# MACHINE LEARNING AS BUILDING BLOCK FOR MACROMAGNETIC SIMULATIONS

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## ABSTRACT

Microstructural features play an important role for the performance of permanent magnets. While micromagnetic simulations are capable of including these effects, due to the high demand on computing resources the system dimensions are typically limited to a few micrometers. In applications and experiments the specimen size is usually orders of magnitude larger. Often, this size limitation in simulations lead to different absolute values in results. We introduce a type of reduced-order model to bridge the length scale from micromagnetism to experiments. In contrast to the work of Blank [1], we also consider the microstructural features of the magnet. We subdivide the computation of a large sample into multiple independent feasible-sized subsets. The nucleation fields of the subsets can be calculated by micromagnetic simulation. Due to the higher number of subsets, we simulate only hundreds of structurally unique subsets and use them to train random forest and gradient boost regressors. This decision trees can then predict nucleation fields of hundred of new subsets within seconds [2].

The subsets along with their microstructure and nucleation fields are fed into a newly developed python code to spatially reassemble the entire specimen. Using the Stoner-Wohlfarth model and the prestored nucleation fields the overall hysteresis is computed. In each calculation step the magnetostatic field and the exchange field of the entire sample is calculated from the subsets.

## References

[1] R. Blank. *What determines the demagnetization in Nd-Fe-B magnets?*, J. Magn. Magn. Mater. 101 (1991), 317–322.

[2] M. Gusenbauer, et. al. *Extracting local nucleation fields in permanent magnets using machine learning.*, npj Comput. Mater. 6 (2020), 89.

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