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# Environmental FX for Multiple Productions

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# ENVIRONMENTAL FX FOR MULTIPLE PRODUCTIONS

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A Thesis  
Presented to  
the Graduate School of  
Clemson University

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In Partial Fulfillment  
of the Requirements for the Degree  
Masters of Fine Arts  
Digital Production Arts

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by  
Hugh Kinsey III  
December 2014

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Accepted by:  
Dr. Jerry Tessendorf, Committee Chair  
Dr. Joshua A. Levine  
Dr. Brian Malloy

# Abstract

This thesis presents methods for creating visually interesting environmental visual effects using Houdini. Four different types of environmental effects are shown: Dust trails, Waterfall mist, Snow, and Underwater dust. Each of these effects emulate real world phenomena, but also have the ability to be artistically driven to fit the visual artist's need.

# Acknowledgements

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# Chapter 1

## Introduction

Prior to the widespread adoption of computer graphics in film, film productions created or recorded elements of nature when control of natural phenomena was needed in the story. Today, with the advancement of computer graphics, we no longer need to rely solely on the elements we can capture practically. The ability to simulate natural events digitally has improved rapidly. Modern films like 2012, The Day After Tomorrow, and Avatar, have fully embraced 3D computer technology when creating visually spectacular environments. In these films, environmental effects serve many purposes: setting the mood of the story, showing strange and mysterious worlds, or even setting the stage for large scale disasters. In 2004, director Roland Emmerich released a disaster film called The Day After Tomorrow. This film depicted catastrophic climate changes that left most of the United States completely covered in ice. The theme of the movie addressed the concerns of global warming by realizing an ice age as the consequence of the increased planetary environmental problems. The plausibility of this movie depended on the environmental visual effects in the film. Cities were covered in water as sea levels rose, massive flooding and earthquakes brought the North American continent to ruin, as depicted in figure 1.1a. Tornadoes ran rampant from sudden temperature changes, levelling cities and destroying everything in their path, as seen in figure 1.1b. As climate changed further, most of the water that flooded the cities froze and turned the entire continent into a frozen wasteland, as seen in figure 1.1c. The emphasis on detail put into each of these stunning environmental visual effects leaves the audience believing in the destruction of humanity. Predictably, The Day After Tomorrow won the Environmental Media Award in 2004 for their spectacular environmental effects, and the BAFTA Award in 2005 for the best achievement in



special visual effects.

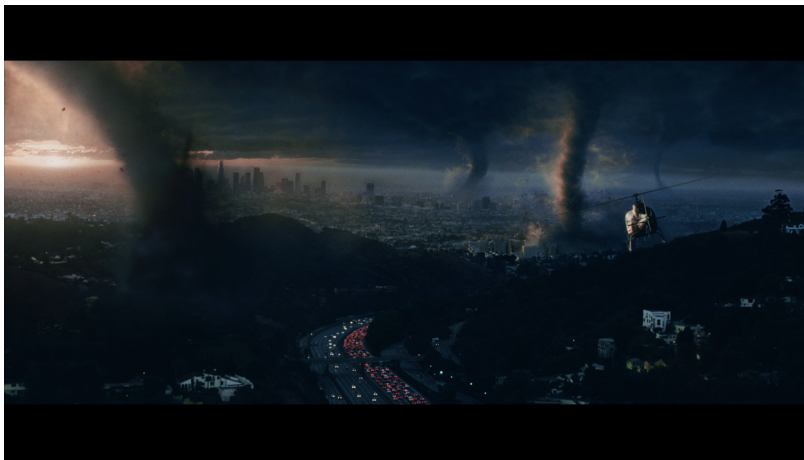
In more recent movies, environmental effects have taken on a whole new level in terms of their ability to mesmerize and capture audience imaginations. In the 2009 film *Avatar* [2], audiences were invited to explore a fantasy world replete with lush plants and wildlife. More than 60 percent of the scenes were fully produced with computer graphics helping to bring the audience into this new world and believe that these environments actually existed. *Avatar* had an underlying message that also spoke to environmental awareness, as it tried to persuade moviegoers through its beautiful imagery of lush tropical rain forests, exotic animals, rolling hills, dense mist, miles of waterfalls, and bio-luminescent vegetation. Examples of the environmental effects can be seen in figure 1.2.

The 2009 disaster movie *2012* was devoted almost entirely to environmental effects, depicting a global scale destruction, based on the premise that the world ended in 2012. The movie delivered on the expectations of the audience through non-stop destruction including tornadoes, meteors, tsunamis earthquakes volcanoes floods, hailstorms, and avalanches as depicted in figure . Each environmental effect was highly detailed and believable. In an interview with Roland Emmerich, the director of *2012*, Emmerich stated that "The most daunting task of the film was the attention to detail needed in every shot even down to the level of detail on a street corner. To make something photo real and believable you have to be very detail oriented" [8]. This attention to the detail of even the smallest effect is what drives the visual effects industry forward and continues to produce visually appealing content that meets or surpasses the viewers expectations.

