Implementing Fluid Simulation using DPD

Student: Francesco Costa

Advisor: Prof. Antonio Carzaniga

Motivation

The objective of this project was to take an existing simple physics engine created by Prof. Carzaniga and expand it in interesting ways. Fluid dynamics simulations are a classic example to showcase the power of digital simulations, but they require either very optimized models or high computational power. The method we use to emulate the behaviour of fluids is called Dissipative Particle Dynamics and revolves around considering agglomerates of atoms to reduce the elements in the system, hence the computational cost.

Technologies

DPD method

The method used to simulate the behaviour of fluids relies on special formulation of forces to account for interaction between particles and momentum conservation.

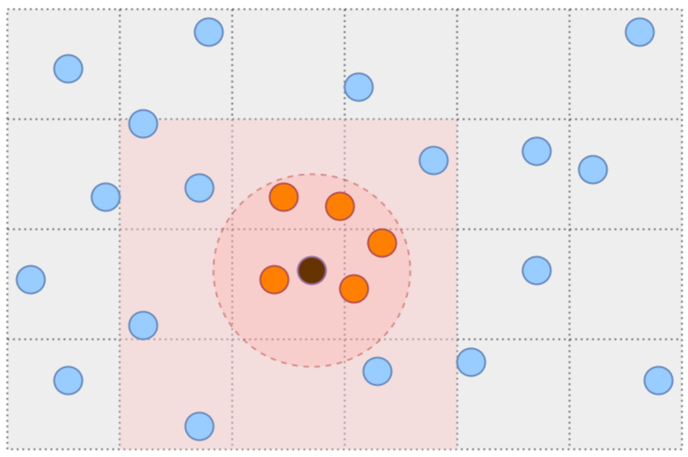
- Conservative force
  This force accounts for repulsion between particles
- Dissipative force
  This force acts as friction in the interaction between particles
- Random force
  This force is used to keep the system in balance

Randomized system

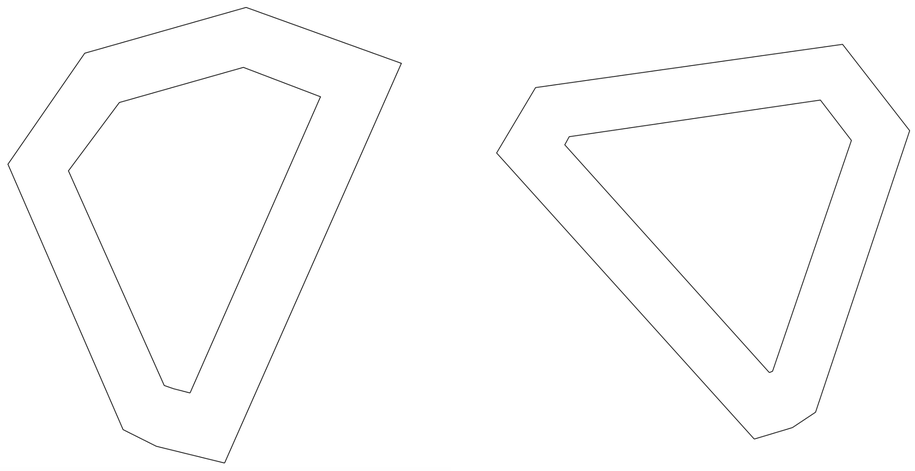
Given the nature of the existing tool serving a mainly didactical purpose, during the implementation one of the key factors was to generalize as much as possible the definition of the system, creating interesting scenarios. The creation of the environment for the particles resulted thus in the addition of polygons that would represent boundaries for the movement of the fluid.

Optimizing the simulation

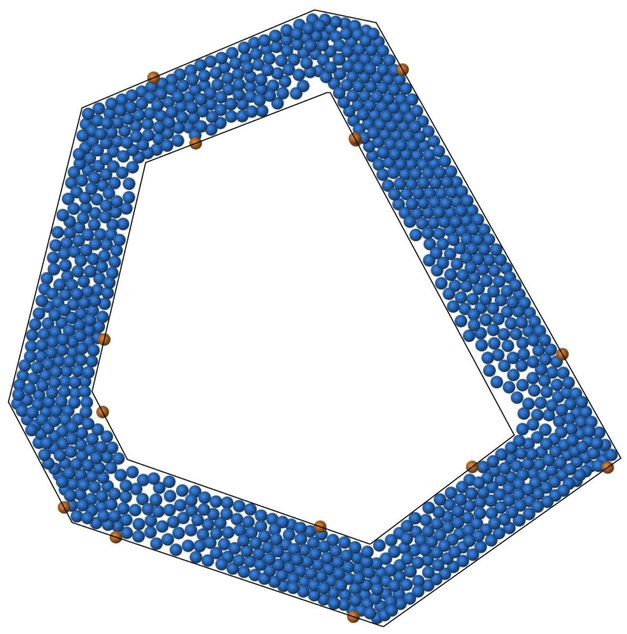
The nature of the model used allowed for further optimization. Each particle could in theory interact with all other particles in the system but, in practice, the range at which particles interact is small enough to make a cell list an efficient data structure to record the neighbourhood of each particle and cut the complexity of the program.



Visual examples of the simulation



Randomly generated tracks for the particles



Running system representing flow of a fluid