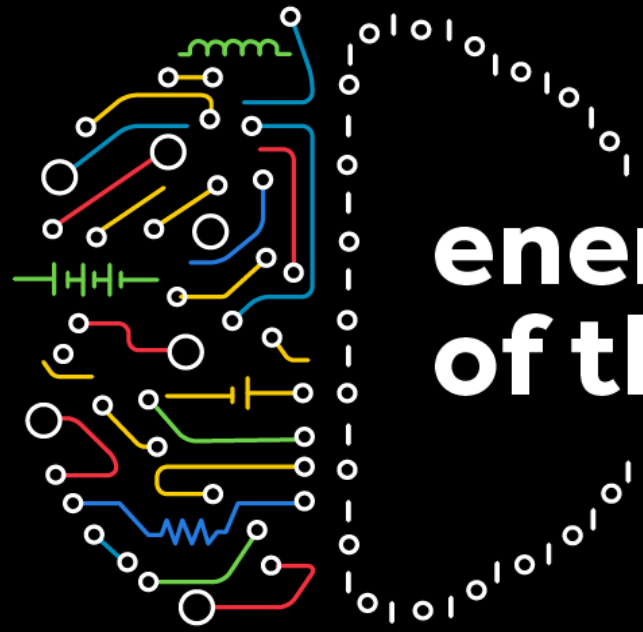


energy systems of the future

INESCTEC

FEUP Main Auditorium

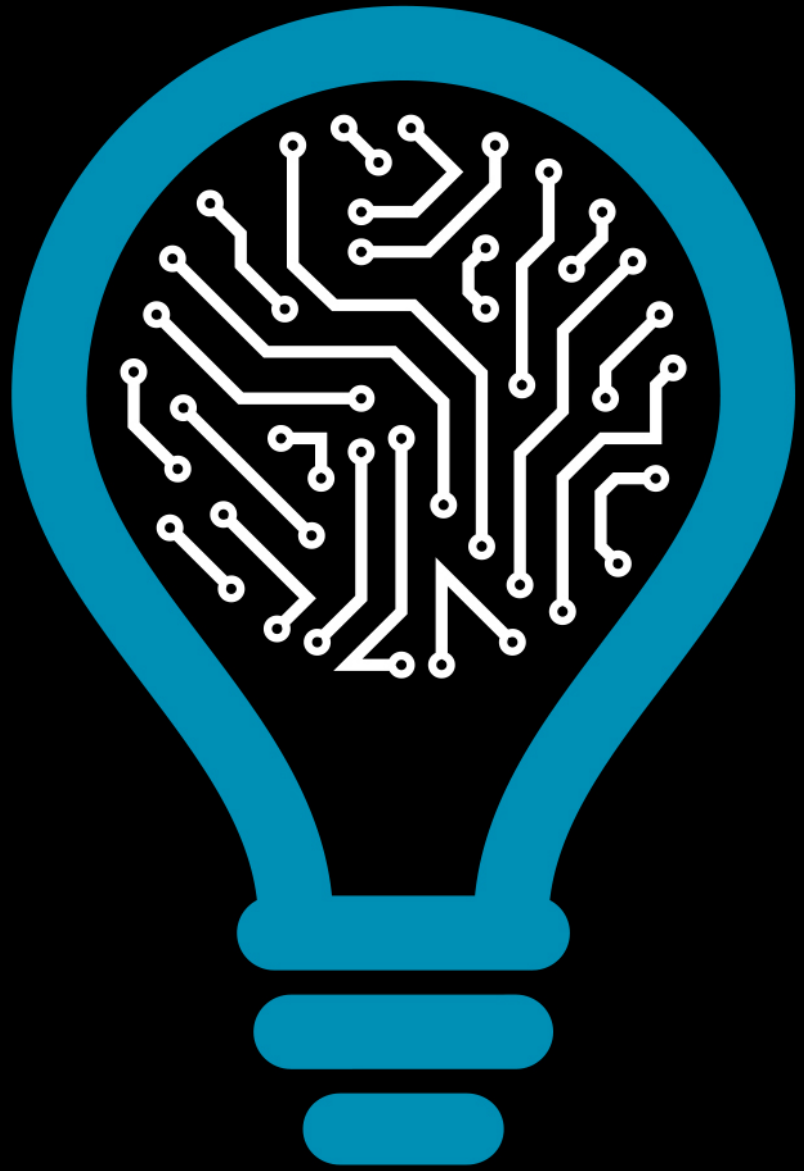
May 29 ○ 14h00

Artificial intelligence in the energy sector: hype, hallelujah or outdated?

