Convergent Turbulence Refinement toward Irrotational Vortex

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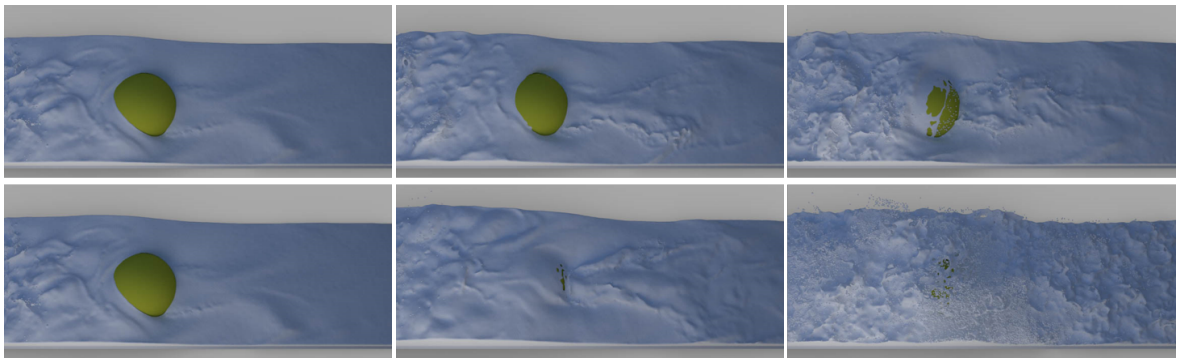

Figure 1: Breaking dam with 94K fluid particles(The radius of them is 0.1m) injected per second using MP method[Bender et al. 2018] (second row) and our method (first row) simulated with different coefficients (left to right): $\alpha = 0, 0.2, 0.6$.

ABSTRACT

We proposed a detail refinement method to enhance the visual effect of turbulence in irrotational vortex. We restore the missing angular velocity from the particles and convert them into linear velocity to recover turbulent detail due to numerical disspation.

CCS CONCEPTS

• **Computing methodologies** → **Physical simulation**; *Real-time simulation*; *Interactive simulation.*

KEYWORDS

turbulence simulation, SPH, vortex-based method

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1 INTRODUCTION

Fluid simulation is a hot topic in computer graphics, which was first introduced by Stam in 1999 [Stam 1999]. Recently, higher demands for fluid simulation is put forward, such as the simulation of turbulence with complex surface details. Over the last years, turbulent fluid simulation has been more and more popular.

There are two kinds of method that used to increase the resolution of turbulent fluid, that is, up-res method and vortex-based method. The main idea of up-res method is up-sampling under coarse discretization, such as CNN, example-based method [Sato et al. 2018]. However, Up-res methods act as a post processing step which can be combined with our method.

Vortex-based method aims at creating and preserving turbulence through vorticity field. It could be divided into two main categories, vorticity confinement method and Lagrangian vortex method. Vorticity confinement was introduced in computer graphics by Fedkiw [Fedkiw et al. 2001]. The core idea is recover existing vortexes and enhanced them by adding a new force. Lagrangian vortex methods build on vorticity representation of Navier-Stokes equations. They are naturally divergence-free and inherently immune to numerical dissipation. They could be implemented by surface[Weißmann and Pinkall 2010], filaments[Eberhardt et al. 2017] and particles[Bender et al. 2018]. Our method can be regarded as a vortex particle method. When higher efficiency is desired in particle-based approach, particles' size would become larger. The inertia tensor being absent from the equation could lead to severe numerical dissipation. To