Documentation for oven and spatula.

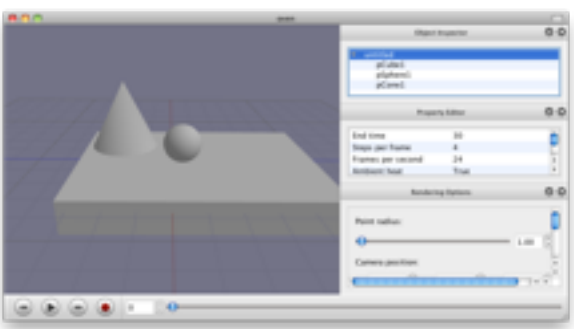
Programs developed by Omar Rodriguez-Arenas to create the animations in the thesis “Physically-Based Baking Animation Using Smoothed Particle Hydrodynamics for Non-Newtonian Fluids”

oven

Description:

This program is used to describe a scene for the fluid simulation, run the simulation and view the results in realtime. Its input is a scene built in an external 3D digital content creation tool such as Maya in Collada format.

Once a Collada scene is loaded the Object inspector, Property Editor, and Rendering options windows will become usable as shown in the next screenshot:



The Object inspector window shows the objects contained in the scene in a tree format, with the scene node itself as the root of the tree.

By clicking on each node on the Object inspector, the Property editor is populated with the objects properties. The scene node properties will be different from those of an object node.

The properties of interest from the scene node are:

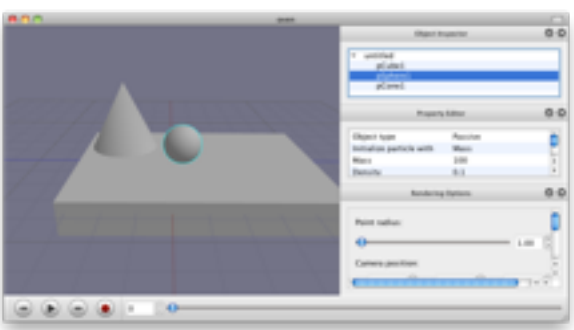
- **End time**: Ending time of the simulation.
- **Frames per second**: How many frames will make up a second of animation.
- **Steps per frame**: Base to define the time step with the formula:

$$\frac{1}{f \times 2^s}$$

where f is the frames per second and s the steps per frame.

- **Ambient heat**: Boolean to indicate if the particles temperature should be integrated.
- **Perform baking**: Boolean to indicate if external heat should be applied.
- **Min temperature**: Lower temperature in the simulation.
- **Max temperature**: Higher temperature in the simulation.
- **Start cooking at**: Time to start changing the temperature.

The following screenshot illustrates a geometry node selected (highlighted in cyan) with its properties displayed in the Property inspector:



The properties of interest from a geometry node are:

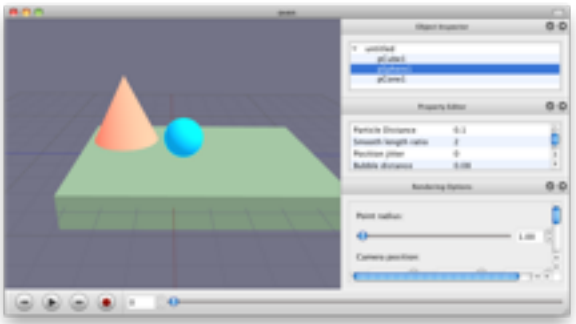
- **Object type**: Geometry nodes can behave as passive, solid, fluid or cutout node.
- **Initialize particle with**: Defines weather to initialize the particle's mass with a defined value or computed with a set density.

- **Mass**: The mass value used to initialize the particles.
- **Density:** The density value used to initialize the particles.
- **Particle distance**: The distance between the fluid particles.
- **Smooth length ratio**: The ratio used to defined the smoothing length based on the initial particle distance.
- **Position jitter**: The max jitter distance used to introduce some randomness on the fluid particles initial position.
- **Bubble distance**: The distance between the bubble particles.
- **Bubble jitter**: The max jitter used for the initial position of the bubble particles.
- **Heat conductivity**: Heat conductivity of the fluid. The higher the value the faster the fluid's temperature will change.