Ricardo Bessa, rbessa@inesctec.pt

Energy Systems of the Future

Porto, 29th May 2019



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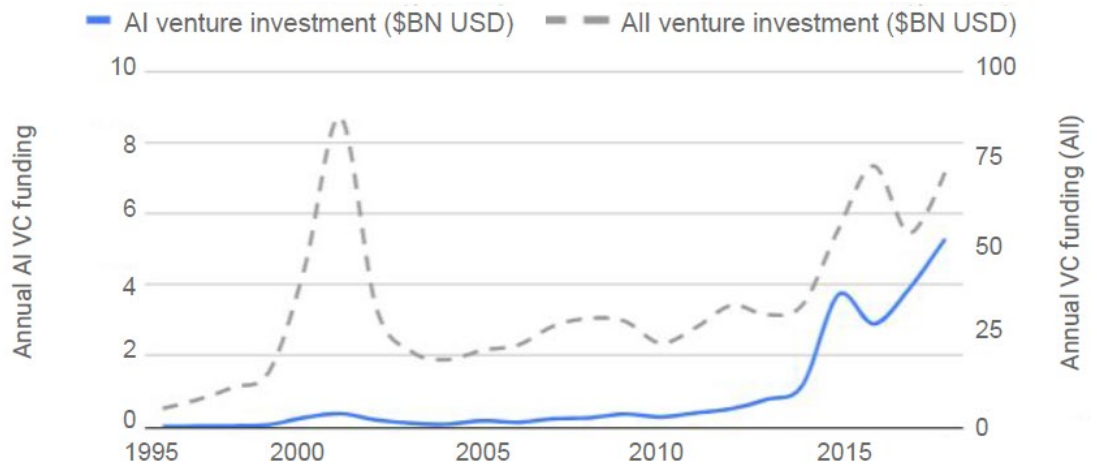
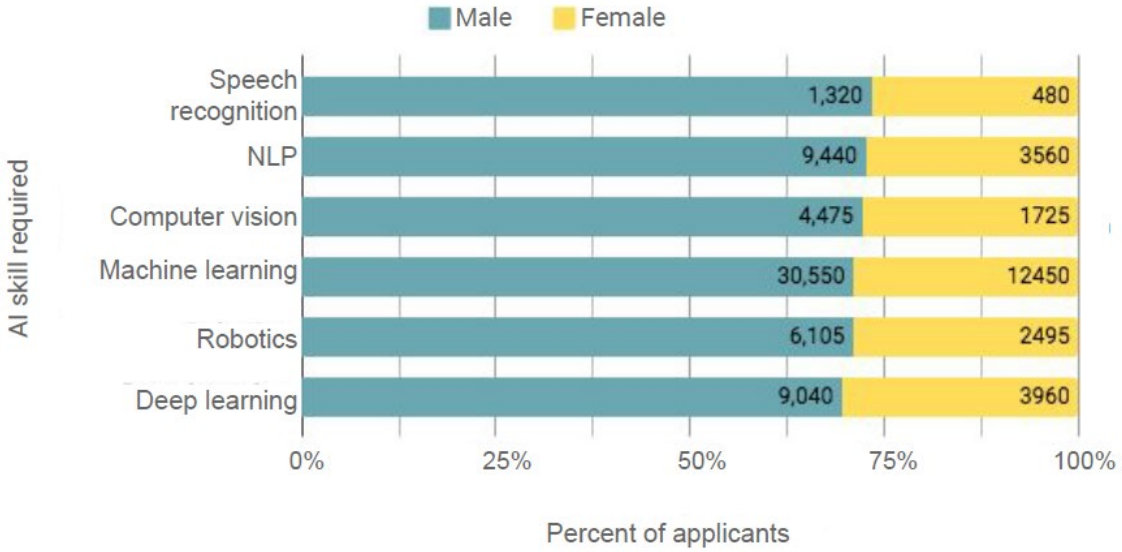
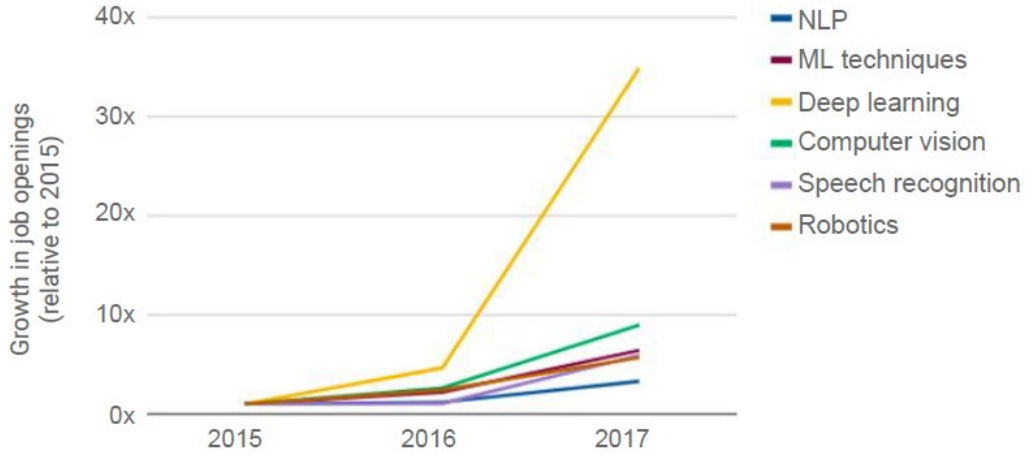
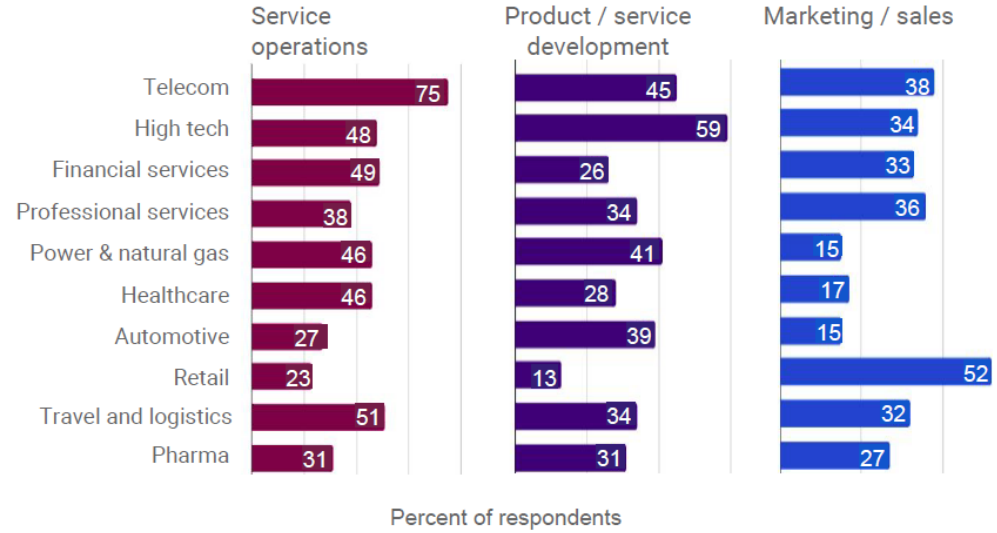
The Hype of Artificial Intelligence