This thesis presents four different environmental effects: (1) dust trails and (2) mist environmental effects that were used to set the mood of the story in the *Alien Oasis* film, (3) the snow blanketed winter landscape of *Dragon Slayer*, and (4) the underwater dust that established a sense of underwater impacts in the film *Peanut Butter Jelly*. The challenges faced and overcome in the productions, as well as the reasoning behind the choices made during production, will be discussed. The parameters that are necessary to reproduce the effects are shown and are paired with insights from real world references.



(a) Water flooding the city in *The Day After Tomorrow* (2004).



(b) Twisters and tornadoes ripping apart the city in *The Day After Tomorrow* (2004).



(c) An ice and snow covered wasteland in *The Day After Tomorrow* (2004).

Figure 1.1: Environmental effects from the movie *The Day After Tomorrow*. [3]



(a) An establishing shot of the environment covered in mist from the film Avatar 2009.



(b) A waterfall shot from the film Avatar 2009.

Figure 1.2: Environmental effects from the movie Avatar. [2]



(a) An earthquake shot from the movie 2012 (2009).



(b) An tsunami shot from the movie 2012 (2009).



(c) A volcano shot from the movie 2012 (2009).

Figure 1.3: Environmental effects from the movie 2012. [4]

## Chapter 2

# DustTrail FX Design Methods

In the short film Alien Oasis, the robot character drove across an arid and dusty planet in a search for water. Dust drifted into the air as its tires made contact with the ground. This environmental effect proved critical to plant the character in the environment. While subtle, there is a perceptible impact on the feel of a film from this real world cue.

The dust trail effect consisted of a fluid simulation emitted from each of the tires. Dust volume flowed into the air, and along the ground. The robot's tire configuration and body style closely resembled that of a four-wheeled all terrain vehicle (ATV). Video and photos of such vehicles in action served as reference for simulation and design. These references offered real world size and shape on which to base the dust trail digital simulation. As important as it was to match the size and shape of the robot to something in the real world for comparison, it was also necessary to obtain an accurate approximation of the amount of dust that would be lifted by the robot driving through a desert environment. Reference of an ATV driving at a moderate speed across a sandy, desert landscape provided just such an approximation [7]. Examples of these reference images can be seen in figure 2.1

The reference footage and images showed that when driving against a desert landscape, dust kicked up from each tire swirled violently before dissipating into a fine sand mist and settling back down on the ground. The dust kicked up from each tire collided with the body and swept along its side. To recreate this type of behavior, dust emitted from each of the tires was based on the robot's movement and speed. This allowed the animator to make changes to the direction and speed of the robot, and have the dust trail react to the animation. Each tire had a set of parented emitters, one



(a) Dust reference from an ATV ad.



(b) Dust reference of an ATV going the approximate speed of the robot.

Figure 2.1: DustTrail Reference [7]

to handle dust and spread along the ground, and the other for the dust being lifted into the air by the robot's speed. As the character moved across the desert, the lower emitter pushed dust against the ground and created a turbulent wave pattern that spread across the ground. The upper emitter produced dust that swirled in the air before returning to the ground and dissipating.

Each emitter was created with its own simulation network in Houdini, so that each emitter could be simulated and rendered separately or all together if necessary. This can be seen in figure 2.2. In the network, each set of emitters corresponded to individual tires. Each cluster of nodes consisted of an emitter object, a simulation object (dop) and a render element. The small red and blue sections were emitters for the front two tires. The large yellow and blue sections were for the back tires. The back tires each had two sets of emitters for rising and falling dust. The pink, purple, and green areas were for render nodes, lights and imported robot geometry respectively. While the option to combine all emitters into a single simulation was possible, the simulation time, memory, and render time would increase drastically. Also, by separating each emitter into its own autodop network, it was possible to resimulate the dust for a single tire quickly as opposed to simulating all the tires together. This gave the compositors more freedom to control the position and color of each dust trail depending on what each shot needed. In figure 2.3, there is an example of the dust element passed to the compositors.

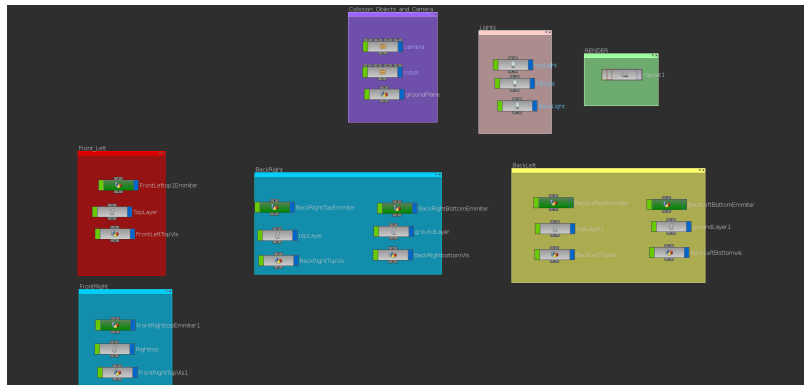


Figure 2.2: The dust trail object network in Houdini.

