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Optimization of a bending mirror system for dynamic focusing

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In this paper, we present the preliminary development and optimization of a bending mirror system conducted as a preparatory study for the Shenzhen Superconducting Soft X-ray Free-Electron Laser (S3FEL).
A prototype of the dynamic bending system is fabricated for experimental validation. It is designed to bend a flat mirror to 500 m radius of curvature (360 m RoC experimentally achieved eventually). Surface quality of the mirror before and after then bending are characterized in a cleanroom to minimize environmental disturbances. The bending system was mounted on the granite base of a long-trace profiler (LTP) for high-precision metrology.
Two technical approaches are explored on this system. The first involved a coarse force estimation method based on analytical bending formulas, combined with manual fine tuning. The second employed a surrogate model constructed through transfer learning-based neural networks to enable rapid prediction and inverse optimization of actuator forces. Experimental evaluations of both approaches confirm the system's capability to achieve large-range curvature modulation while maintaining sub-microradian slope precision.

Footnotes

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