MATH-352 Numerical Methods (BESE-28 C)

Numerical Methods

Project

Report

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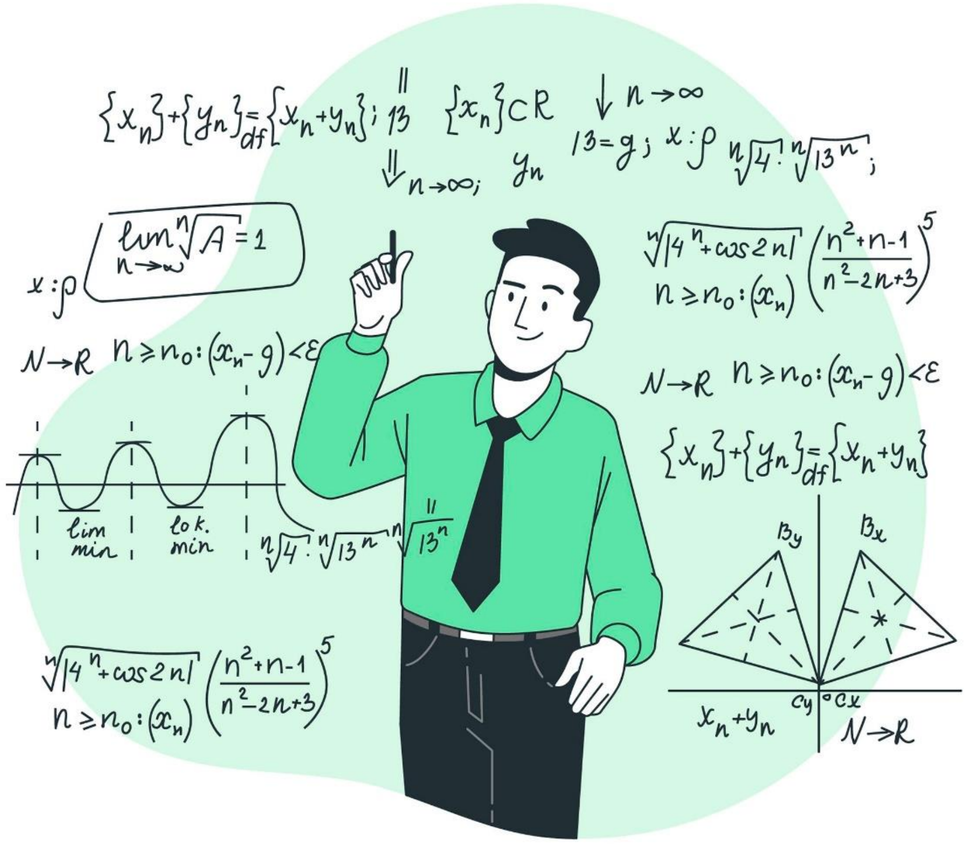

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BESE-28 C

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Introduction:

The 2D Fluid Simulation project in MATLAB aims to model the dynamics of fluid flow using numerical methods. This simulation provides insights into how fluids behave under various conditions, leveraging the power of computational fluid dynamics (CFD) techniques. The primary focus is on solving the Navier-Stokes equations for incompressible flow using the Eulerian approach, combined with methods such as the Jacobi iteration and Runge-Kutta 4th order method for numerical solutions.

Objectives:

- To simulate the motion of fluids in a 2D grid.
- To implement and solve the Navier-Stokes equations for incompressible flow.
- To visualize fluid particle movement and velocity fields.
- To employ numerical methods to ensure stability and accuracy of the simulation.

Methodology:

- **Grid-Initialization:**
  The simulation initializes a 200x400 grid (aspect ratio 2:1) with zero velocity and pressure fields. Particles are uniformly distributed across the grid for visualization.

- **Navier-Strokes Equation:**
  The incompressible Navier-Stokes equations are the foundation, ensuring mass and momentum conservation. These are:

- Continuity Equation: $\nabla \cdot v = 0$
- Momentum Equation: $\partial v/\partial t + (v\cdot\nabla)v = -\nabla p + \nu\nabla^{2}v + f$

- **Jacobi Method:**
  The pressure Poisson equation, derived from the continuity equation, is solved using the Jacobi iteration. A stencil-based convolution operation iteratively updates the pressure field to minimize velocity divergence.

- **RK4 Method:**
  For particle advection, the RK4 method provides high accuracy. It computes new particle positions using intermediate steps k1, k2, k3 and k4 to achieve a stable and precise solution.

Results:

The simulation accurately depicts fluid motion through the visualization of particles. Velocity fields are updated dynamically, reflecting the influence of initial conditions and external forces. The implementation of the Jacobi method ensures that the pressure field is properly adjusted to maintain incompressibility, while the RK4 method provides a robust solution for particle advection.

Conclusion:

This project successfully demonstrates the application of numerical methods to solve fluid dynamics problems in a 2D environment using MATLAB. The combination of the Jacobi iteration and RK4 method ensures stability and accuracy, making it a valuable tool for visualizing and understanding fluid behavior in various scenarios.

THE END

Assets