Fluxion: An Innovative Fluid Dynamics Game on Multi-touch Handheld Device

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Abstract. We explore the possibility of implementing real-time fluid simulation on iPhone to create an innovative game experience. Using fluid dynamics and water tri-states as game mechanics, players can manipulate fluid and solve puzzles through the unique input controls of iPhone, such as accelerometer and multi-touch. We implement particle-based fluid simulation and integrate our particle system with a physics engine, Box2D, to realize the interactions between particles and rigid body. The playtest showed that Fluxion is not only a fun game, but also educational since it provides players the basic concepts of how fluid behaves in the real world.

1 Introduction

Water plays an important role in our daily lives, and it is always fun to play with it. Nowadays, fluid simulation has become an increasingly popular topic in computer graphics for generating realistic animations of water, smoke and related phenomena. With the novelty of iPhone, we aim to create an iPhone game using fluid dynamics as game mechanics, so that players can use iPhone featured input controls to manipulate fluid and solve puzzles.

We develop an immersive game experience and explore the possibilities of innovative game mechanics based on fluid dynamics. There are three main features in our game. First, our game mechanic is based on fluid dynamics. The biggest difference from others is that we integrate the water tri-states into our game (Figure1.(a)). Players can use tools such as heater, cooler, freezer etc. to play with state changes between gas, liquid and solid. Second, iPhone's input controls have a great potential for intuitive and interesting game interaction. The 3-axis accelerometer senses the orientation of the phone and changes the content in the game accordingly (Figure1.(b)). For example, with the accelerometer, players can tilt the iPhone to move or to speed up the fluid flow. Third, our game involves a lot of conceptual challenges for players to utilize fluid features to solve puzzles. We design tools to help players solve problems (Figure1.(c)). For example, players can place a heater to turn water into gas or place a freezer to turn it into ice.

(a) (b) (c)

Fig. 1. (a) The tri-states of water: gas, liquid, and solid. (b) The according liquid behavior when the accelerometer senses tilting right motion. (c) The item menu, showing all items that players can use in the current level.

2 Game Design

In fluxion, the objective of each level is to collect enough fluid particles to reach the goal. Players can tilt the iPhone to control the gravity of fluid. They can also use different items to perform state changes between gas, liquid and solid, or change the flowing direction to pass through obstacles and solve puzzles. There are some other interesting features such as using fingers to block the fluid movement and using multi-touch to control camera movements.

Fluxion is a game introducing tri-state features. It includes solid, liquid, and gas. As shown in Figure 2, three elements form a bi-directional chain where each element can be transformed into its neighbor states.

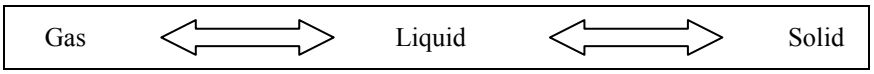

Fig. 2. State Transitions

Fluxion provides seven kinds of items that help players pass each game level. These items are freezers, coolers, heaters, and four kinds of fans blowing (upward, downward, rightward and leftward)(Figure3.).

(a) (b) (c)

Fig. 3. (a) A heater turns water into gas. (b) Water is turned into an ice cube so that the cart can carry it. (c)Fans blow gas away.

3 Technical Approach

Fluid dynamics is a wide topic. There are a lot of approaches to simulate realistic fluid in computer graphics. In general, these approaches can be divided into two groups: grid-based and particle based fluid simulation. In our system, we apply Smooth Particle Hydrodynamics (SPH) [1], which is a particle-based simulation method.

An important issue is how to implement fluid transformation between different states. We set a temperature variable to control the state change. When the temperature of a particle reaches a certain threshold, the particle will change its state. For freezing water into ice, we use a physics engine (Box2D) instead of our particle system to form a rigid body as an ice and handle the interactions between particles and the rigid body.

We optimize the OpenGLES drawing pipeline and our rendering algorithm by using texture-based rendering instead of grid-based rendering, which enormously improves the performance. Fluxion has been performed on iPhone 3GS at 30 frames per second with 150 particles.

4 Conclusion

Beyond recreational purpose, Fluxion is also educational. Players can learn the fluid physics through playing Fluxion. It completely shows the property of fluid dynamics and the tri-state of water: solid, liquid and gas. In addition, Fluxion demonstrates phenomena of fluid particles: water splashes while colliding to walls, gas always flows up, and ice cubes always floats on top of water. Moreover, our game allows players to perform logical thinking in the process of solving the puzzles using the knowledge they learned from the game. All in all, Fluxion gives players a basic idea of fluid behaviors in the real world.

Another achievement of our work is that we implement a real time fluid simulation on iPhone. Since iPhone has limited computation power, we manage to utilize the most efficient way to simulate fluid. Reducing unnecessary function calls and optimizing the algorithm make our game run at an acceptable frame rate. Our game takes advantages of iPhone features that make it more intuitive for players to observe and manipulate water particles around on a portable device rather than pressing arrow keys and watching the simulation on a still monitor.

References

1. Matthias Müller, David Charypar, Markus Gross**:** Particle-Based Fluid Simulation for Interactive Applications. In: SIGGRAPH Symposium on Computer Animation (2003)