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Surrogate model for third-integer resonance extraction at the Fermilab delivery ring

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We present ongoing work in which a surrogate model is developed to reproduce the response dynamics of the third-integer resonant extraction process in the Delivery Ring (DR) at Fermilab. This is in pursuit of smoothly extracting circulating beam to the Mu2e Experiment's production target. The DR contains 3 harmonic sextupoles that excite a third-integer resonance and three fast, tune-ramping quadrupole magnets that drive the horizontal tune towards the 29/3 resonance. In our initial work the surrogate model trains on a semi-analytical simulation provided in the same format as live data. Using Reinforcement Learning, the trained surrogate acts as the "environment" in which a simple ML control agent learns to dynamically adjust the quadrupole ramp at 40 break points within the 43 microsecond spill window, hosted on a dedicated FPGA. We compare the ML control agent performance to the simple PID-loop fallback in the developed surrogate model.

Footnotes

Paper preparation format

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