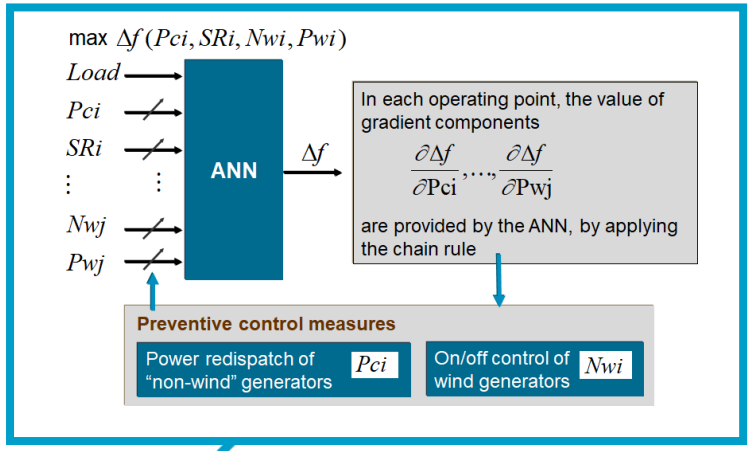


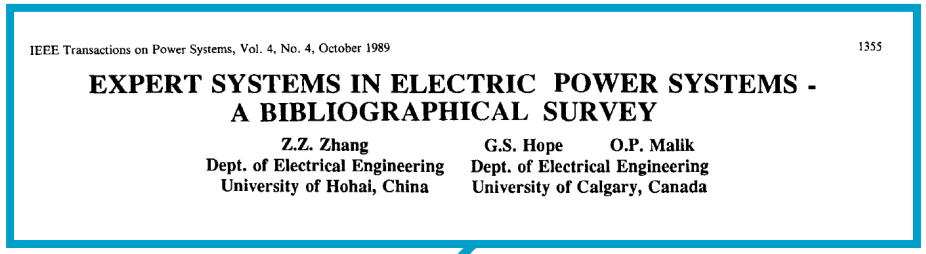
AI adoption by industry and function (2018)
Source: McKinsey & Company



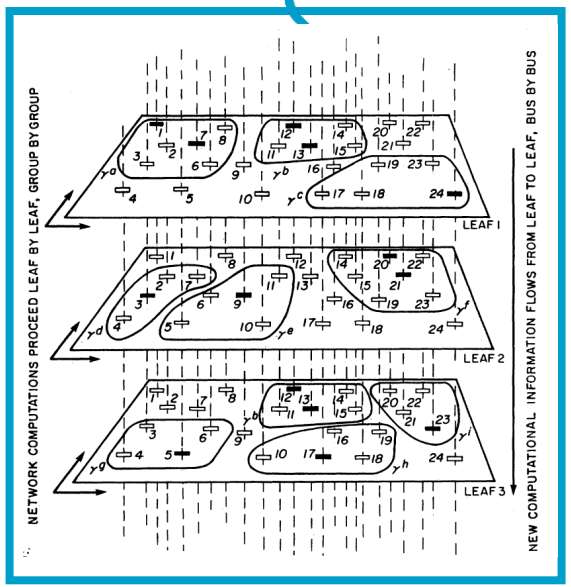
Source: Artificial intelligence index. Annual Report 2018

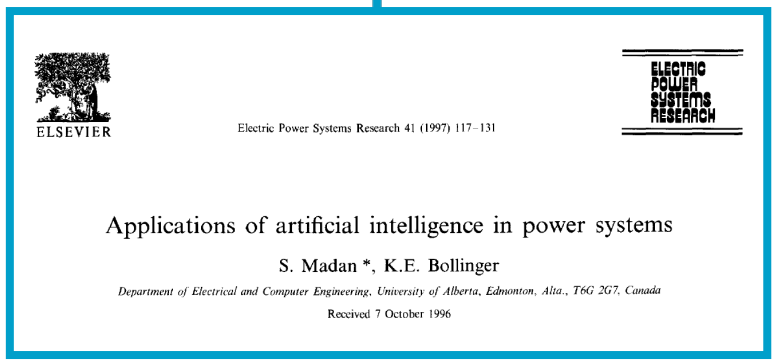
Is AI Outdated in the Energy Sector?





1985 1989 1997 2002 ...





Where is the potential for innovation?

Recent Research and Technical Breakthroughs

AI Hardware

Semiconductor performance is a key driver behind progress in AI applications. Graphics processing units (GPU) mean **fast training** and model iteration

Deep Learning

Breakthrough in **computer vision** (detecting objects, understanding actions) and in **learning goal-oriented behavior** (reinforcement learning)

Neuroscience

Better understanding of biological brains inspired new concepts for AI: **episodic and working memory, attention, continual learning, imagination,** etc.

Transfer Learning

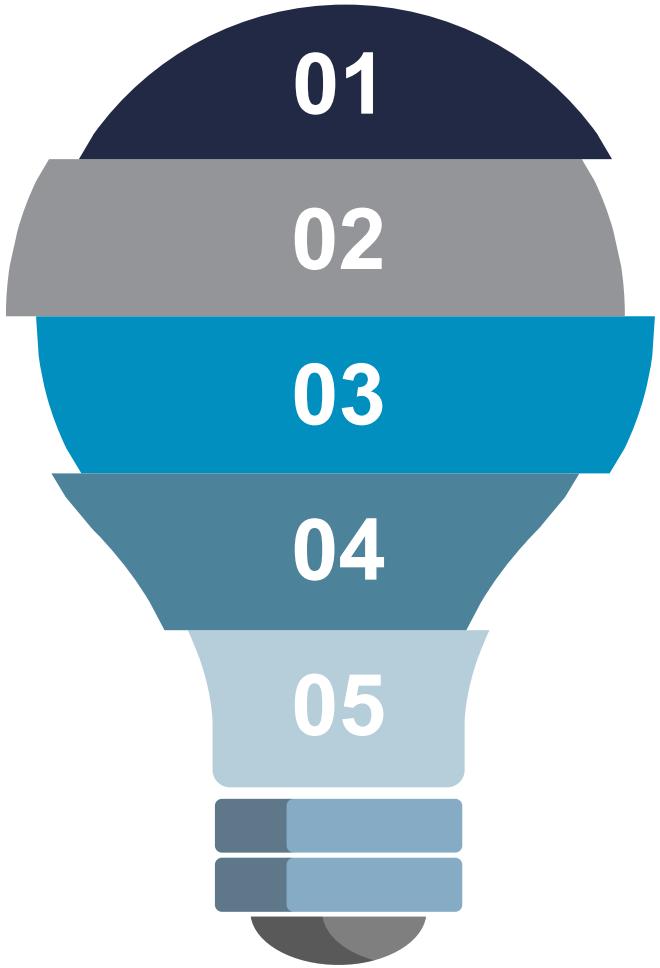
Knowledge acquired by a trained model can be re-applied during the training process for a new task. **Reduces the amount of data needs**

Automated AI

Automatically discovers the best model architecture for a specific task (**reduces human craft**)

Selection of AI Use Cases @ Energy Sector

Drivers of AI impact



1 Too much information

Reduce cognitive load of humans & exploit memory from repeated situations

2 Need to act fast

Increase decision confidence & find complex solutions

3 High uncertainty

"Process" and communicate uncertainty information without increasing stress levels

