

Teaching AI Magnetic Frustrations

Scientific Achievement

By integrating dynamic functional transitions into artificial spin ice analysis beyond structure-only AI approaches, a CINT User Team developed a deep generative framework that enables automated, high-fidelity classification of magnetic frustration states and advances programmable ASI and frustration-engineered spintronic devices.

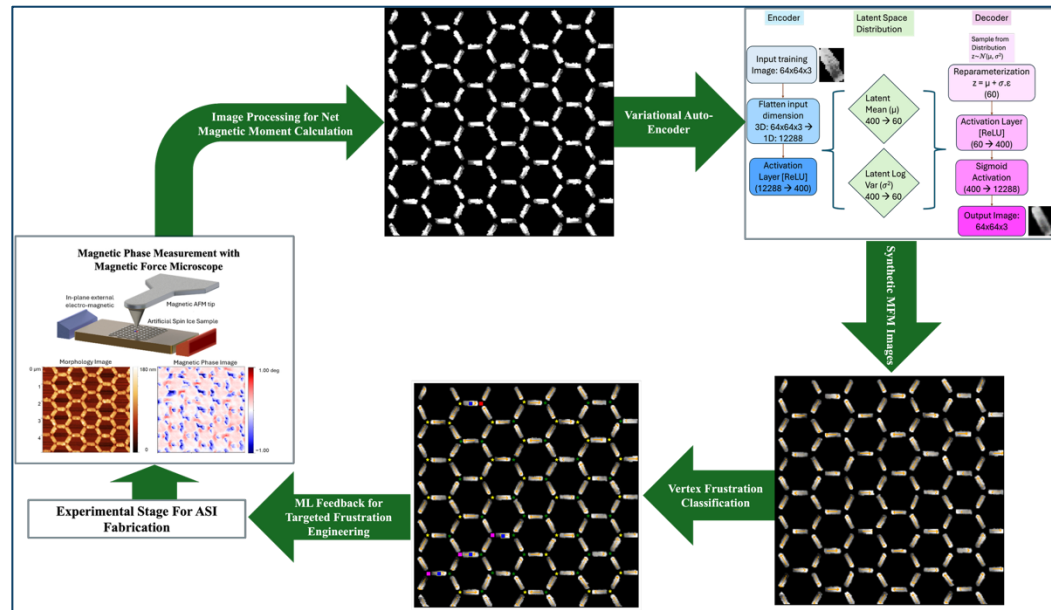


Figure: Flowchart illustrating the machine learning-driven approach to synthesizing ASI samples with precisely engineered frustration states. ML feedback guides the optimization process, systematically tuning energy distributions.

Significance and Impact

This deep generative approach goes beyond characterization by enabling precise control of ASI configurations through frustration engineering, representing a major advance in materials science and enabling the optimization of magnetic metamaterials for targeted applications.

Research Details

- Developed a deep generative framework combining VAEs with MFM to analyze artificial spin ice beyond static structure.
- Enabled programmable frustration engineering via iterative magnetic moment optimization in ASI lattices.

Neogi, A.; Mishra, S.; Iyer, P. P.; Lu, T.-M.; Bussmann, E.; Tretiak, S.; Jones, A. C.; Zhu, J.-X. Deep Generative Learning of Magnetic Frustration in Artificial Spin Ice from Magnetic Force Microscopy Images. *npj Comput. Mater.* 2026.

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