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**Physics-Informed Learning: Accelerating Scientific Modelling and Discovery**

**Abstract**

Physics-Informed Machine Learning (PIML) represents a paradigm shift in computational science by seamlessly integrating established physical laws, symmetries, conservation principles, and governing equations directly into the training of the neural networks known for their highly efficient inference. Thus, the models become physically consistent solutions to complex, nonlinear, and multi-scale systems. This synergy between domain knowledge and machine intelligence is proving especially transformative in accelerating scientific discovery, from uncovering hidden governing equations and predicting emergent behaviors to enabling real-time digital twins and autonomous optimized control

The presentation shows how PIML can be successfully used in accelerated modelling of electrochemical energy devices (batteries, fuel cells, and electrolyzers) which are sharing strongly coupled multi-physics phenomena governed by PDEs. A new concept for AI battery management enabling ultrafast sensorless scanning of core temperature for safety in large battery packs for EVs. will be described. Next, the power grid is a large, interconnected nonlinear network whose operating conditions change continuously due to renewable energy variability, load fluctuations, and topology changes during outages or faults. Here, PIML with Graph Neural Networks (GNN) proves to be a suitable representation technique as it can encode both topology and electrical distances (impedance) along with the physics constraints considering both spatial and temporal dynamics.

In conclusion, if scaled successfully, PIML can become an universal optimization framework for any domain where the governing physics is fully or partially known like: physics, chemistry, biology, earth sciences, engineering, and emerging interdisciplinary frontiers.



## Short Bio

**Remus Teodorescu**, IEEE Fellow is professor with the Department of Energy Technology at Aalborg University. He is the founder and current coordinator of the [Center of Research for Smart Battery and AI-X](#) focusing on accelerating the green transition with help from artificial intelligence. He is currently the recipient of the prestigious Villum Investigator Project: Smart Battery 2021-2027 and of the [AIGREEN Villum Infrastructure Grant](#) (NVIDIA B300 DGX AI- Research Center for Green Energy Transition). His main current research area is centered along Physics-Informed Machine Learning for accelerated modelling of electrochemical energy devices (batteries, fuel cells and electrolysers) and power grid