It is important for an fx artist to have full control over the shape, speed and flow of the dust trail at the various stages of its creation, lingering, and dissipation. When working with DOPS in Houdini, there are a number of controls that help with this. Among the most important are gravity, buoyancy lift, turbulence, wind, drag, swirl size, disturbance and confinement.



Figure 2.3: The dust trail element sent to the compositors.

Buoyancy lift and wind are broad forces that control the speed and direction at which the dust rises, and served as the dominant force of the dust trail simulation. By controlling the buoyancy lift and wind, the dust volume could be made to rise quickly in a short period of time, or rise very slowly over a long period of time. They also controlled the direction that the volume moves immediately after emission. By setting this control first, the emission speed of the volume could be matched to the rough speed of the robot as it traveled throughout the scene, giving the artist a quick way to block out the rough shape and speed at which the volume should be moving. Drag set a dampening force for the wind and buoyancy force. A constant gravity force grounded the simulation in real world motions. While it is possible to increase drag depending on the situation, it is often more beneficial to use other forces to control the movement of the volume and allow gravity to stay constant. By doing this, the other forces have a real world basis. Wind with a constant gravity will have predictable results, a frequently changing gravity will produce unexpected and unrealistic motion.

For the dust trail effect, gravity was set at a constant value of earth normal gravity and buoyancy lift was used to quickly get an approximation of the direction, away from the direction of the tire, that the dust would be moving. By controlling the buoyancy lift, dust speed could be quickly matched to the speed of the robot's movement. And by animating the direction vector associated with buoyancy lift, the dust could be easily updated when a change in the robot's movement called for the dust to move in a different direction. Wind was used to push it toward the ground or lift it out into the air. By separating out these forces, determining which forces were affecting different



parts of the simulation was easier to resolve and control individually, obtaining the overall desired look and feel for the dust.

Once the overall shape and direction of the dust was set to match the movement of the robot, the dust trail was refined to have the detailed swirls and quick movement visible in the reference footage. To control the swirl and the detail of the dust trail, turbulence and swirl size noises were added to the buoyancy lift and gravity. Turbulence noise served to break up the volume and give it more interesting and defined internal movement and structure. Low amounts of turbulence stirred the outside of the thick dust volume in small amounts, while large amounts of turbulence caused the dust trail to lose its connection to the moving emitter, and was more like a cloud of violently swirling dust moving on its own. The swirl size increased the size of the eddy motion in the turbulence. The dust was intended to look like it was from a robot while driving at low speed. Increasing the turbulence to high levels made the dust in the trail swirl much faster than the actual movement of the robot and the movement of the trail itself. Finding the balance to the speed at which the dust was being kicked up from the robot to the amount of internal motion to the cloud was critical to emulate real world motion, yet be art directable for the story. The intention was for the dust to look like a real world dust trail, but on an alien planet. This meant that the way the dust trail rose into the the air and fell along the ground would be heavily impacted by the type of gravity or wind that was found on this planet. For this particular effect however, the planet's gravity was earth norm and with typical weather patterns. These factors were important for informing the simulation parameters and avoiding unnecessary simulation.

Since the intention was for the dust to look like a real world dust trail, but on an alien planet, this meant that the way the dust trail rose into the air and fell along the ground would be heavily impacted by the type of gravity or wind that was found on this planet. For this particular effect however, the planet's gravity was set to earth norm and featured typical weather patterns. These factors were important for informing the simulation parameters and avoiding unnecessary simulation.

figure 2.4 depicts solely the use of buoyancy lift in the dust trail. The lift controls the direction that the emitted smoke rises as the tire moves, sending it straight up. In figure 2.6, notice the increasing horizontal movement at the top of the dust, the wisp has begun to curl and bend. This is the movement produced from low levels of turbulence. In figure 2.5, the turbulence parameter was much too high. While it added quite a lot of detail, the dust appeared very thick

and did not accurately represent the speed of the robot's movement. The dust with a high level of turbulence caused the dust to move quickly and rapidly. Using these parameters as a way to shape the simulation, ultimately gave rise to the desired effect and allowed art directable control.



Figure 2.4: The dust trail element with only the Buoyancy lift affecting its motion.



Figure 2.5: The dust trail element with high amounts of turbulence.