4 Not enough meaning

Find patterns in sparse data & simplify information & imagine future scenarios

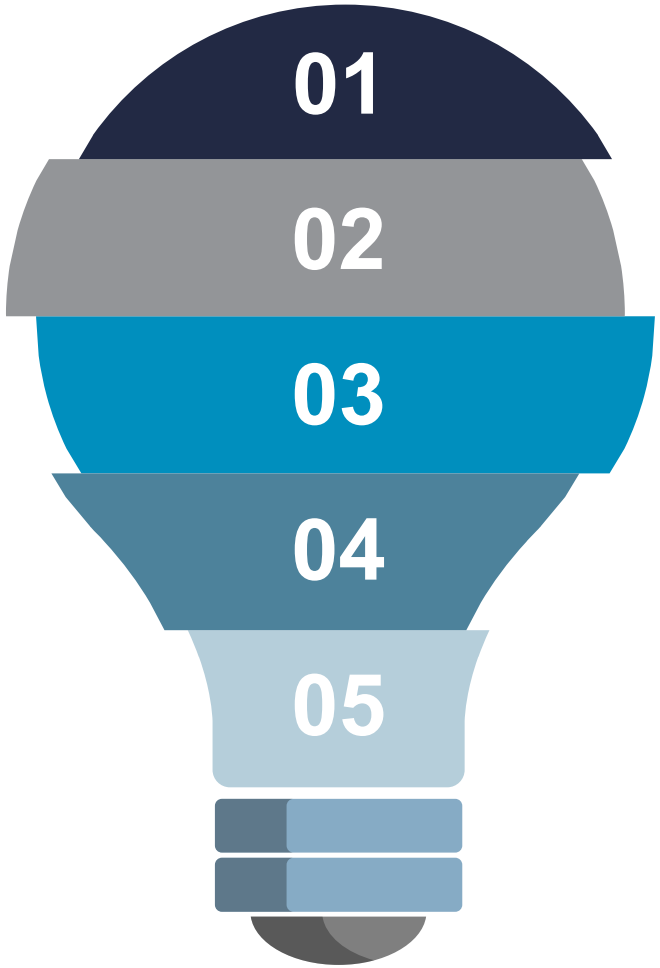
5 High complexity

Handle cases where the modelling of the physical system is complex and/or expensive

partially inspired by "Cognitive Bias Codex", Buster Benson and John Manoogian III

Selection of AI Use Cases @ Energy Sector

Examples (non-exhaustive!)



1 Too much information

► Alarm management in substations
► Cascading failure

2 Need to act fast

► Remedial actions for transmission and distribution grids
► Resilience to extreme weather events

3 High uncertainty

► Trading RES in the electricity market
► Operational planning of power systems

4 Not enough meaning

► Asset condition monitoring and forecasting
► Electricity market data analysis

5 High complexity

► Energy optimization of industrial processes
► Distributed control in VPP, DER and grids

partially inspired by “Cognitive Bias Codex”, Buster Benson and John Manoogian III

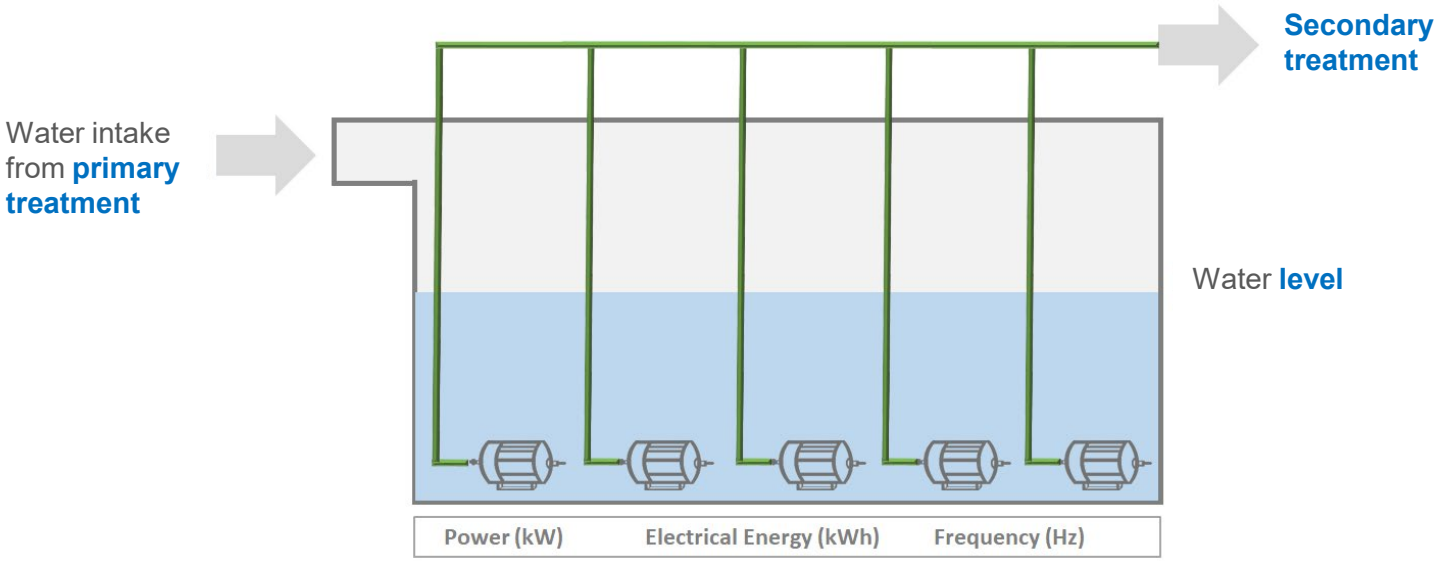
Use Case: Energy Optimization in Wastewater Station

