Simulating Rivers and Waterfalls in Blender

Sammy Berger

Abstract

This project is an exploration of the particle-based fluid dynamics in Blender, with an emphasis on showcasing those dynamics via a river or waterfall. To that end, I created a surrounding environment, experimented and documented the variables that influence the particle-based fluid, and avenues to texturing the fluid to achieve the desired result.

—

Crafting the Environment

Creating the environment is the first step to take when creating *any* scene, and a waterfall or river is no exception. Depending on the focus of your project, the background can be more or less important. For my purposes, the main focus was on the particle-based fluid.

As it is not really the purpose of this project, I'll avoid going too in-depth into how to model a rock face, or a tree. There are some great online tutorials if you want to learn modeling by yourself, and there are a number of websites that offer free assets if you don't have the time to model your own. Therefore, I'll just offer some general advice for if you *do* want to make your own models.

In general, a single, versatile model - like a cliff with a smooth face and a rough face - is easier to make and work with than multiple niche models. Also, don't be afraid to use textures to replace detailed modeling. A bush model with thousands of leaves looks the same as a model that uses a few planes and textures with blank space - however, the plane-based model is much less difficult to work with for your CPU.

—

Particle Physics

To properly simulate water (or indeed any liquid) is not an easy task. Blender provides two main options for simulating liquids - via particles and via meshes. Both options have their own strengths and weaknesses - however, analyzing those isn't the purpose of this paper. Instead, we'll only talk about using particles.

Blender provides a number of knobs to turn when editing the parameters of a particle-based fluid. While many online tutorials will go into the creation of some basic fluid, very few will discuss how the various parameters effect the fluid, and how to change them to best obtain your desired interactions. I will now explain my process and experimentation towards creating water.

Damp was one of the first parameters I experimented with. I had noted that the simulation's particles were bouncing far more often than water particles do in real life. Therefore, I started adding a small amount of Damp (usually 0.01 to 0.05). Dampening seems to sap energy out of all interactions the particles go through - at high enough levels, it even makes groups of particles fall slower. *In general, Damp helps particles clump together and prevents extraneous bounces, but also slows forward momentum.*

Repulsion Factor is not subtle in it's purpose. It literally makes the particles repulse one another; however, it tends to do so on a very low scale. As can be seen in the picture I've provided, liquids with Repulsion Factors of 1 can still stay together quite well; it takes a factor of 5 or 10 to really stop all clumping. It should also be noted that decreasing the Repulsion seems to increase the distance your liquid can move; I'd assume the is because of fewer intervening forces. *In general, the Repulsion Factor keeps particles apart, and even halts forward momentum a bit.*

Stiff Viscosity is hard to explain precisely, but easy to manipulate. To be honest, despite understanding how it effects the fluid, I don't understand quite what it is - treating the symptoms without knowing the disease, as it were. *In general, at low levels stiff viscosity thins your particles and allows them to move erratically; at high levels, it keeps your particles together, and tamps down on some erratic movement.*

Interaction Radius is quite literally the radius at which your particles will interact with each other. When lowered, it allows your particles to overlap without treating each other as touching. When raised, it makes your particles feel as though they're touching despite being far apart. Initially, I made the mistake of lowering it to increase the density of my fluid; I soon realized that doing so made the physics of the fluid nonsensical in some cases, and I had to revert it to a much more normal value. *In general, Interaction Radius changes how dense your fluid looks, but doesn't properly replicate the physics of a fluid of that density.*

Rest Density is also hard for me to explain, like Stiff Viscosity. As you might expect, higher Rest Density means that your particles will form a more dense liquid (they'll stay together more). However, as you can see in the picture, it also seems to make your particles congregate to the detriment of their forward velocity. *In general, Rest Density will make your fluid more dense, but also more likely to stay at rest.*

