PiAI Seminar Series: Physics informed AI in Plasma Science
8:00-9:00, 24 October 2022 (EDT)
14:00-15:00, 24 October 2022 (CET)
21:00-22:00, 24 October 2022 (JST)
Web Seminar

Normalizing flows for likelihood-free inference with fusion simulations

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Comparing scientific models contained in computer simulations to real physical experiments is crucial not only for validation of those models, but to aid scientists in their physical interpretation of experimental results. Making this process routine and robust could greatly benefit researchers, and more easily point out breakdowns in the simulation, or new physics in the experiment to explore further. We leverage recent work in the area of likelihood-free inference ("simulation-based inference" or "SBI") to train a neural network which enables accurate statistical inference of physical simulation inputs from experimental diagnostic measurements. Several thousand example pairs of physics inputs/experiment observable outputs are generated using a forward model that include the simulator, then the neural network based on normalizing flows is trained to learn the inverse process of the forward model, complete with uncertainties in a Bayesian manner. Using this technique, we show two areas of experiment/simulation comparison which are enhanced. The first is the inference of anomalous transport coefficients (representing mostly the absence of explicit turbulence calculations in these fluid-based codes) from a fluid based scrape-off layer transport code (UEDGE). Typically users must tediously tune the input anomalous transport coefficients manually to match experiment, but with SBI techniques, routine extraction of these coefficients can be done, and point out uniqueness of a given set of inputs. Second, we show how SBI can be used to make routine the inversion of line-integrated visible spectrometry diagnostics to output neutral density, and how to combine with models based on other diagnostics for a more complete understanding of the edge of fusion devices.