Non-regularized reconstruction of magnetic moment distribution of magnetic nanoparticles using barnacles mating optimizer

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ABSTRACT

Core size estimation of magnetic nanoparticles (MNPs) using magnetization curves has been reliably utilized to obtain a fast and simple size estimation technique compared to transmission electron microscopy. This estimation technique involves solving the inverse problem of the magnetization curve. However, conventional methods, such as the singular value decomposition (SVD) or non-negative least squares (NNLS) algorithms, require a regularization threshold to mitigate the overfitting issues of an ill-conditioned problem. This prior information on the regularization requirement may lead to inaccurate magnetic moment reconstruction if the regularization degree is high due to broad distributions of the reconstructed magnetic moment. This research proposes a non-regularized reconstruction technique of magnetic moment distribution using the recent machine learning technique of the Barnacles Mating Optimizer (BMO) algorithm. A simulated magnetization curve of unimodal moment distributions from 1 mT to 1 T is used to minimize a model-free magnetic moment distribution. A reconstruction comparison among the BMO, Particle Swarm (PSO), Genetic Algorithm (GA), Sine Cosine Algorithm (SCA) optimizers, and NNLS method is presented. The magnetic moment reconstruction using the BMO algorithm shows significantly less noise and smooth distribution compared to the PSO and GA algorithms with fewer computation times. Furthermore, the constructed peaks' position matches the original distribution and shows comparable performance with the conventional NNLS algorithm.

KEYWORDS

Barnacle mating optimizer; Magnetic nanoparticles; Magnetization curve; Numerical method; Size distribution

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