Stiffness represents how incompressible a fluid is; at lower levels your fluid can compress more, and at higher levels your fluid can compress less. As you might expect, this sounds very similar to Interaction Radius, and indeed the two do key off one another. However, Stiffness is more than just a renamed Interaction Radius - different values of Stiffness can also increase or inhibit the fluid's overall movement. I'd recommend not increasing it too high, or else your particles will just bounce all over the place. *In general, Stiffness acts similarly to Interaction Radius, although it does have a few other effects..*

Viscosity, finally, represents how viscous the fluid is (as you might expect). It acts very similarly to Stiff Viscosity. Due to the additional clumping of viscous fluids, there's slightly less forward motion; lone particles and small groups that would otherwise move far forwards just don't form. *In general, viscosity decreases erratic movement and increases congealment.*

So, after all this analysis, what settings did I use? I emitted 600,000 particles over a timespan of 150 frames from an emitter with a surface area of approximately $1.2u^2$. The particles were emitted with a normal of 3. They had a mass of 3.0, 0.01 damp, 1 stiffness, 4 viscosity, 0 repulsion factor, 0.2 stiff viscosity, 0.9 interaction radius, and 0.8 rest density. Again, the most important part is knowing how each quantity changes your result, because then you can create whatever effect you want.

—

Graphics of the Water

Admittedly, this was the part I had the most problems with. When working with mesh-based fluids, simply using the Cycles engine and giving the fluid a Glass texture will suffice; but when working with thousands and thousands of particles, I've found that most glass or partially transparent Cycles shaders will yeild large portions of the liquid indiscriminately pitch black, even when they shouldn't.

The naive solution is to compromise; represent water as an opaque light-blue (or any other color). I classify this as a naive solution for two reasons; it doesn't correctly depict water's color, and it also doesn't mimic how water really gains it's color. That being said, if your main purpose is to get a working model of water without caring too much about how it looks, an opaque texture will allow you to easily see the motion.

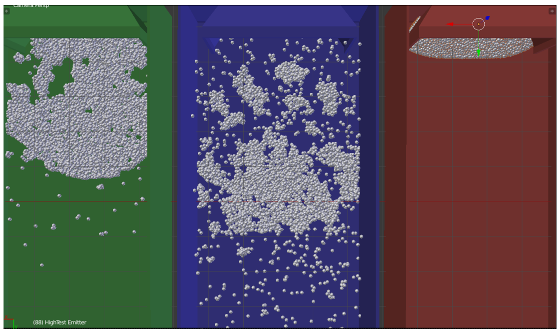
The more complex solution is to attempt to realistically recreate refraction and such in water. To be completely honest, I've had many issues doing so, and haven't succeeded to a level where I'm satisfied yet. In the Blender render, you can easily turn off shadows, and edit the Alpha (transparency) of the material and specular (artificial shininess) easily. To make an approximation of water, I set the material alpha to zero, and the specular alpha to slightly more than that. This made the water slightly cloudy (from particle shines overflowing with each other), but shiny as you might expect.

To properly get the particles to mimic water visually is beyond what I am currently capable of. As a general guide, you'd want near-zero material transparency, nonzero specular, and potentially some mirroring effect.

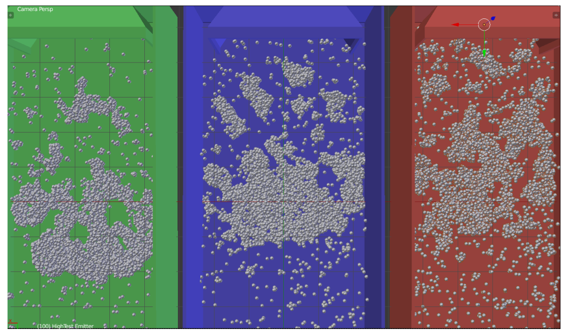
Additional Material: Visual Representation of the Effects of Various Variables.

Below, you'll see some basic representations of the how changing the variables will effect your fluid. All three boxes had a separate particle system that ejected the particles from one end to the other - you are seeing this at a bird's eye view.

