized by **uncertainties**), we develop **Hybrid AI**, fusing physics and data-driven AI to deploy the innovative Hybrid Twins concept. This solution combines **structural knowledge** with **machine learning** and offers a better way to make **diagnosis, prognosis and decision making** as it champions:

FRUGAL-AI	SECURED-AI	TRANSPARENT-AI	ETHICAL-AI
with less data	certified and regulated	in a human-centric way	by empowering people

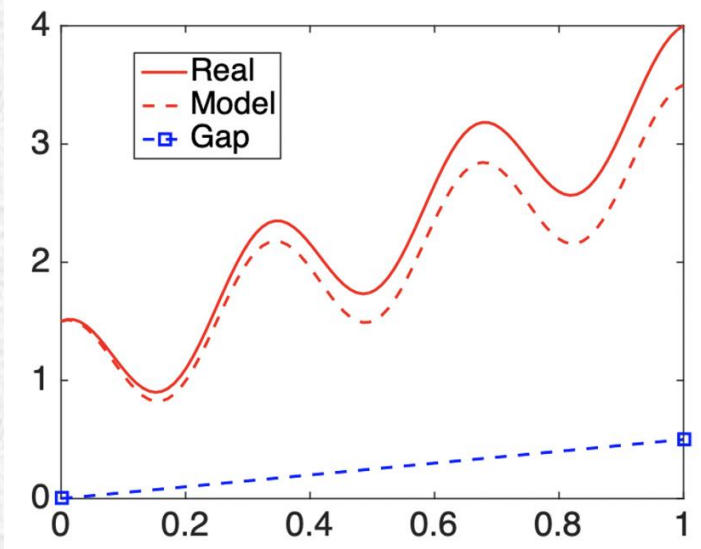
METHODS

2 main approaches for Hybrid AI developed by DesCartes:

- Physics-informed learning:** AI learns an accurate model, constrained by the existing physical knowledge in order to agree with it;



- Physics-augmented learning:** we consider the existing physical model, complemented with a term to represent the learnt deviation between the prediction made by the existing models and the observations. This correction (or enrichment) term is learnt by AI.



KEY DISCUSSION POINTS

- The most remarkable methodology generated by our research applies to the **environmental modelling and control system** that constitutes a sort of urban scale, knowledge-informed digital twin.
- The **Hybrid Twin** is **versatile and valuable in urban planning**, aiding with challenges like extreme weather, pollutant dispersion, drone optimization...

CONCLUSION

The works already developed show promise in **urban decision-making**.

The **DesCartes Builder's platform** will integrate techniques for transparently creating hybrid twins of complex systems. This adaptable system will be able to support urban planning and human-centered decision-making for agencies and industries.



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