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정 문 열[*1]

FLUID SIMULATION METHODS FOR COMPUTER GRAPHICS SPECIAL EFFECTS

Moon-ryul Jung[*1]

In this presentation, I talk about various fluid simulation methods that have been developed for computer graphics special effects since 1996. They are all based on CFD but sacrifice physical reality for visual plausability and time. But as the speed of computer increases rapidly and the capability of GPU (graphics processing unit) improves, methods for more physical realism have been tried. In this talk, I will focus on four aspects of fluid simulation methods for computer graphics: (1) particle level-set methods, (2) particle-based simulation, (3) methods for exact satisfaction of incompressibility constraint, and (4) GPU-based simulation. (1) Particle level-set methods evolve the surface of fluid by means of the zero-level set and a band of massless marker particles on both sides of it. The evolution of the zero-level set captures the surface in an approximate manner and the evolution of marker particles captures the fine details of the surface, and the zero-level set is modified based on the particle positions in each step of evolution. (2) Recently the particle-based Lagrangian approach to fluid simulation gains some popularity, because it automatically respects mass conservation and the difficulty of tracking the surface geometry has been somewhat addressed. (3) Until recently fluid simulation algorithm was dominated by approximate fractional step methods. They split the Navier-Stoke equation into two, so that the first one solves the equation without considering the incompressibility constraint and the second finds the pressure which satisfies the constraint. In this approach, the first step introduces error inevitably, producing numerical diffusion in solution. But recently exact fractional step methods without error have been developed by fluid mechanics scholars), and another method was introduced which satisfies the incompressibility constraint by formulating fluid in terms of vorticity field rather than velocity field (by computer graphics scholars). (4) Finally, I want to mention GPU implementation of fluid simulation, which takes advantage of the fact that discrete fluid equations can be solved in parallel.

Key Words : Fluid simulation, computer graphics, particle level-set, particle-based, fractional step, GPU implementation.

1 서강대학교 영상대학원 미디어공학/예술공학 전공
* E-mail: moon@sogang.ac.kr