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Simulating Electrohydrodynamic Ion-Drag Pumping on Distributed Parallel Computing Systems

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Abstract

Objectives: This paper aims to simulate EHD ion-drag pumping model using Finite Difference Method (FDM) and to apply the idea of parallelism to reduce the computational time. **Methods:** The numerical simulation of EHD ion-drag pumping plays an important part not only to understand the different working principles but also enables to model the designs with better performance. Since the performance of EHD pumps depends on the shapes and geometries of the actuator electrodes, therefore the variation in the geometric dimensions of the electrodes require dense and fine meshes for numerical solution. Consequently, the numerical simulations take unacceptably more execution time on sequential computers. For that reason, a Data Parallel Algorithm for EHD model (DPA-EHD) is designed. To implement the parallel algorithm a distributed parallel computing system using MATLAB Distributed Computing Server (MDCS) is configured. The computational time and speedup with respect to the different number of processors is evaluated. **Findings:** This results show that the parallel algorithm for EHD simulations may provide 4.14 times more speedup over sequential algorithm for large grid sizes. **Improvements:** This study shows the feasibility of using the parallelism to reduce the computational time in the EHD model enabling to simulate the micropumps with very small dimensions of electrodes.

Keywords: Data Parallelism, Electrohydrodynamic, Ion-Drag Pumping, Parallel Algorithms, Parallel Distributed Computing Systems

1. Introduction

The Electrohydrodynamics (EHD) is concerned with the interactions of electrically charged fluids and their motion. This phenomenon is used in a wide range of attractive engineering applications and microfluidic devices. EHD micropumps have gained much attention due to their reliability and distinctive advantages of no moving parts[1]. Experimental research on the ion-drag micropumps has been widely carried out in the current years to improve their performance for different applications, particularly in cryogenic cooling of micro electro mechanical systems and most recently being used in jet printing[2,3]. But the development of new designs of such devices is challenging because of instrumentation cost and microfabrication complexity[4]. This issue provides an extensive research prospect for numerical modeling and simulation of micropumps. Since the performance of the micropumps depends on the shapes and geometries of the actuator electrodes. The variation in the geometric parameters requires the fine meshes resulted from the Discretization of the computational domain. Consequently, the computational time in obtaining the numerical simulation increases indefinitely. That is why; this work is aimed at the reduction of computational time in EHD ion-drag model by utilizing the art of parallelism. Few related studies have already been done to reduce the computational time of numerical simulation of specific EHD governing equation. For instance[5,6] have attempted to simulate only electric potential in 2D and3D prototype

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