Collisions for the dust trail consisted of the dust interacting with the body of the robot, the ground, and the tires of the robot. The dust that spread outward along the ground behind the robot collided with a static ground plane that was positioned to match the planet's surface. The robot's body had a base section, allowing the dust to wrap around the robot itself. The reference footage of the ATV provided an understanding of the amount of interaction between the dust and the body of



Figure 2.6: The dust trail element with low amounts of turbulence.

the vehicle to convey a sense of collision. For a robot going at slow speed, very little of the kicked-up dust reached the body. The position of the dust as it was emitted from the tires was important because it had to appropriately wrap around the robot tires and body, and then dissipate. A small offset had to be applied to each tire for the dust to wrap around the tire convincingly. The offset allowed for the collision surface of the object to be lifted, giving the dust to have a larger surface to collide with. As a static object, the modeled tires were too thin to act effectively as collision objects. By applying a small offset, the collision boundary was increased, allowing the simulation to handle collisions in a more satisfactory way. It is important to note that the tires were also animated, so the colliding dust also needed to move with the tire rotation slightly before being thrown off behind the robot.

Each section of the dust was rendered with Mantra. The micropolygon mode was used, to break complicated geometry up in to smaller pieces before rendering each individual small piece. When choosing a render method like mircopolygon or raytracing, it is important to take into account the type of effect, or object being rendered. The micropolygon render was used to improve memory performance, by dicing geometry up and rendering the smaller pieces before throwing away what it does not need afterwards. This proved useful for rendering large volumes, in that an animator does not have to have the entire density in memory at one time.

One of the most important settings when rendering volumes is the volume step size. Normally, the volume step size should be the same size as your volumes grid. If the volume step size is smaller than the volumes grid, then the memory and time to render the volume will increase without



(a) The first shot from the film without dust.



(b) The first shot from the film with dust.

Figure 2.7: A comparison of the first shot of the film, with and without the dust.

adding any extra detail. One useful strategy was found by setting a value larger than the actual grid size. This sped up the render and generated a lower quality version of the image when testing the volume for correct motion, size and density. The use of rand in this equation uses the frame number as the seed. The same seed number returns the same result, so that "random" can be repeatable. For final high quality renders, each dust volume was rendered in RBG (red, green, blue) lighting to give compositors more control over the layers of the dusts lighting. This also freed the fx artist from time consuming tweaks of lighting. The compositors were also free to art direct the color and shadows of the dust. In figure 2.7, you can see the full dust trail element in the scene.

## Chapter 3

# WaterFall Mist FX Design

## Methods

On the film *Alien Oasis*, there is a lush cave oasis filled with many plants and a flowing waterfall. This oasis was meant to replicate an oasis on a distant planet that had not been visited for thousands of years. The goal of the Waterfall mist effect was to create a mist cover that would add to the mystique of the waterfall environment. The mist would cover the entrance of the cave, surround the plants, and create a thin veil for the waterfall, in order to make the oasis seem as if it had not been touched or visited in a very long time.

The reference footage and images show that there were three distinct waterfall mist phenomena that had to be reproduced to give the sense of a thick wall of mist. The first was the mist that fell with the waterfall, along the main spout toward the ground. Due to the varying speed of the waterfall, the mist along the waterfall column had breaks in its emission. One region emitted mist, while the next did not, all in a non-uniform pattern. The second type of mist was produced at the collision point between the waterfall column and the surface of the pool. This type of mist tended to hug the surface of the water, covering it completely depending on the time of day and temperature of the air. The second type of mist gave rise to the third type of mist: tendril-like mist chains that flowed in seemingly turbulent directions toward and away from the initial impact of the waterfall. The tendril mist that flowed away tended to drift a few feet away from the waterfall spout and would eventually be caught by wind before dissipating. The tendril mist that flowed back

toward the waterfall, was quickly pulled back into the first type of mist along the waterfall and then traveled downward. Frames from one particular waterfall mist video can be seen in figures 3.1.

The waterfall mist effect consisted of multiple particle effects as the basis of the mist: a base layer tracking with the waterfall, a particle mist layer that hit the ground and lingered around the bottom of the waterfall, and multiple layers of hero particle bursts to fill out the scene. The base layer had to closely match the speed and shape of the waterfall, and the flowing mist tendrils had to flow in a natural non-uniform way, in order to match actual waterfall mist phenomena.

The base mist was made up of particles from multiple emission points, that collided with geometry of its surrounding environment rocks, plants, and so on. This method provided several advantages over the simulation method. First, it gave more control over the direction and shape of the particles. Certain sections of particles could be manipulated in order to make them collide with the rock geometry, while other sections could continue to flow freely along the waterfalls edge. It was also possible to have art directable hero mist bursts that could be placed in compositing to add more fullness and life to the mist effect. It is important to note that simulating a fluid system for the mist effect would have had yielded very little control, and was not guaranteed to work well for the scene.

