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Supercomputers, Machine Learning and Fusion Energy

Advances in Big Data Machine Learning for Fusion Energy Applications

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Building the scientific foundations needed to develop fusion power in a timely way can be facilitated not only by familiar "hypothesis-driven"/ first principles approaches but also by engaging modern big-data-driven statistical methods featuring machine learning (ML) -- an exciting R&D approach that is increasingly deployed in many scientific and industrial domains.
The recent growth and success of machine learning in industry (e.g. Google, the new Internet services economy, etc.) suggests that these techniques can be formulated and adapted to enable new avenues of data-driven discovery in key scientific applications areas such as Fusion Energy with exciting potential for accelerating scientific knowledge discovery. An especially timeurgent and very challenging problem facing the development of a fusion energy reactor today is the need to deal reliably with large-scale major disruptions in magnetically-confined tokamak systems such as the EUROfusion Joint European Torus (JET) today and the burning plasma ITER device in the near future. Significantly improved methods of prediction with better than 95% predictive capability are required to provide sufficient advanced warning for disruption avoidance or mitigation strategies to be effectively applied before critical damage can be done to ITER -- a ground-breaking $25B international burning plasma experiment with the potential capability to exceed "breakeven" fusion power by a factor of 10 or more. This truly formidable task in Fusion Energy Science (FES) demands accuracy beyond the near-term reach of hypothesis-driven /"first-principles" simulations that dominate current research and development in the field. Statistical ML methods trained on very large data sets hold significant promise for delivering the much-needed FES predictive tools that can be generalizable at the basic level to multiple application domains.

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