PiAI Seminar Series: Physics informed AI in Plasma Science
9:30-10:30, 15 February 2021 (CET)
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Web Seminar

Diagnostic data integration using deep neural networks for real-time plasma analysis

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Recent advances in acquisition equipment is providing experiments with growing amounts of precise yet affordable sensors. At the same time an improved computational power, coming from new hardware resources (GPU, FPGA, ACAP), has been made available at relatively low costs. This led us to explore the possibility of completely renewing the chain of acquisition for a fusion experiment, where many high-rate sources of data, coming from different diagnostics, can be combined in a wide framework of algorithms. If on one hand adding new data sources with different diagnostics enriches our knowledge about physical aspects, on the other hand the dimensions of the overall model grow, making relations among variables more and more opaque. A new approach for the integration of such heterogeneous diagnostics, based on composition of deep "variational autoencoders", could ease this problem, acting as a structural sparse regularizer. This has been applied to RFX-mod experiment data, integrating the soft X-ray linear images of plasma temperature with the magnetic state.

However to ensure a real-time signal analysis, those algorithmic techniques must be adapted to run in well suited hardware. In particular it is shown that, attempting a quantization of neurons transfer functions, such models can be modified to create an embedded firmware. This firmware, approximating the deep inference model to a set of simple operations, fits well with the simple logic units that are largely abundant in FPGAs. This is the key factor that permits the use of affordable hardware with complex deep neural topology and operates them in real-time.