The ground mist system rose a few feet off of the ground before dissipating. Forces like wind and drag were added to recreate the wind and air conditions that surround waterfall mist. These wind and drag forces gave the artist a way to shape the flow of the mist as it was pushed away from waterfall collision area. By animating these forces, a non uniform dispersion of mist could be achieved. The artist also had a way to control the direction and speed of this mist in a controlled and directable way. With the shape and flow of the particles set, noise could be used to add curl and detail to the ground mist. Curl noise and perlin noise were particularly useful in effecting the flow of the mist, and adding curling motion to the mist. Adding noise to the simulation brought out fine detail in the ground mist. The ground mist produced for a shot can be seen in figure 3.2. The ground mist network can be seen in figure 3.3.

The base mist that tracked the waterfall needed to match the speed and direction of the waterfall when the mist was close to the water. However, as the mist moved away from the water, the mist would get caught in the wind, curl and sometimes be pulled into a wind current that pushed the mist back up the waterfall, in a cyclical movement. To recreate this effect of the mist effect, a path in the rock geometry was created, as seen in figure 3.4. Mist particles flowed over the cliff, colliding



(a) Waterfall reference for the waterfall and ground mist.



(b) Waterfall reference for the hero mist bursts.

Figure 3.1: Waterfall mist reference [5]



Figure 3.2: The ground mist for shot one of Alien Oasis.

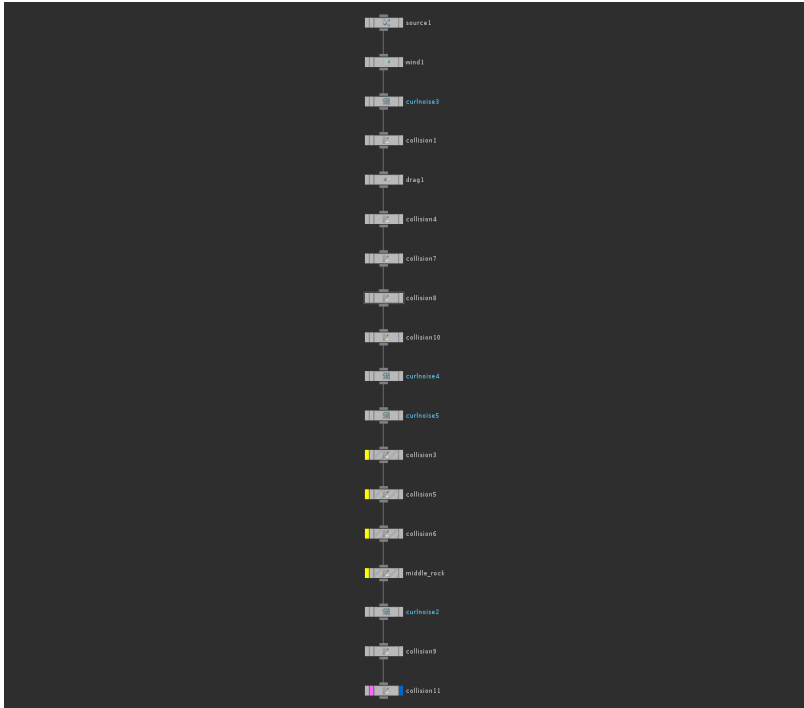


Figure 3.3: The ground mist network.

with the multiple rocks and facets of the geometry until it landed on the ground. Using the same path as the waterfall liquid simulation meant that the mist was able to conform to the shape of the waterfall, even though the water and mist were created independently. This greatly improved the integration of the rock, the mist and the waterfall. While this method succeeded in creating a mist



element that closely matched the water simulation and geometry, two distinct problems arose from it. The first problem was that the particles were colliding with everything causing some particles to flow over rocks that were close to the waterfall mouth along multiple streams flowing to the ground. This can be seen in 3.5. To fix this problem multiple sinks had to be placed in areas where the waterfall mist collided with these rocks in order to redirect the particle back down the main stream. The second problem was that the mist fell at a constant speed, creating uniform structure made it difficult to distinguish shapes and motions in the mist. mist fell at a constant speed, making it hard to distinguish the mist shapes as separate entities.

