Nonlinear Dynamics and Systems Theory, **22** (4) (2022) 432–446

A Neural Network Approximation for a Model of Micromagnetism

M. Moumni * and M. Tilioua

MAIS Laboratory, MAMCS Group, FST Errachidia, Moulay Ismail University of Meknès, P.O. Box: 509 Boutalamine, 52000 Errachidia, Morocco.

Received: January 24, 2022; Revised: September 13, 2022

Abstract: Micromagnetics is a continuum theory describing magnetization patterns inside ferromagnetic media. The dynamics of a ferromagnetic material are governed by the Landau-Lifshitz equation (LL). This equation is highly nonlinear and has a non-convex constraint. In this work, we propose two new algorithms for solving this equation in high dimension, by using deep neural networks. Numerical and comparative tests using TensorFlow illustrate the performance of our algorithms.

Keywords: *data-driven scientific computing; machine learning; numerical analysis; micromagnetism; Landau-Lifshitz equation.*

Mathematics Subject Classification (2010): 78A25, 35Q60, 35B40, 93-10, 70K75.

1 Introduction

Differential equations, including ordinary differential equations (ODEs) and partial differential equations (PDEs), formalize the description of the dynamical nature of the world around us. However, solving these equations is a challenge due to extreme computational cost and because most PDEs do not have an analytical solution, their solution can be approximated using classical numerical methods (which are based on a discretization of the domain) [17], [18], [11]. These methods are particularly efficient for low-dimensional problems on regular geometries; however, finding an appropriate discretization for a complex geometry can be as difficult as solving the partial differential equation itself. This problem is particularly severe if the space dimension is large as there is no straightforward way to discretize irregular domains in space dimensions larger than three. Solving equations is a high-level human intelligence work and a crucial step towards general

* Corresponding author: mailto:md.moumni@gmail.com

© 2022 InforMath Publishing Group/1562-8353 (print)/1813-7385 (online)/http://e-ndst.kiev.ua