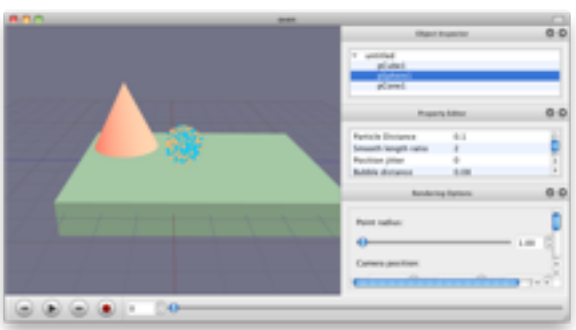
The four roles of a geometry node are defined as follows:

- **Passive**: Does not add anything to the simulation.
- **Solid**: A solid defined by particles along the facets of the mesh. This solid is static and can influence the movement of the fluid.
- **Fluid**: This object will be replaced in the resulting scenes with particles that will be affected by viscosity, stress, gravity, and other forces.
- **Cutouts**: Volumes that define a subset of particles which are inside them on the first frame. This subset of particles will can then be ignored in the surface reconstruction process in order to view only part of the fluid surface.

The particle distance between particles on a fluid should be at least twice of that defined for a solid object to avoid the fluid particles from going into the solid.
After the scene is set up the real time viewport should show the color-coded scene as follows:



The record button will start the animation process. If the “Live save” option is turned on from the “File” menu each frame will be saved into an individual Collada file in a directory named after the initial scene file appended with the text “_animation.” During the simulation the particles will become visible as shown in the following screenshot:



After the files are generated the surfaces for each individual frame can be generated with the spatula program.

Libraries used:

- QT
- COLLADA
- CGAL
- gmp
- mpfr
- boost

Directory structure:

- **integration**: Helpers for transmuting from a Collada structure to the native data structure.
- **primitives**: Primitives used to defined the scene.
- **scene**: Scene definition.
- **simulation**: All of the functionality having to do with the actual simulation. The contents of this directory are improvements to the work of Dr. Hai Mao.
- **system**: Description of the system including the front end and the communication with the back end in charge of the simulation.

Due to different circumstances, when creating the animations some values were hardcoded into the system. The following table lists these values:

Animation	Ti	Tc	Tf	μi	μc	μf	μei	μec	μef	Cλ	εi	εf
Angel cake	26	45	120	100	10	1000	1000	100	10000	50	0.3	0.5
Bread of the dead	26	45	120	500	100	5000	5000	1000	50000	1000	0.3	0.5
Bread roll	26	45	120	500	100	5000	5000	1000	50000	1000	0.3	0.5
Volcano*	100	45	20	10000	10000	10000	1E+05	1E+0	1E+05	1000	0.05	0.6

spatula

The Spatula program is used to generate the surface mesh of the fluid at each individual frame. After starting the program the interface will come up as shown on the following screenshot:

Here one can select the animation directory to work with. After selecting the directory one can click the “Get Colors” button which will generate the surface mesh for every frame. The Collada files will be stored in a new directory with the working directory’s name followed by the word “Processed”.

Similarly to the oven program, some parameters have to be set inside the code. These parameters have to do with the marching cubes algorithm and they can be found on the file SurfaceMesher.cpp:

- **__cellSize**
- **isoDensityRadius**
- **isoThreshold**

This program has a memory leak, for this reason a console version (also included on with this documentation) was created called spatulaConsole. This program can create a surface for an individual Collada file without the need of the rest of the series and can be run with a simple script to create the whole animation.

Libraries used:

- QT

- COLLADA
- CGAL
- gmp
- mpfr
- boost
- Plugins developed for Meshlab

Notes

This program was developed by creating an interface around, and improving Dr. Hai Mao's work. Although originally the purpose was to create a program that could be used as a base for further research, this objective changed with the pass of time. I would not advice to extend this software further. Instead, the best approach to continue in this line of research would be to study the original work by Dr. Hai Mao (included without modifications in the directory named "Copy of testing copy v6") and the changes made in the oven program under the "simulation" directory, and improve on that work. Starting from scratch would be too time consuming, for this reason I would recommend building on an existing framework such as:

- OpenTissue (http://www.opentissue.org/wikitissue/index.php/Main_Page)
- Gadget (http://www.mpa-garching.mpg.de/gadget/)
- Fluids (http://www.rchoetzlein.com/eng/)
- ISPH (http://isph.sourceforge.net/download)

For any questions you may have about this project please contact me at omar.rodrigueza@gmail.com .

Omar Rodriguez-Arenas