AI Value Proposition

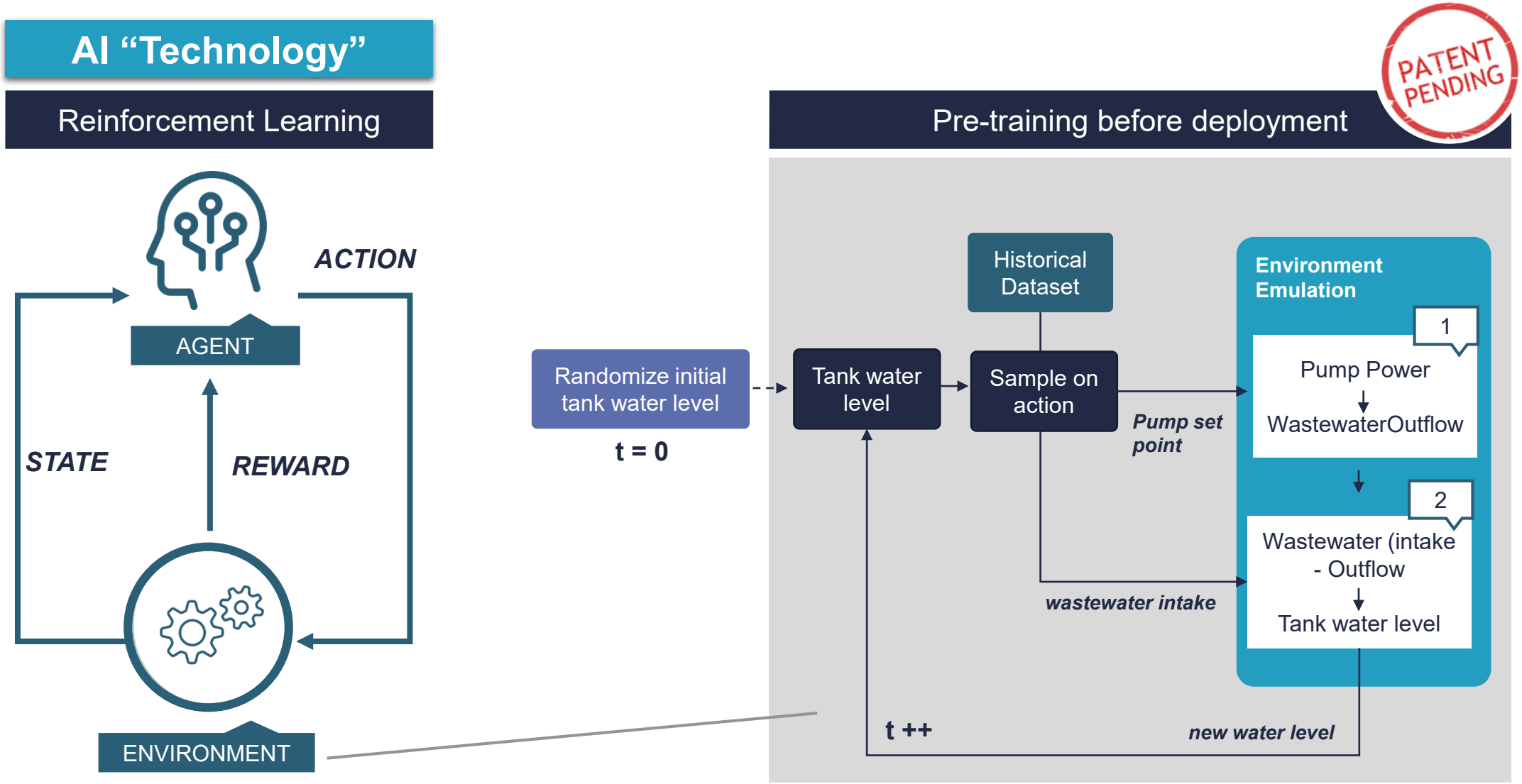
Avoid modelling the wastewater system AND explores data already available from the SCADA

Minimize electrical energy consumption

- Predictive control of variable-frequency pumps
- Anticipate periods of high wastewater intake
- Include different levels of wear and tear of the pumps
- Be easily implemented and it is scalable to other systems



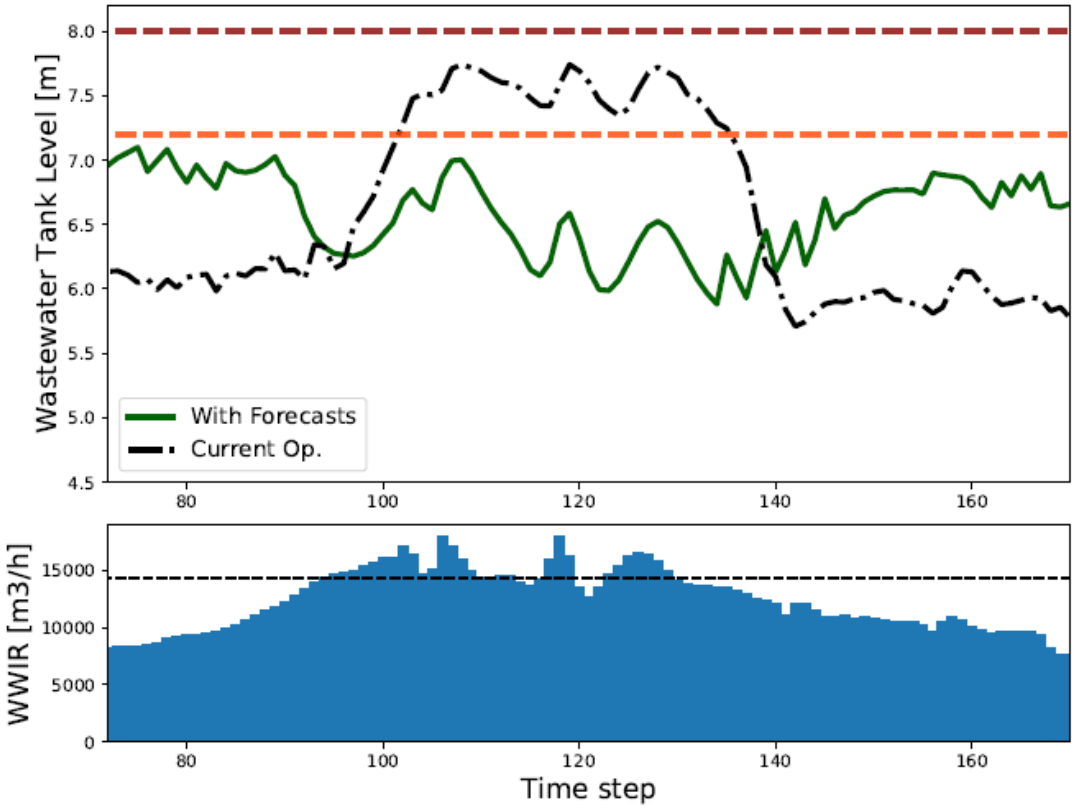
Use Case: Energy Optimization in Wastewater Station



