Art directing particle flows with custom vector fields

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Introduction

Complex physically based fluid simulations can take hours or even days to process, yet the degree of user control over them is never as detailed as directors and supervisors would like.

By creating and combining user defined vector fields, we gain a level of control over fluid simulations that allows us to directly address these particular needs without having to worry about breaking the simulation and allowing faster turnarounds to give us more iterations of each shot.

FELT

FELT is Rhythm and Hues’ award winning Field Expression Language Toolkit, a flexible standalone application that allows the artist to manipulate both scalar and vector fields as well as handling interaction with traditional models. An interface has been added to Side Effects Houdini by means of a SOP that allows the artist to import, create, manipulate and export fields within the program’s procedural workflow.

The resulting vectorfield is then used to advect particles either by directly controlling their velocities or by applying an additive force. These particles will ultimately be used to populate the voxel buffer used in the final render, which is itself a FELT scalar density field.

In Production

In the first example, from The Incredible Hulk, Hulk is bursting his way through the front wall of a large glass walkway filled with teargas.

Initially we started with a conventional grid based fluid simulation (i), to direct the overall motion of the particles that will ultimately be used within the voxel render. Once the vector field is generated, a Houdini POP allows us to advect particles within that domain.

Specific art direction dictated that the impact force by Hulk as he smashes the front of the walkway apart needed to be more forceful. Rather than increasing the magnitude of the force used within the simulation and hoping it didn’t lead to instability later on, it was a simple matter to “sculpt” a force using implicit surfaces and then convert this into an vector field (ii). "Curl-noise" based turbulence was introduced as another vectorfield (iii). Lastly, a simple upwards flowfield was created and then modulated by a spatial scalar noise field to introduce some apparent randomness (iv). The resultant advection field is generated as a simple summation of these “basis” fields (v).

Most of these flow fields are required to act only in very specific regions of the particle simulation defined by the scene geometry; getting fine control over the domain of POP style particle forces can be problematic, but with FELT we are able to specify regions using signed distance functions built from modeled geometry to mask or modulate the intensity of our forces. It is apparent in (iii) and (iv) that the volume representing the interior of the walkway (ghosted) has been masked off from the flowfield.

In the second example, Hulk leaps from the shattered walkway through the previously generated gas cloud. This presented it’s own challenges, such as the use of slow motion for the jump itself.

The use of slow motion makes a physically based simulation awkward to implement, however, with FELT, we can control the magnitude of the composite vectorfield and so directly manipulate the velocities of the advected particles. This allows us to directly control the particle velocities to match the shot’s timing. Additionally, a reasonable approximation to incompressible fluid flow can be obtained by stamping the velocities of the rapidly moving objects into the flowfield and then returning the divergent free part of the flow using the fourier transform.

Conclusion

The biggest advantages to building fields in this manner are that it allows rapid turnarounds of particle simulations with a greater degree of control than conventional particle forces allow. Whilst these user directed flows somewhat break the physically based nature of the simulation, we can still maintain some measure of incompressibility. The result is a solution that appears pleasing to the eye.

References

Curl-noise for procedural fluid flow. ACM SIGGRAPH.