Name(s)
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Project Number
S0312

Project Title
Computer Simulation of Free-Surface Fluid Flow Using MPS

Abstract

Objectives/Goals
When mixed liquid and gas fluid flows undergo violent motions, a free surface forms between the liquid and the gas. If the motion is severe enough, such as the breaking of a dam or oil lubrication in an engine, the shape of the free surface becomes increasingly complex. Traditional numerical simulations of fluid flows, for example finite difference, finite volume and finite element technologies are incapable of simulating such severe free-surface fluid flows due to their reliance on grids, the decomposition of the volume into small, regular shapes, to interpolate velocity and pressure fields. Severe free-surface motions entangle the grids, making these methods rather useless. Therefore, grid-less methods are necessary for solving severe free-surface flows. One such proposed method is the #Moving Particle Semi- Implicit# (MPS) method, developed by S. Koshizuka and Y. Oka in 1996. Instead of utilizing a grid, MPS relies on an approximation kernel function to reconstruct the velocity and pressure field at each given particle position based on the surrounding particles. These values are necessary to approximate the spatial differentials of these fields, which are integral to solving the Navier-Stokes equations, the governing equations of fluid motion, for each particle. This research project attempts to code a unique implementation of the MPS theory using modern algorithms to optimize performance in the C programming language.

Methods/Materials
The software consists of an input phase, where the walls and fluid of the problem are artificially constructed, and a time-stepping algorithm, where the gravity and viscosity are modeled using an explicit algorithm and the conservation of mass is solved using the solution of a pressure Poisson equation.

Results
The program's performance is tested with a sample dam break problem. The software's output closely resemble experimental values extracted from literature, validating the feasibility of the implementation of the MPS method.

Conclusions/Discussion
The program is extremely sensitive to user-inputted values, illuminating the need for a stabilizer. The next step in extending this project is to enhance the robustness of the solutions by incorporating numerical methods and then to further improve the performance through a split-tree search algorithm and an Algebraic Multi-Grid solver for the pressure Poisson equation.

Summary Statement
This project computationally solves the differential equations proposed in the Moving Particle Semi-Implicit theory in order to create a coherent software that is able to simulate free-surface fluid flows with violent motions over time.

Help Received