Enhancing SOT-MRAM Switching Using Machine Learning

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Abstract:

Spin-orbit torque magnetoresistive random access memory (SOT-MRAM) is a highly promising contender for replacing charge-based memories which currently dominate the fields of high-performance and high-density static RAM in registers and high-level caches. SOT-MRAM is non-volatile and exhibits ultra-fast operation and large endurance.

However, an unwanted external magnetic field is still required for deterministic switching of perpendicularly magnetized structures. A recently proposed SOT-MRAM cell architecture eliminates the need for this external magnetic field by sending current pulses through two orthogonal heavy metal lines attached to the magnetic free layer and is thus operated purely electrically. Finding and optimizing efficient pulse sequences for field-free switching remains a challenging problem.

Reinforcement learning (RL) approaches have been shown to be efficient in finding solutions to this kind of complex problems. In RL an agent repeatedly interacts with an environment and learns to maximize its cumulative reward by adapting its policy of action.

We apply RL to determine optimal pulse sequences for fast switching of perpendicular SOT-MRAM cells. Micromagnetic simulation serves as RL environment and is used to evaluate the performance of the learned pulse sequences. The results show that with the help of RL, pulse sequences can be found that lead to reliable switching even under variation of the current values and material parameters.

Bio

Johannes Ender finished his Master's studies in Mechatronics at the University of Applied Sciences in Vorarlberg in 2013. After working in industry for three years he pursued the Master's studies of Computational Science at the University of Vienna. In November 2018 he joined the Christian Doppler Laboratory for Nonvolatile Magnetoresistive Memory and Logic at the Institute for Microelectronics where he started his PhD studies researching the simulation of non-volatile magnetic memory devices.