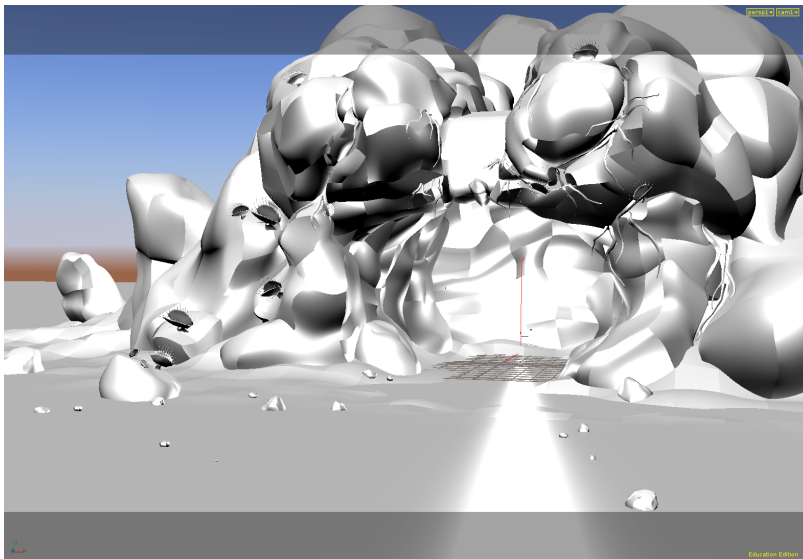


Figure 3.4: The rock model used in Houdini for collision objects.

The top section of the waterfall was especially uniform, as can be seen in figure 3.6a. To break up the uniform distribution of particles the emission was randomly modulated frame-by-frame, emitting particles in bursts rather than at a uniform rate. The number of emitted particles in each frame was computed in the expression:

$$\text{Clamp}(\text{floor}(\text{fit01}(\exp((2 * \text{rand}(\$F * 120.254) - 2) * 75)), 0, 80000)), 0, 40000) \quad (3.1)$$

This expression generates a controlled random number of particles based on the frame number of the animation. In some frames 10,000 particles were emitted, but three or four frames



Figure 3.5: The mist collision with multiple rock faces.

preceding that frame zero to 1000 particles would be emitted. in this expression,  $\$F$  refers to the frame range for the animation. The terms 120.254 and 75 are constants that can be tweaked for more artist control.  $\text{Fit01}$  takes the number generated from the exponent and scales it to the range of 0 to 80000. The last step is to clamp the particles between the ranges of 0 to 40000. This equation creates sharp peaks of a large number of particle being created, and valleys of very little to no particles being generated. The effect of this particle breakup can be seen in figure 3.6b, effectively breaking up the waterfall mist sufficiently that the viewer could see bursts and motion in the mist. Tweaking the 80000, and 40000 variables of this equation will allow for the control of the number of particles on screen. Visually looking at the effect as adjustments are made, is the best way to get a feel for each parameter, and matching the desired particle emission. After the breakup expression was applied to the emission source of the particles, drag, curl noise, and wind forces were added to give more control over the break up and flow of the particles.

The hero burst mist was used to address the cyclical motion of the mist that surrounded the falling mist, and the tendril shaped mist that was caught by the wind and blown around. These mist bursts were elements that could be layered in sections surrounding the waterfall mist to fill out the scene as the artist desired. Each burst of mist lasted for only a few sections, however multiple varieties of bursts were created so that the entire mouth of the cave could be filled, and to keep the mist bursts from looking uniform through the film. Compositors had the ability to freely control both the timing of the bursts and the locations for the higher concentrations of stacked mist tendrils. Figures 3.7 displays just three of the six different types of hero mist bursts that were created. Some



(a) The Waterfall mist for shot 1 of Alien Oasis, before the particle break equation was applied.



(b) The Waterfall mist for shot 1 of Alien Oasis, after the particle break equation was applied.

Figure 3.6: Waterfall mist break up before and after.

of the distinct features of each mist burst is the type of noise applied to the initial velocity of the emission. The noises used were alligator, simplex, and perlin noise. The curl noise parameters can be seen in figure 3.8. This served to create multiple types of bursts from just a handful of noise types. Within each, the noise could be further manipulated to produce different distinct tendril-like patterns in the mist. Turbulence also played a large factor in changing the shape and variety of each mist burst.

The waterfall mist environment effect was used to enhance the water environmental effect in the scene. The mist helped add the desired mysticism to the shot that the artists required. The compositors had the ability to heavily layer the ground mist, and to place a curtain of hero burst mist to really accentuate the waterfall. The mist was also used to mask trouble areas for other portions of the production, including one particular rock in the waterfall cave. In the film, when the robot starts to fill his water bottle with water, the waterfall suddenly turns off, and the mist stops emitting. In figure 3.9, the finalized mist is depicted.



(a) The first hero mist burst for shot 1 of Alien Oasis, using original perlin noise.



(b) The second hero mist burst for shot 1 of Alien Oasis, using plex noise.



(c) The third hero mist burst for shot 1 of Alien Oasis, using alligator noise.

