Performance Based Melting in *Spies In Disguise*

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Figure 1: Storyboard(left), melt simulation with drips(center left), molten material(center right), final composite(right).© 2020 Twentieth Century Fox Film Corporation.

ABSTRACT

Achieving a performance-based, physics-defying, melting of a bronze bust was essential for maximum comedic timing in our film Spies In Disguise. With specific story-boarded facial gestures in mind, the directors wanted to convey a feeling, rather than a physical execution of melting metal. In addition to crafting a simulation based on pose to pose animation, the material of the bust had to evolve from bronze to copper. This required a non-linear, multi-departmental collaboration. Our solution allows fine control over the melt while keeping the believability of a substance phase change. It also maintains high-resolution details of the model, preserving our curvature-based procedural animated texture, which carries across a temporally incoherent topology. In our case, signal passes generated from both the materials and the simulation were needed to assemble all the rendered layers and integrate the effect into the scene. Our method allows for quick iteration and is intuitive to implement. We demonstrate our approach by categorizing them into departments: Animation, Effects and Look Development, for clarity.

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CCS CONCEPTS

• **Computing methodologies** → **Computer graphics**.

KEYWORDS

Melting, Art-directable, Effects, Curvature, Materials, Procedural

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1 INTRODUCTION

Current methods for melting in computer graphics are physically based models that are able to simulate viscoelastic materials convincingly with accurate results. Art-directing such simulations is challenging because they rely on indirect forces and fields, such as temperature and viscosity for motion, which provide limited control. Our technique targets scenarios where the performance of the object being melted is of paramount importance. We are able to achieve this by decoupling fluid simulation from mesh deformation, which allows several post-simulation adjustments necessary to meet the artistic goals. Our method also permits layering secondary effects such as drips, on top, accenting specific areas for aesthetic purposes. Since the final output mesh of our technique has dynamically changing topology, we use a temporally and spatially smooth curvature-based procedural texturing approach, which can accommodate the deforming mesh.

2 ANIMATION

Since the performance required an asset to melt in a very art directed way, the fidelity necessary to control the animation's inbetween frames were not able to be hand keyed and interpolated as usual. Attempts at doing so would have required many additional rigging controls and several hours of hand sculpting each individual posed frame of animation, while still producing unwanted "jitter" in the interpolation between those poses. Therefore the animator focused on creating rough key poses that capture the essence of the performance to help the Effects department interpret the inbetweens in an organic way. Once the director bought off on these foundational poses, the Animation and Effects collaborated tightly to art direct the overall motion as well as make any additional pose adjustments.

3 EFFECTS

We filled the Beethoven mesh with particles and ran a coarse FLIP simulation driven by signals. These signals were based on animation blocking timing which activated different parts of the simulation at different times. The simulated points were then used to deform the reference mesh by using a point cloud lookup based deformation. This allowed us to preserve key details in the model and maintain a static point count. This was critical to applying post-simulation adjustments such as opening the mouth and bulging the eye, which were animated by pushing vertices on the simulated mesh. For additional melting drips, we scattered particles in cavities created within the model. These were then sourced to run independent FLIP simulations on a static pose and deformed post-simulation based on a custom solver as described in section 4. These drips were then merged with the FLIP driven model by first converting them to signed distance fields (SDF) and then back to polygons. This helped get rid of degenerate polygons and intersecting geometry introduced due to extreme deformations. We transferred rest data, heat signal, temporally blurred curvature signal and several other masks from deformed mesh onto the final SDF converted mesh which was then passed onto the Materials department. A hole in the table as the bust melts was created by boolean operation between an animated custom shape and the table. As time progressed, cooling off the melted mesh was achieved by increasing the viscosity of FLIP particles that collided with the table.

4 DEFORMING SIMULATED DRIPS

We scattered points on the rest pose which followed the point deformed geometry. For each drip particle, we stored nearby points within a certain radius along with their normalized distances. Locations of these neighbors on the animated geometry were then queried and the difference in corresponding positions on the rest and deformed geometry weighted by the normalized distances was used to offset drips as shown in Figure 2.

5 LOOK DEVELOPMENT

We had to preserve the traditional aged bronze patina and also convey extreme heat-induced melting to achieve the exaggerated performance. Layering a complex material with usable signals for Lighting and Compositing with a continuously evolving mesh, while preserving the metallic properties of a hot metallic surface texture, requires many iterations between the Materials and the Effects departments. As we started developing the materials, we determined fairly quickly that a stable reference space was the key to collaborating with the Effects and Compositing departments, to allow textures and mattes to stick to the mesh frame to frame without swimming. Since the Effects deliverable for texturing was a tri-mesh, standard surface-normal based signals like curvature and facing ratio proved to be very jittery. The most stable solution was temporally blurred curvature data from the Effects department which was piped through our proprietary renderer's procedural facedata shader to drive the materials. The shiny copper mixed with an aged patina also meant that the tri-mesh had to be a very high resolution to eliminate banding effects. To help grow the melting frame by frame in an organic way, we created a cylindrical mask with an animated scale attribute in the X and Z axes that expanded per frame as the mesh melted through the spot.

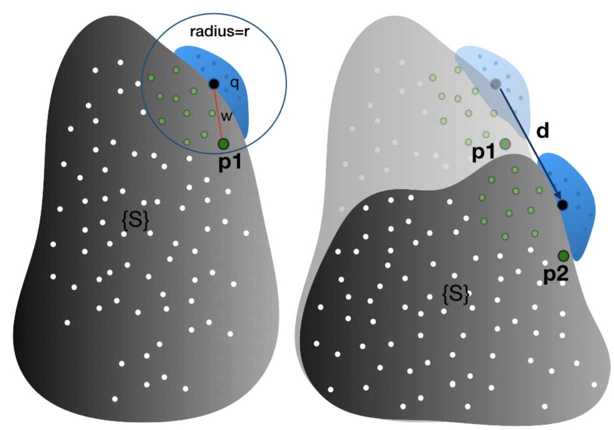

Figure 2: Blue drips on rest pose (left) and animated geometry (right). © 2020 Twentieth Century Fox Film Corporation.

6 CONCLUSION

Characterization is a key aspect that all of us here at Blue Sky Studios strive to maintain, regardless of the department. In Spies In Disguise, we developed a technique for successful art directed melting that is intuitive to implement and provides artists the controls needed for timing and performance.

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