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Predicting the transverse emittance of space charge dominated beams using the phase advance scan technique and a fully connected neural network

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The transverse emittance of a charged particle beam is an important figure of merit for many accelerator applications, such as ultra-fast electron diffraction, free electron lasers and the operation of new compact accelerator concepts in general. One of the easiest to implement methods to determine the transverse emittance is the phase advance scan method using a focusing element and a screen. This method has been shown to work well in the thermal regime. In the space charge dominated laminar flow regime, however, the scheme becomes difficult to apply, because of the lack of a closed description of the beam envelope including space charge effects. Furthermore, certain mathematical, as well as beamline design criteria must be met in order to ensure accurate results. In this work we show that it is possible to analyze phase advance scan data using a fully connected neural network (FCNN), even in setups, which do not meet these criteria. In a simulation study, we evaluate the perfomance of the FCNN by comparing it to a traditional fit routine, based on the beam envelope equation. Subsequently, we use a pre-trained FCNN to evaluate measured phase advance scan data, which ultimately yields much better agreement with numerical simulations. To tackle the confirmation bias problem, we employ additional mask-based emittance measurement techniques.

Summary

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