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Accelerating dynamic aperture evaluation using deep neural networks

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The Dynamic Aperture (DA) is an important concept for the study of non-linear beam dynamics in a circular accelerator. The DA is defined as the extent of the phase-space region in which the particle's motion remains bounded over a finite number of turns. Such a region is shaped by the imperfections in the magnetic fields, beam-beam effects, electron lens, electron clouds, and other nonlinear effects. The study of the DA provides insight into the mechanisms driving the time evolution of beam losses, which is essential for the operation of existing circular accelerators, such as the CERN Large Hadron Collider (LHC), as well as for the design of future ones.

The standard approach for the numerical evaluation of the DA relies on the ability to accurately track initial conditions, distributed in phase space, for a realistic time scale, and this is computationally demanding.

In order to accelerate the DA calculation, we propose the use of a Machine Learning (ML) technique for the DA regression based on simulated HL-LHC data. We demonstrate the implementation of a Deep Neural Network (DNN) model by measuring the time and assessing the performance of the DA regressor, as well as carrying out studies with various hardware architectures including CPU, GPU, and TPU.

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Footnotes

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Yes

Primary authors: DI CROCE, Davide (Ecole Polytechnique Fédérale de Lausanne); GIOVANNOZZI, Massimo (European Organization for Nuclear Research); PIELONI, Tatiana (European Organization for Nuclear Research); SEIDEL, Mike (Paul Scherrer Institut); VAN DER VEKEN, Frederik (European Organization for Nuclear Research)

Presenter: DI CROCE, Davide (Ecole Polytechnique Fédérale de Lausanne)

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