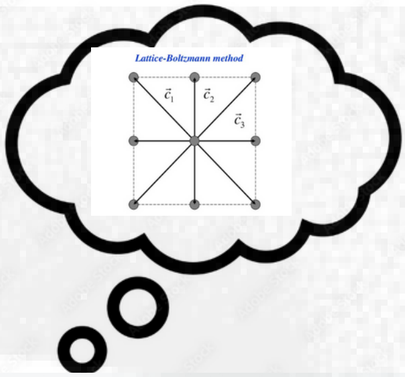

SIMULATION OF NON IDEAL FLUIDS USING LATTICE BOLTZMANN CONSTANT

PRESENTED BY:

Vasudhara Mahajan 102103032

Avantika Raina 102283002

Angel 102103328

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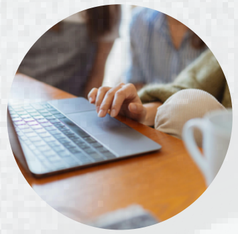
Background

Demand for Fluid Simulation: "Efficient fluid simulations are crucial for studying complex flows in engineering and environmental fields."

Limitations of Traditional Methods: "Conventional methods struggle with complex boundaries and require high computational power."

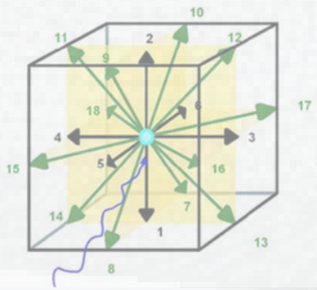


Advances in Lattice Boltzmann Method: "LBM and JAX allow faster, more efficient simulations with adaptable boundary handling.

Opportunities with LBM: "LBM enables detailed study of flow patterns, improving design and analysis in fluid dynamics."

OBJECTIVE

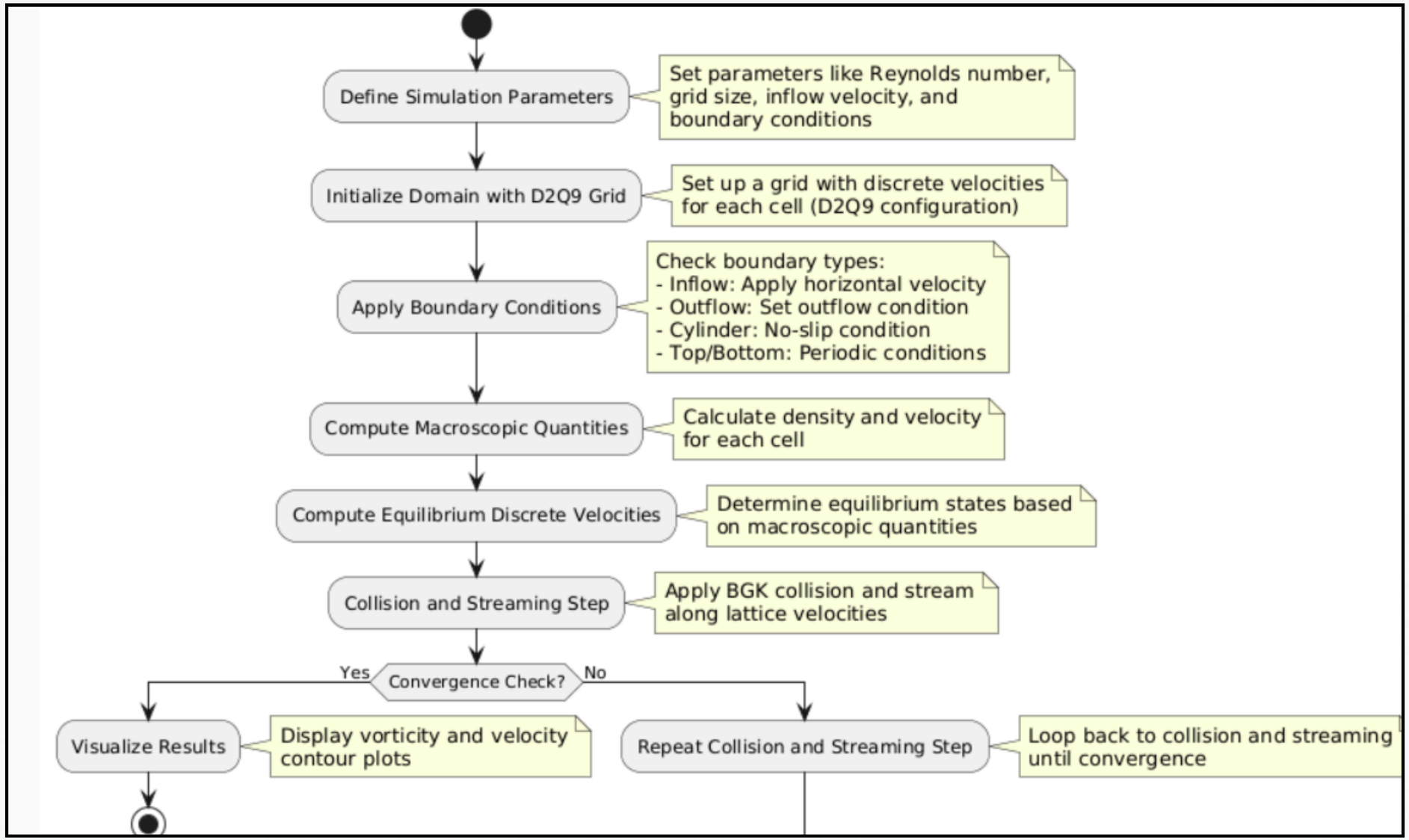
- Develop an Efficient Fluid Simulation Model
- Implement LBM on High-Performance Hardware
- Analyze Vortex Shedding Around Obstacles
- Enhance Stability at Low Mach Numbers