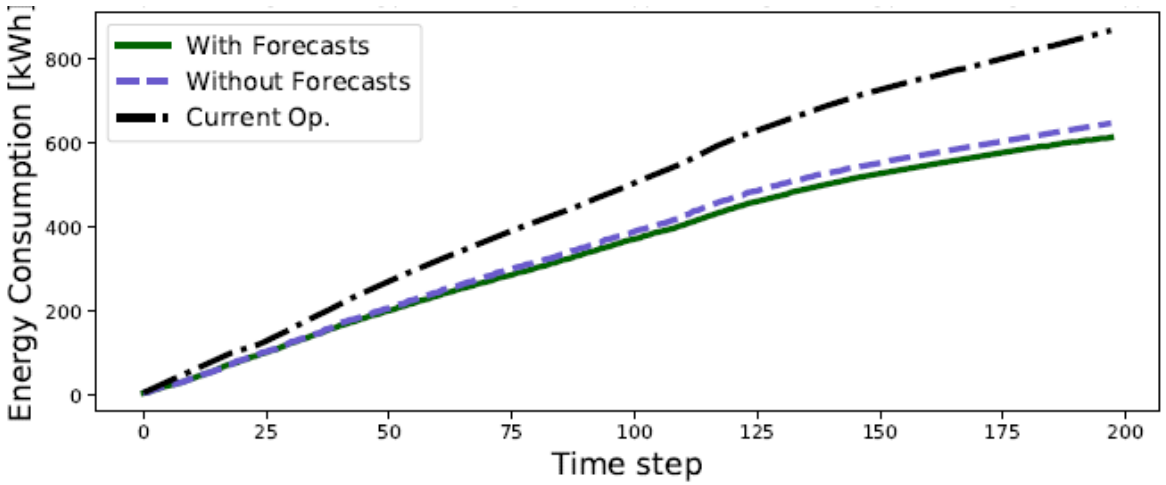
Use Case: Energy Optimization in Wastewater Station

Predictive approach

("imagining" and acting based on future states)



Energy Savings with AI



Reduce energy consumption by 15 - 30%

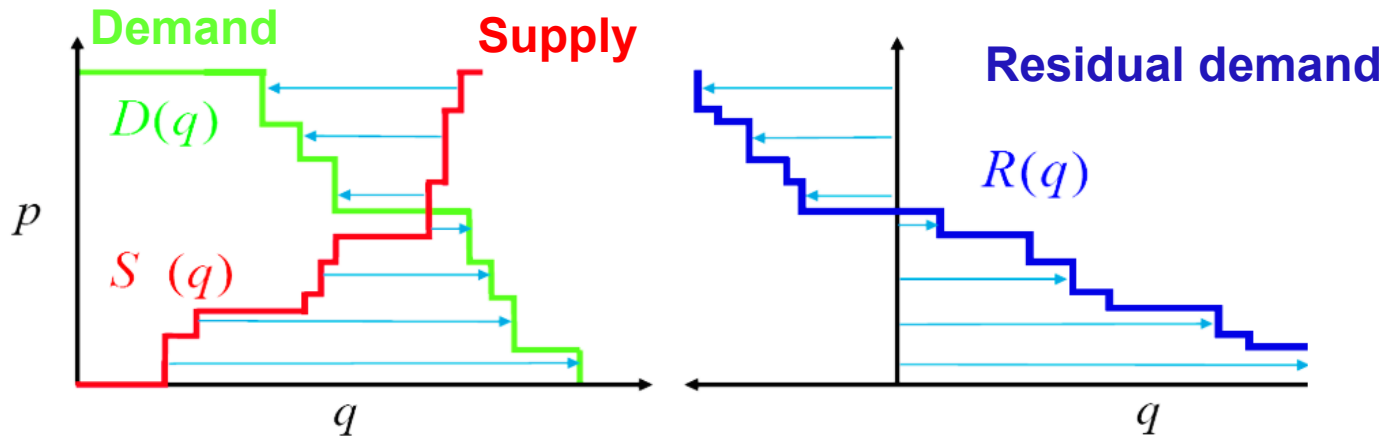
Use Case: Electricity Market Data

AI Value Proposition

Predict competitors bidding behavior AND improve market offers with this valuable information

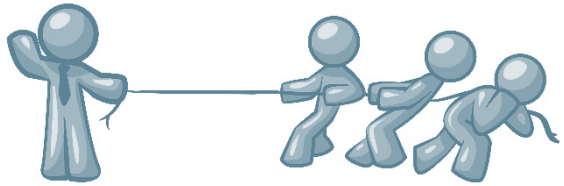
Predict residual demand curves

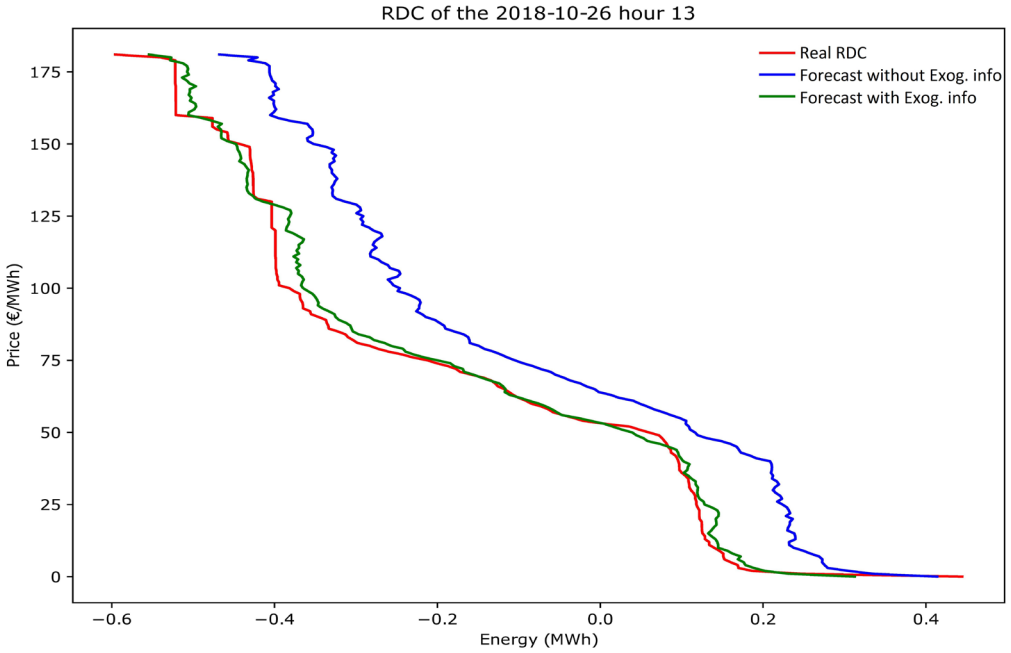
- Predict residual demand curves for the 24 hours of day D+1
- Use biologically-inspired models, i.e. convolutional layers and memory networks
- Exploit the capacity of deep learning in handling frames/images

