Melting a Terminatrix

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1 Introduction

For Terminator 3: Rise of the Machines, one of the many challenging sequences ILM was presented with depicted the films antagonist, the ”TX”, struggling to free itself from the pull of a magnetic field. The TX embodies the features of both the previous films assailants, being comprised of both an armored endoskeleton and a liquid metal exterior. The primary challenge in the sequence was to digitally create the gradual liquefaction of the TX’s exterior. To achieve this we turned to a fluid simulation approach, utilizing a *particle level set* method [Enright et al. 2002; Foster and Fedkiw 2001]. While this gave us the means to produce the desired dynamic effects, production requirements necessitated the development and implementation of techniques and tools that allow artists to control *every* aspect of the simulation. Developing intuitive and accurate control is essential to achieving an aesthetic vision while producing a dynamically realistic simulation. This sketch describes the production processes and techniques developed to complete this sequence.

2 Evolution

While a variety of techniques were being used to create liquid metal effects in the film using both particle simulations and animated geometry, none of these techniques provided the detailed structure or the dynamic nature required to produce a plausible fluid flow and suspend the audience’s disbelief. To achieve realistic dynamics, we turned instead to a physics-based 3d fluid simulation engine based on the particle level set technique. This method uses a level set stored on a regular volume grid to represent the fluid/air interface, which is augmented with particles on either side to help prevent volume loss as the level set is advected through the fluid velocity field. Identifying the level of control needed over the simulation parameters became an evolving process, the requirements of the engine growing in parallel to the requirements of the shots. A method for inputting this information into the engine was required, and it needed to be extensible on both a global and local definition scale.

3 Simulation and Control

We used Maya particles to control and direct the fluid. A poisson distribution technique was used to evenly disperse particles over the outer surfaces of our creature, and these particles carried animation dependent properties such as position, velocity, viscosity and surface normals. This provided us with a generic method for inputting control properties into the fluid. We rasterized the geometry in order to describe both the fluid’s initial condition and the endoskeleton interior as a collision volume. The exported particles were used as global or local controls for defining regions of the flow with varying viscosity and areas where the fluid was constrained to track the particle motion. Geometry was used as fluid erasers or emitters to enhance the degree of control. To produce simulation results with a reasonable resolution within a practical turn around time, we employed various techniques. The engine was not multithreaded, and we instead divided the simulation domain into several smaller (possibly moving) overlapping domains. To cope with localized simulation over large domains, we implemented grid sourcing. That is, a pre-simmed higher resolution, but smaller domain

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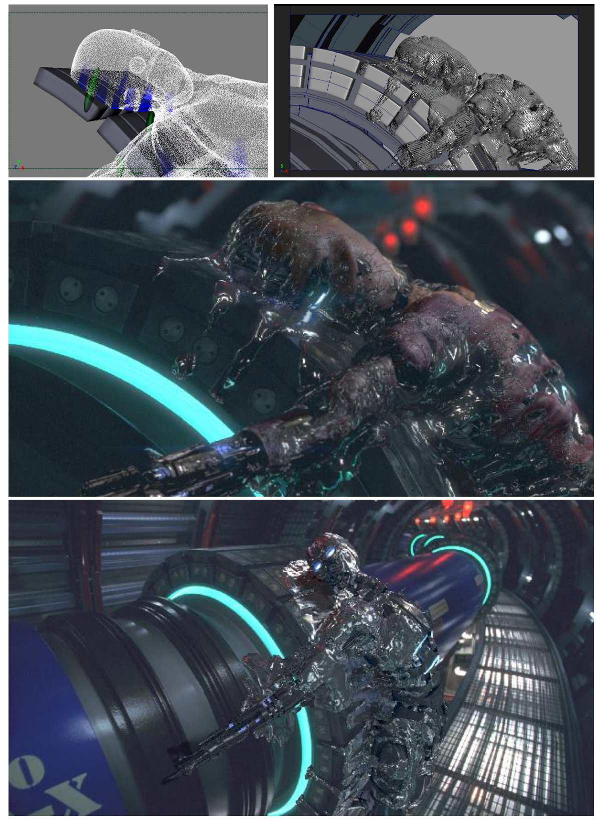

Figure 1: Various aspects of our pipeline highlighting control, preview, texture and liquid metal.

was used to generate level sets that in turn act as input into a larger secondary domain thereby increasing the physical simulation area covered. The overhead of collision grid lookup was reduced significantly by caching out composite grids increasing engine performance and reducing memory overhead.

4 Rendering

We render the implicit surface defined by the level set directly by ray tracing. This is very efficient since the level set defines the distance to the fluid surface at all points in the volume. The fluid is rendered within the final scene so we can include reflections and occlusions of other objects. A potential difficulty with rendering level sets is the lack of texture coordinates. This was overcome by advecting particles through the fluid, which carry texture coordinates and any other information the artist desires. The information from the particles nearest each intersection point is blended and used to define texture coordinates and attributes to control the surface appearance. Because the particles have been advected through the fluid, the textures flow smoothly with the surface.

References

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