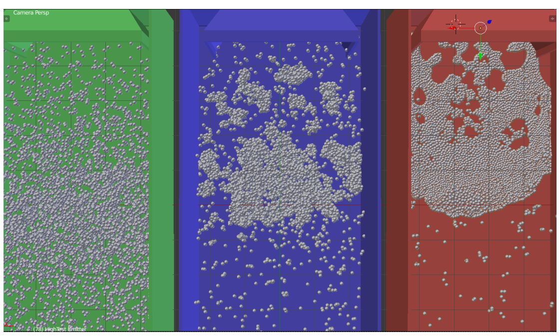
The center (blue) box is the control, and has the same parameters as a newly created particle system. The left (green) box has the relevant parameter at a low value; sometimes this is still larger than the control. The right (red) box has the relevant parameter at a high value.



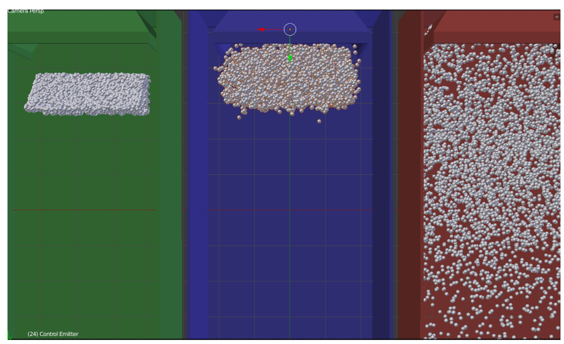
(a) Damp at 0.1 / 0.0 / 1.0



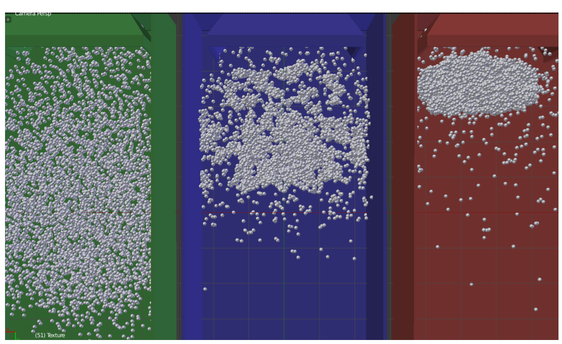
(b) Rep. Factor at 0.0 / 1.0 / 2.0



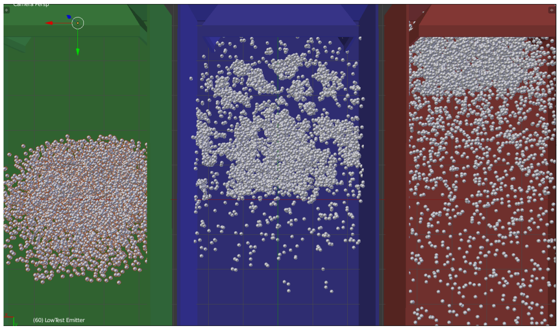
(a) Stiff Visc. at 0.0 / 0.1 / 1.0



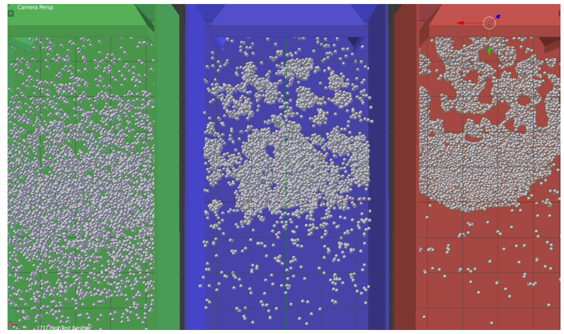
(b) Int. Rad. at 0.0 / 1.0 / 2.0



(a) Rest Density at 0.0 / 1.0 / 2.0



(a) Damp at 0.0 / 1.0 / 5.0



(b) Viscosity at 0.0 / 2.0 / 5.0