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An intelligent computing technique for fluid flow problems using hybrid adaptive neural network and genetic algorithm

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A B S T R A C T

A new hybrid adaptive neural network (ANN) with modified adaptive smoothing errors (MASE) based on genetic algorithm (GA) employing modified adaptive relaxation (MAR) are presented in this paper to construct learning system for complex problem solving in fluid dynamics. This system can predict an incompressible viscous fluid flow represents by stream function (ψ) through symmetrical backward-facing steps channels. The proposed learning system is constructed as an intelligent computing technique by enforcing three stages run simultaneously; the first stage concerns to construct finite-element method (FEM) employing a new approach named modified adaptive incremental loading (MAIL) to build-up in run-time a dataset driven that contains an effective patterns represented by ψ for specific Reynolds number (*Re*), these patterns are associated to three kinds of clusters. The second stage is pertained a new hybrid neural network with new modification of adaptive smoothing errors and the third stage illustrated to modifying the numerical values of neural network connection weights through certain training algorithm with new optimization approach. The present simulation results of the proposed learning system are in good agreement with the available previous works and it is fast enough and stable.

1. Introduction

The numerical solution of partial differential equation (PDE) that governing the fluid flow is not easy to solve specially for turbulent fluid flow and the solution needs a long time to get an approximate result. It is also very expensive with respect to the storage if mesh points refinement is used [1,2]. Navier–Stokes equations (NSE) are one good example. These equations have the widest of applications as they govern the motion of every fluid, being a gas or liquid. The popular methods for the numerical solution of PDE's are finite difference method (FDM), finite-element method (FEM), boundary element method (BEM) and finite volume method (FVM) [3].

The earliest solution of NSE used non-simultaneous solver through FEM on stream and vorticity (ψ–ω) formulation [3,4]. Modelling the dynamics of turbulent floods by using numerical simulation through FEM was studied by Mei et al. [5].

More recently, neural networks approach is introduced as an effective way of developing the approximate solution of fluid flow models using feedback control algorithms [6]. This approach is based on many types of architectures, such as an artificial neural network with single/multi-hidden layer(s) [7–9]. Developing artificial neural models through fluid application was implemented to study the head-flow curves of deep well pump impellers with splitter blades [10]. Flow geometry optimization is employed using neural network [11]. Kaczmarczyk and Waszczyszyn [12] used back-propagation neural networks for the simulation of generalized return mapping algorithm (RMA). This procedure was evaluated to be too large to make hybrid FEM and back-propagation neural network (BPNN) numerically efficient. Sun et al. [13] solved partial differential equations using artificial neural network as an alternative to finite-element analysis.

The optimization approach in fluid flow through any kind of channel's shape by using genetic algorithm (GA) is necessary to ensure the accuracy and stability of the solution. Hacioglu [14] improved a new mutation technique for more efficient GA and named vibrational GA (VGA). Two populations in GA are implemented to increase the quality of solution [15]. More efficient, Espionza et al. [16] developed self-adaptive hybrid GA (SAHGA) to show its performance for a groundwater remediation problem. Haciaglu [17] introduces an augmented GA with artificial neural network as a new design and optimization technique in fluid dynamics problems. Duvigneau and Visonneau [18] devotes to the study of design optimization strategies in the particular framework of complex computational fluid dynamics using GA as the optimization strategy.

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