Figure 3.7: Hero mist bursts

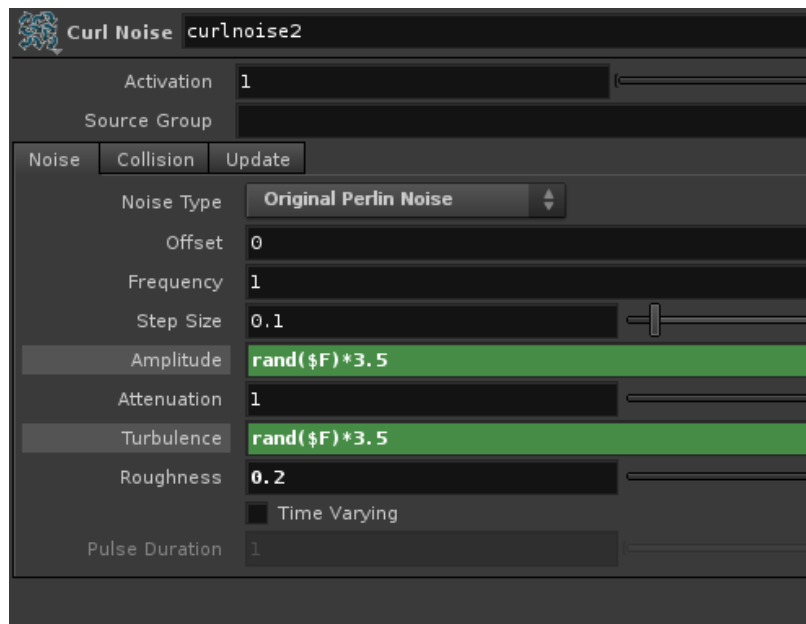


Figure 3.8: An example of the curl noise parameters used for each burst.



(a) Shot 1 of Alien Oasis without the mist elements.



(b) Shot 1 of Alien Oasis with the mist elements.

Figure 3.9: A comparison of the first shot of the film, with and without the mist.

## Chapter 4

# Snow FX Design Methods

In the film *Dragon Slayer*, the main character is in a valley with a lake covered in snow. The director wanted a snow effect that could be used in every shot, and would simulate falling snow in the foreground and background. The director also asked that the snow be blustery and fast. He provided reference for the particular effect that he was looking for, which can be seen in figures 4.2 and 4.3 [1]. This snow reference combined with snow footage that was acquired when snow fell in Clemson in February 2014 allowed for the creation of a falling snow system that could be used in every shot 4.1.



Figure 4.1: A frame of the reference snow footage taken in Clemson. In order to capture footage of falling snow, a person stood behind the falling snow to accentuate it.





Figure 4.2: The first reference shot of the snow from World of Warcraft



Figure 4.3: The second reference shot of the snow from World of Warcraft [1]

The snow system generates particles of varying sizes and shapes and offers the artist control over animating the wind direction, speed of the particles, and rotation interval of each particle. The system was built to accept an input geometry to stamp onto each particle like a sprite. Based on the size and shape of the particle, the stamped geometry also varied. This allows the artist to control how the snow falls in a particular shot. The snow generation interval is a parameter that allows the artist to control the amount of snow that is released each frame. This breaks the snow into non-uniform bursts as it falls to the ground. The technique for stamping particles involved building a particle network in Houdini and using the copy stamp tool to stamp geometry onto the particles. Custom parameters for scale and rotation were created to generate a random value for the size of

each copied particle at the time of generation. When a particle was generated, it was assigned a random size, shape, and rotation based on an artist defined threshold. Motion blur was added to the snow so that no one snow flake would be easily seen. Rather, a flurry of snow would fly past the camera. The snow system interface can be seen in figure 4.4.

