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On-line Source Characterization of Betatron Radiation using a Deep Learning Based X-ray spectrometer

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Betatron radiation produced from a laser-wakefield accelerator (LWFA) is a broadband, hard X-ray (> 1 keV) source that has been used in a variety of applications in medicine, engineering and fundamental science. Recent advances in laser technology has enabled increases in shot-rate and system stability providing improved statistical analysis and detailed parameter scans. However, unique challenges exist at high repetition rate (> 1 Hz), where data throughput and source optimization is now limited by diagnostic acquisition rates and analysis. The characterization of betatron radiation is typically performed by measurements of the X-ray transmission through a series of filters that consist of multiple materials and thicknesses with unique transmission curves. We present the development of a machine-learning-assisted X-ray spectrometer designed to reconstruct spectral characteristics of betatron sources produced by LWFA. A neural network model was used to extract the critical energy and source amplitude from the data in real-time with an average reconstruction time of ~ 4 ms, which provides a 20x increase in speed compared to traditional analysis that uses a forward fitting algorithm to reconstruct only the critical energy. We report on the fielding of this deep learning algorithm for on-line source characterization at the INRS-EMT's Advanced Laser Light Source (ALLS), and discuss future plans to implement the algorithm towards real-time optimization of betatron radiation at ALLS.

Working group

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