

Project1 – Advection

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Context

This project aims to simulate the flow of advection given a set of adjustable parameters using a hyperbolic partial-differential equation (PDE). Snapshots of the progression of the simulation are monitored at 3 points in time – 0 , $NT/2$ and NT . In particular, the program estimates and then visualizes solutions to the following equation:

$$\frac{\partial C}{\partial t} + u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = 0$$

assuming u and v are known constants.

Program Instructions

<https://github.com/hegdetejas/hpc-proj1-hegdetejas>

Requirement C++20:

- In `tasks.json`, add “`-std=c++20`” to `args` or configure system to run with C++20.
- Build and run `/src/advection.cpp`
 - This must be run with desired parameters:
`./advection <N> <NT> <L> <T> <u> <v>`

The output from the simulations are saved in the `/out/out_*.txt` files. The first list in the file is the number of time steps.

Python:

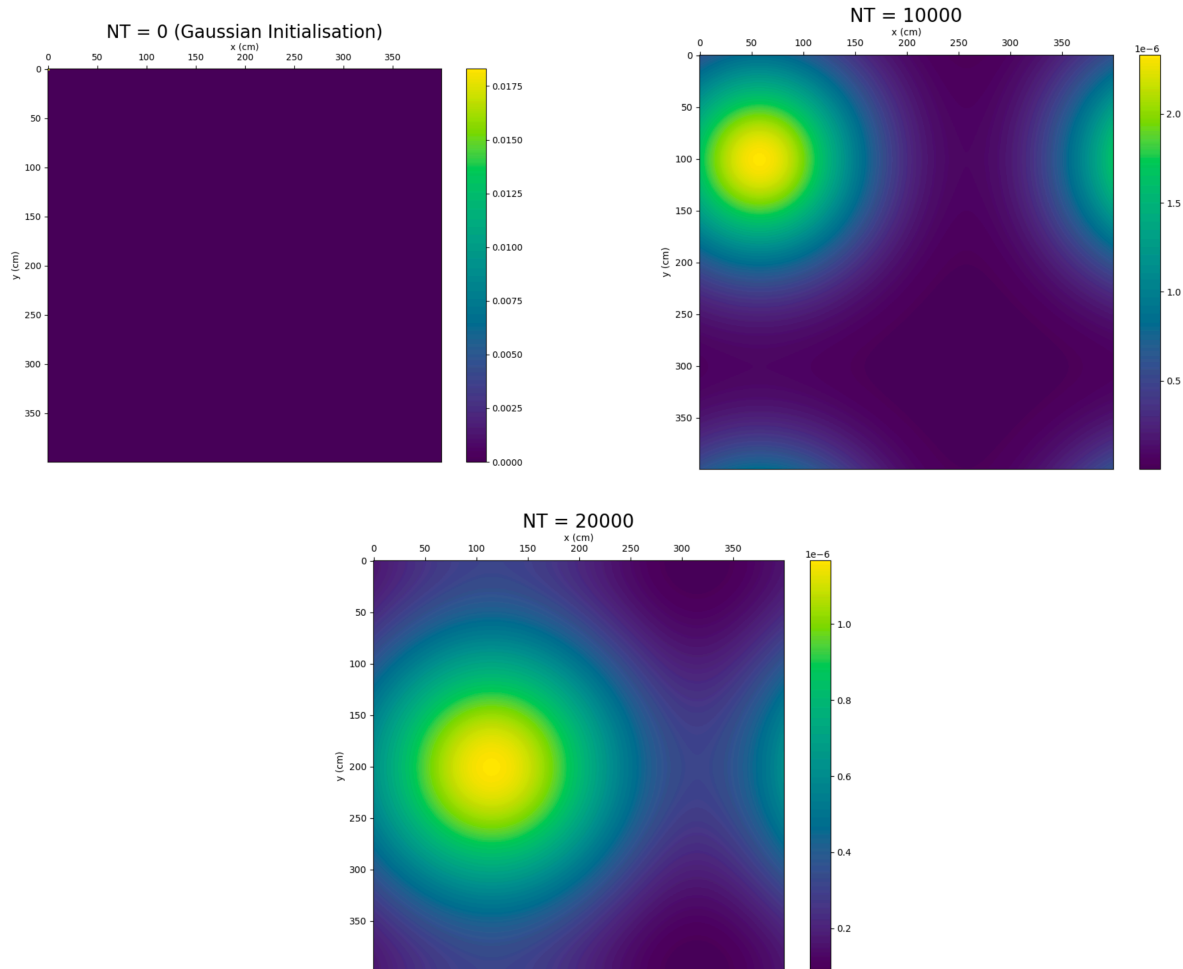
- `visualize.py` is a program that reads in `.txt` files that contain 2D-matrices and saves them as a color plot.
- `numpy`, `matplotlib` and `ast` are required modules for data manipulation.
- Run this program by executing `python3 visualize.py`

Output

The simulation was conducted with the following parameters:

$N=400$, $NT=20000$, $L=1.0$, $T=1.0e6$, $u=5.0e-7$, $v=2.85e-7$

The raw data from the simulation calculated from the C++ program can be found in `/out/out_*.txt`. The visualizations of the color plot from the Python program can be found in `/out/out_*.png` and are also pasted here.



It would be nice to see an animation of the simulation that shows the transformations in continuous time. Nevertheless, from these discrete timestamps, we can see a reflection when $NT=10000$ with the edges of the circles in quadrants 3 and 4 and the entire circle in quadrant 1. Then, at the end of the simulation, it appears as though the circle in quadrant 1 has propagated to the center and expanded. I would predict that if this simulation was ran for double the time period, the entire 400×400 grid would contain a force.