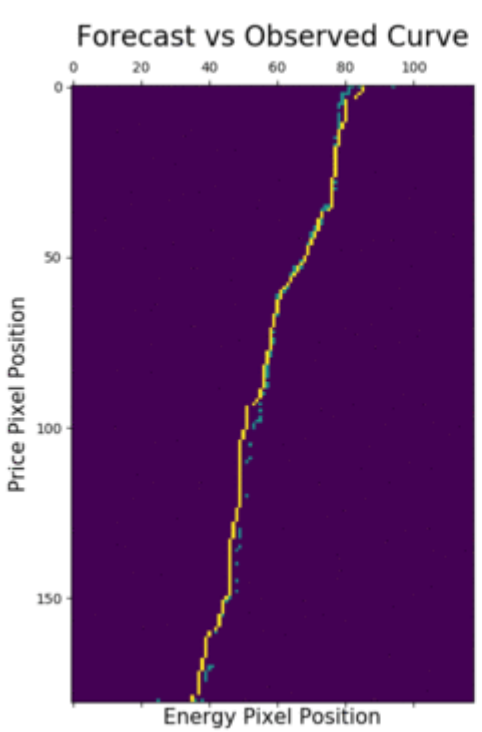


Use Case: Electricity Market Data

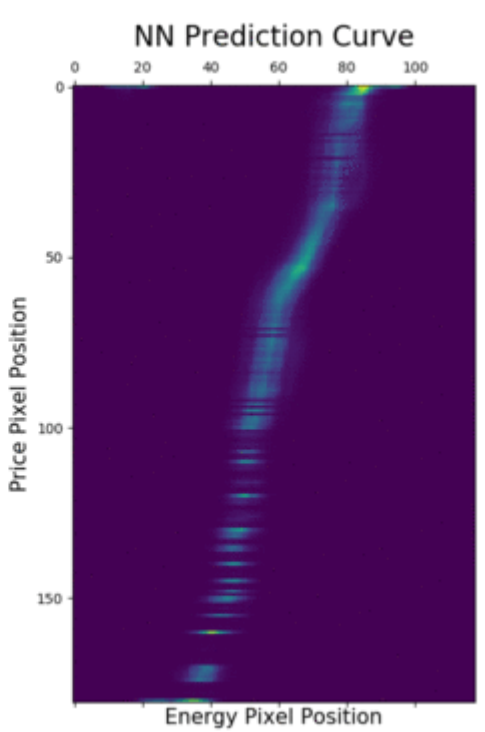
Predict your competitors offers







Day 30 / Hour 0



Use Case: Reduce Cognitive Load in Substations Alarms

AI Value Proposition

Reduce cognitive load of human operators AND provide fast decision-aid

Minimize time-to-first-action

- Analyze the ultra-fast (milliseconds) sequence of alarms
- Detect and classify patterns of events
- Solve issues that cannot be handled automatically
- Knowledge capitalization on operator's historical decisions