OVERVIEW

- Fluid Simulation Modeling
- Lattice Boltzmann Method (LBM)
- 2D Flow Around Obstacles
- High-Performance Computing (JAX)
- Vortex Shedding Analysis
- Cylinder Flow Simulation
- Boundary Condition Handling
- Real-time Visualization

METHODOLOGY

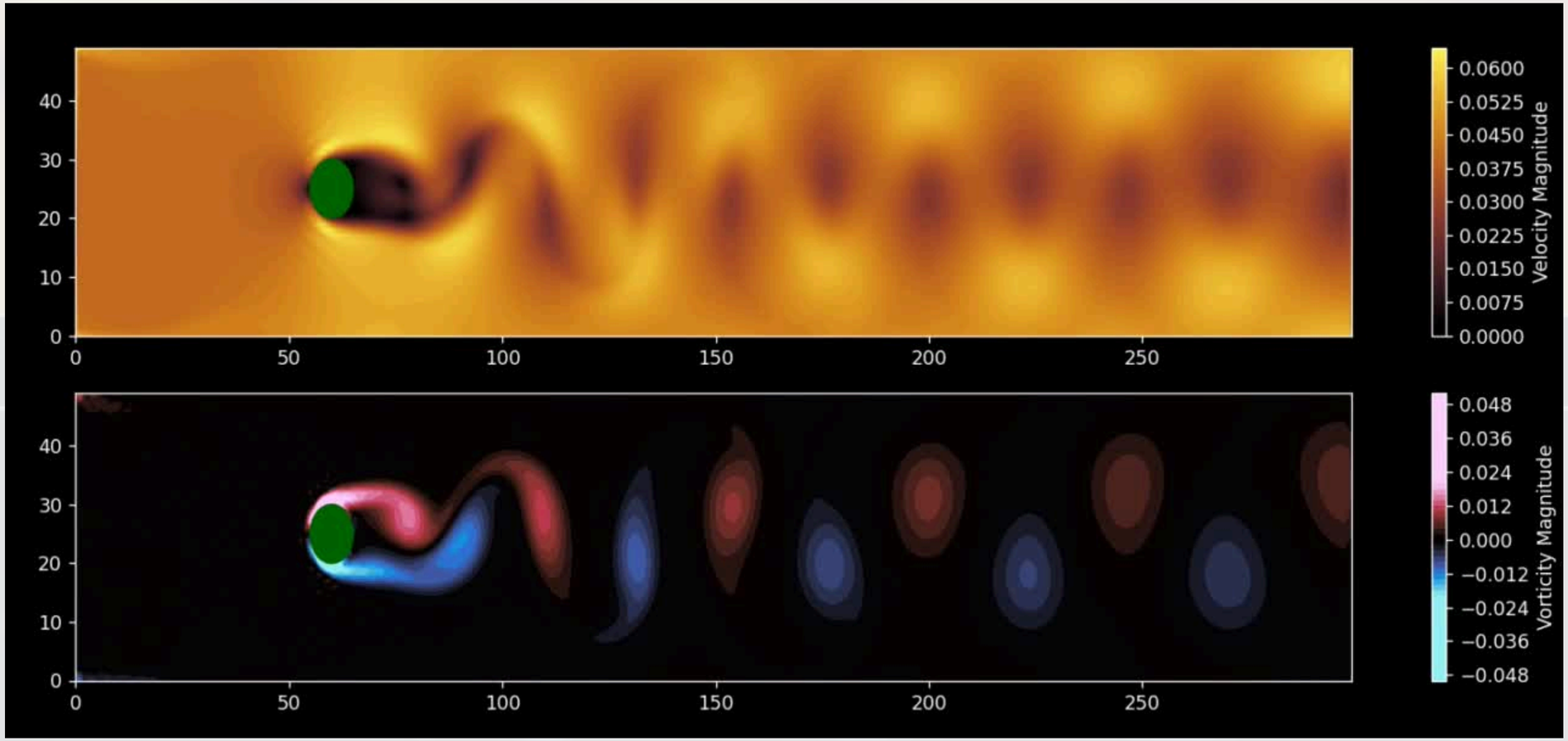


$$\frac{\partial f_i}{\partial t} + \mathbf{c}_i \cdot \nabla f_i = -\frac{1}{\tau}\left(f_i - f_i^{(0)}\right)$$

FRAMEWORK/ARCHITECTURE

- Simulation Engine: JAX is used for fast matrix operations and parallel computing capabilities, which are essential for high-resolution simulations in LBM.
- LBM Grid (D2Q9): The 2D space is discretized with nine discrete velocity directions per node, allowing computation of particle movement and collision across all directions.
- Boundary Condition Modules: Separate modules handle inflow, outflow, no-slip, and periodic conditions, making it easier to adjust and test different boundary setups.
- Visualization: Matplotlib is used for real-time visualization, showing velocity magnitude and vorticity fields to track vortex street formation.

RESULTS


0
10
20
30
40
0
50
100
150
200
250
0.0600
0.0525
0.0450
0.0375
0.0300
0.0225
0.0150
0.0075
0.0000
Velocity Magnitude
0.048
0.036
0.024
0.012
0.000
−0.012
−0.024
−0.036
−0.048
Vorticity Magnitude

REFERENCES

- Succi, S. (2001). The Lattice Boltzmann Equation for Fluid Dynamics and Beyond. Oxford University Press.
- Zou, Q., & He, X. (1997). On pressure and velocity boundary conditions for the lattice Boltzmann BGK model. Physics of Fluids, 9(6), 1591-1598.
- Williamson, C. H. K. (1996). Vortex dynamics in the cylinder wake. Annual Review of Fluid Mechanics, 28(1), 477-539.
- Aidun, C. K., & Clausen, J. R. (2010). Lattice-Boltzmann method for complex flows. Annual Review of Fluid Mechanics, 42, 439-472.

THANK YOU