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Machine learning analysis for the dynamics of hydromagnetic bio-convected nanofluid containing gyrotactic microorganisms using Bayesian distributed neural networks

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ABSTRACT

This study investigates the complex phenomenon of hydromagnetic bio-convected Nanofluid with Gyrotactic microorganisms (HMBNFGM), containing nanoparticles and mobile microorganisms. The nanofluid's flow over a vertical penetrable surface triggers bio-convection, characterized by the intricate interplay of upthrust and electromagnetic fields, which significantly influence the dynamics of microorganisms and nanoparticles. To model this complex system, machine learning analysis is done by employing Bayesian distributed neural networks (MLA-BDNNs), integrating advanced computational techniques with fluid dynamics principles. The Adam numerical approach is utilized to create an accurate dataset for MLA-BDNNs for the analysis of the fluid velocity profile $f'(\eta)$, temperature profile $\theta(\eta)$, concentration profiles $\xi(\eta)$, and microorganism profile $\chi(\eta)$, adjusting twelve parameters each for three distinct cases involving Grashof number (G_r), Eckert number (E_c), Brownian motion parameter (N_b), Buoyancy ratio parameter (N_r), thermophoresis parameter (N_t), traditional Lewis number (Le), bioconvection Lewis number (L_b), bio-convection Rayleigh number (R_b), and Péclet number (Pe). The attained dataset is then employed in numerical computation to quantify the parameters of HMBNFGM fluidic model. The knacks of artificial intelligence is utilized for developing the proposed algorithm MLA-BDNNs for solving the HMBNFGM fluidic model. The best performance in terms of MSE are attained at points 4.92E-13, 4.45E-13, 8.90E-13, 5.01E-13, 1.96E-08, 6.83E-13, 7.62E-13, 8.16E-13 , 9.92E-13 , 5.84E-13 , 2.18E-13 , and 6.591E-12 against 262, 98, 119, 71, 134, 221, 136, 173, 138, 125, 182, and 63 epochs. The accuracy and precision of the proposed algorithm MLA-BDNNs are efficiently established by low level of MSE, near-optimal regression metric indices as well as error distribution on histograms presenting negligible magnitudes. The results got through the AI based MLA-BDNNs technique satisfy the reliability of the contribution in offering fairly and accurate solution of the HMBNFGM.

1. Introduction

The role of fluid dynamics is an essential part in the advancement of various scientific and technological disciplines. The applications of fluid dynamics are impacting different aspects of our daily life and contributing to progress and innovation in various disciplines including energy efficiency, advanced manufacturing, aerospace and aeronautics, biomedical engineering, environmental studies, renewable energy, and engineering applications. Several varieties of fluids appear due to its wide spectrum, each categorized by distinctive properties and nature. Fluid dynamics comprises of various types of fluids, like Newtonian

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