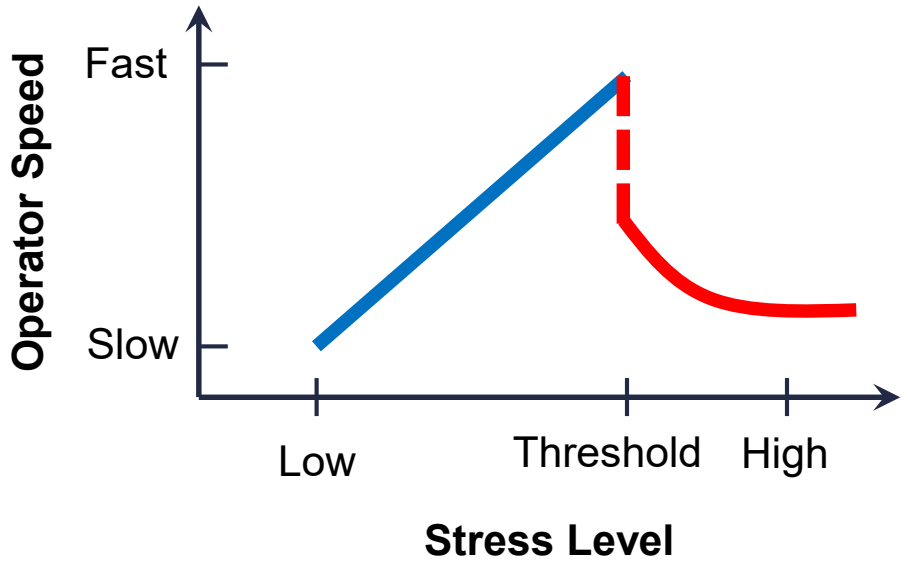
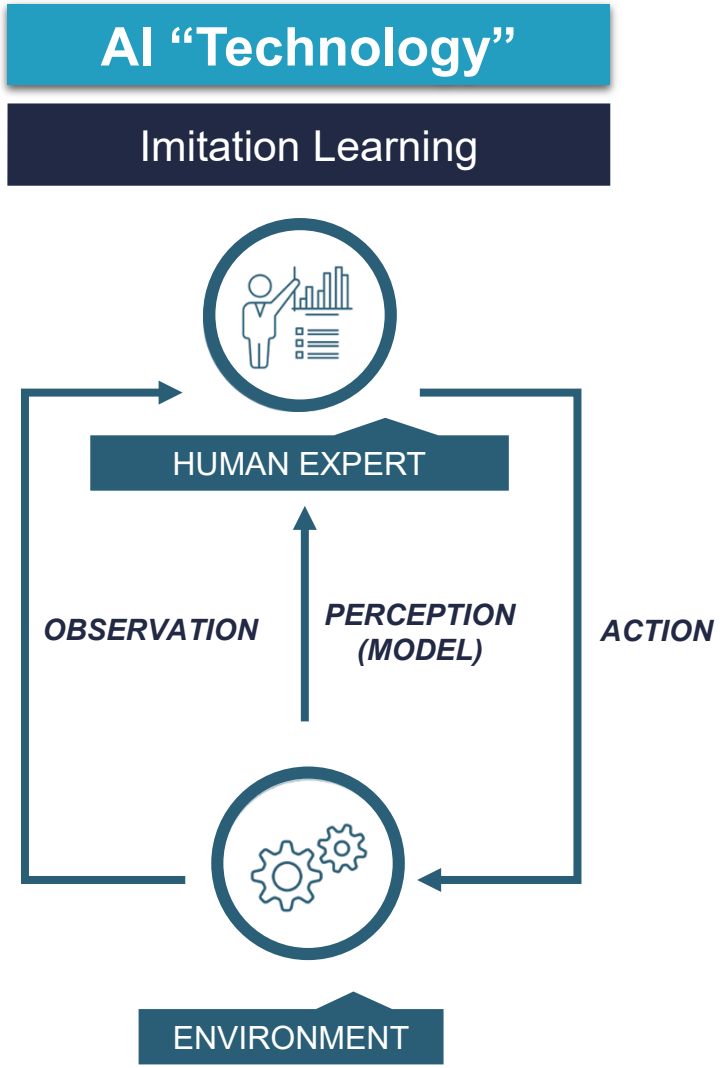
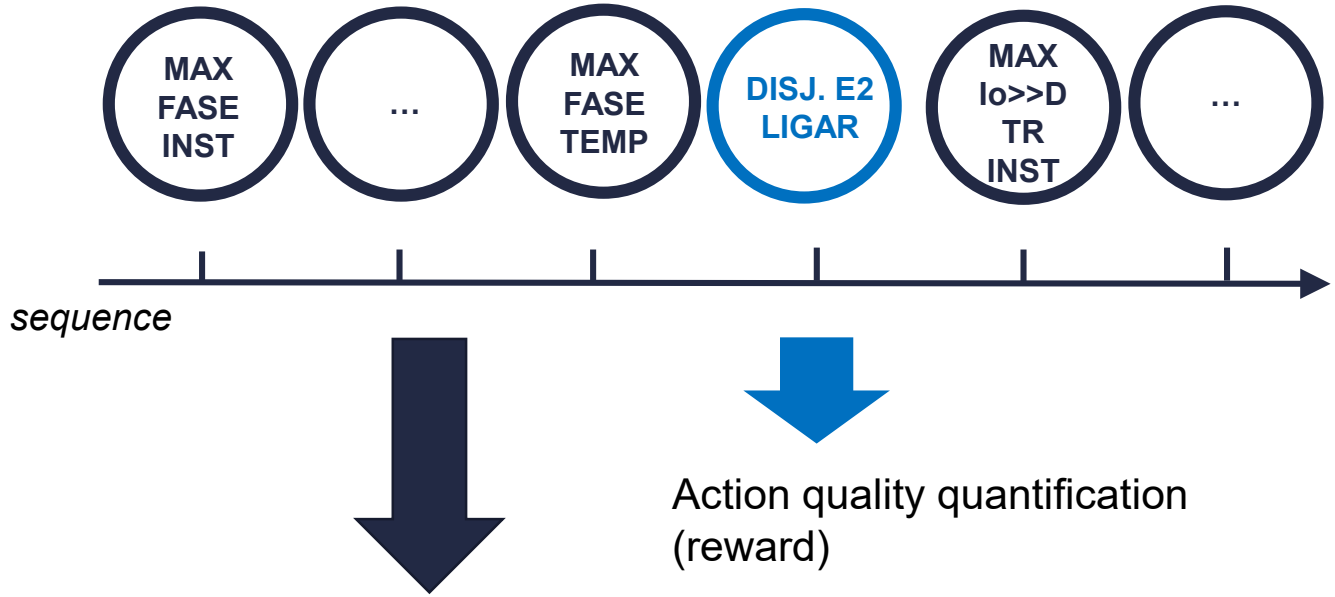


Figure reference: Kirschen, D. S., Wollenberg, B. F. (1992). Intelligent alarm processing in power systems. Proceedings of the IEEE, 80(5), 663-672

Use Case: Reduce Cognitive Load in Substations Alarms



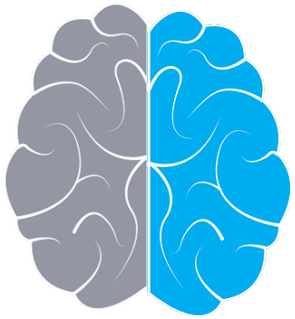


- Similarity analysis
- Selective attentional mechanism

Figure based on: Zuo, S., et al. (2017). Continuous reinforcement learning from human demonstrations with integrated experience replay for autonomous driving. 2017 IEEE International Conference on Robotics and Biomimetics.

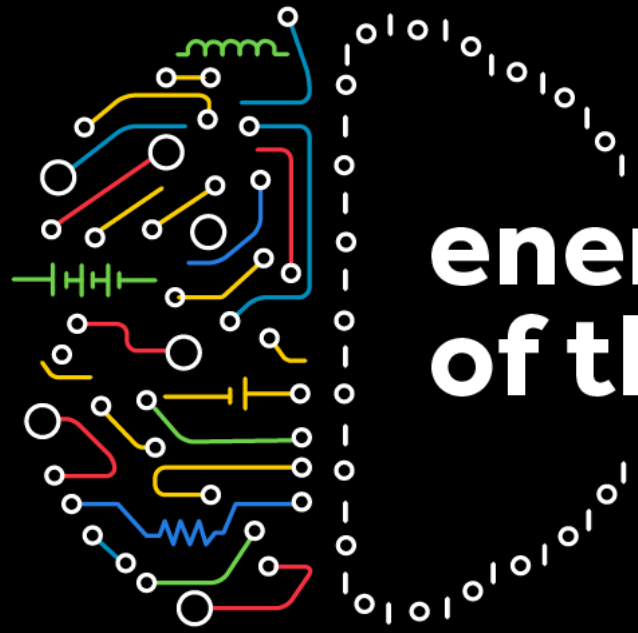
Some Predictions and Impacts

Prediction



Impact

AI-based methods will become “more” explainable	Broader adoption by decision-makers and industry
Hybridization between data and physical models	Fast deployment of AI & Embedded expert knowledge
Attractive business cases in asset and grid management, electricity markets	De-risk investment in AI and R&D from academia
Paradigm shift towards distributed intelligence	Reduce big data requirements & New business models
Humans will remain a core building block in AI @energy sector	Improved human decisions & lower levels of stress



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