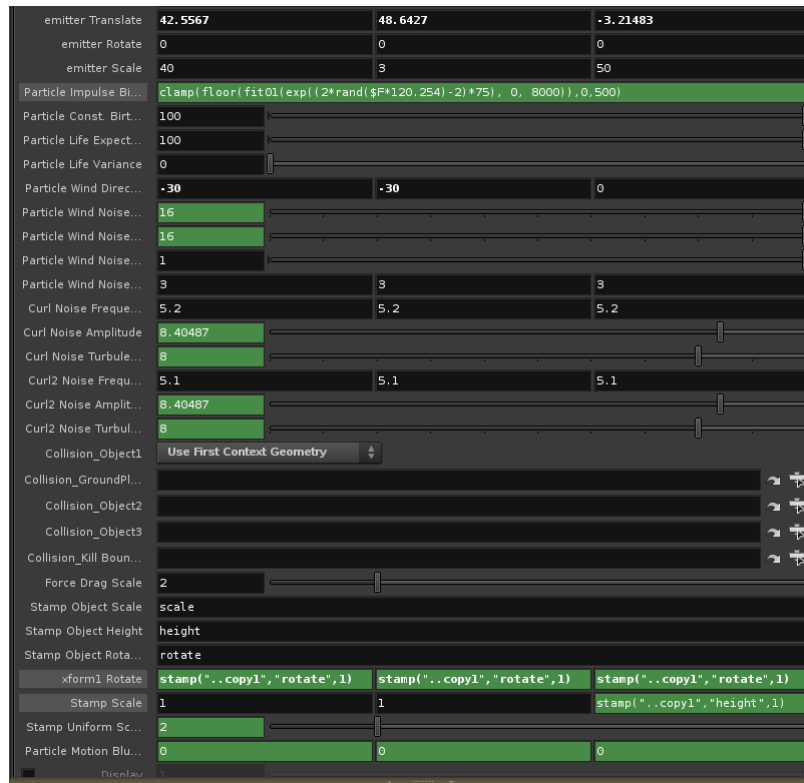


Figure 4.4: The interface and controls for the snow OTL, given to the artist.

To match the reference provided by the director, it was necessary for the snow to fall in two directions at once. Multiple copies of the snow tool were used at varying angles to give the desired effect. Like with the waterfall mist effect, the breakup equation was used to breakup the generation of the snow. Many of the parameters in the equation are kept the same, as the equation was only needed to breakup particle dispersion. By ramping 80000 and 40000 from the waterfall mist, down to 8000 and 500, the density and spread of snow clumps will vary. The snow can be further tuned by adjusting the parameters 75 and 120.254. Each layer of snow was rendered out separately with its own motion blur. This gave the compositor the ability to layer the amount of snow on screen, so that it would not look uniform. The snow falling from both angles can be seen in Figures 4.5 and

4.6.



Figure 4.5: The snow from above falling at a diagonal angle.



Figure 4.6: The snow from side being blown in from the left.

The artists working on the film expressed their joy for having a tool that they can use to make snow from multiple angles based on what each shot demands. It also frees the artist from having to build the snow system for each shot. The plan is to use the snow generated from this tool as a filter over each shot. A concept image for the snow to be composited can be seen in figure 4.7.



Figure 4.7: The snow from side being blown in from the left.

## Chapter 5

# Underwater Silt/Dust FX Design

## Methods

The goal for this effect was to create a simulation that could accurately reproduce the appearance of an underwater collision with the silt at the bottom of the sea floor. The film required that a cannon ball and several bullet objects impact the silt on the sea floor. After researching footage of underwater impacts, many important aspects became clear. One of the key aspects of this effect was that it takes place underwater. After an in-atmosphere cannon ball impact with sand, sediment rose and fell quickly. In underwater impacts however, the surrounding water currents would sweep the sand and cause it to linger much longer before settling to the sea bottom, as seen in figure 5.1 [6]. The sand that lingered, would slowly fall back to the ocean floor. Another important aspect to underwater collision is that when the impacting object would move through dust, water currents would follow after the object for a short time and cause the back draft of the object to leave swirls in the dust. This can be seen in figure 5.2.

Like the dust trail effect of Chapter 2, the underwater dust effect was a volume based simulation, but with a few key differences. This effect had to look and feel like it was underwater and had to have dust that flew up on impact and slowly glided back down to the ground. The simulation used animated wind forces to control the rise and fall of the dust to match the reference footage that was gathered. As a cannon ball impacted the dust, the wind pushes the dust upward quickly following the motion of the cannon ball as in figure 5.3. Once it hit its peak, water gently



Figure 5.1: Undersea reference of just being kicked up from the divers contact with the sand.

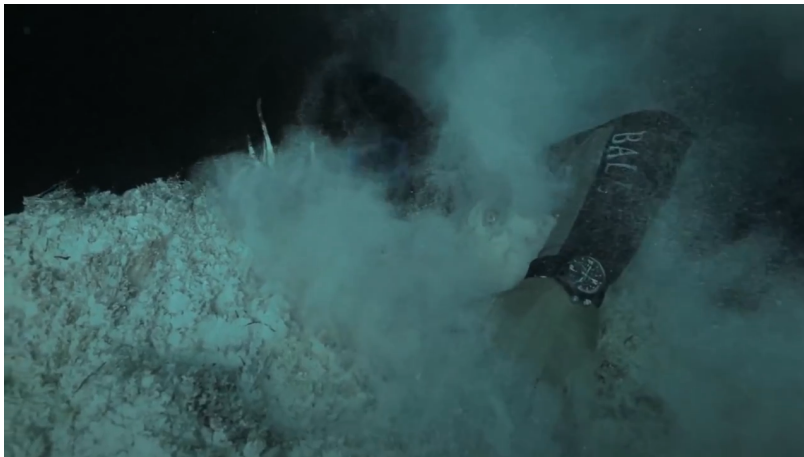


Figure 5.2: Undersea reference of dust being kicked up from the diver's hands in contact with the reef.

push the dust downward toward the surface. This is demonstrated in figure 5.4. In the reference footage, the dust drifted along the water current following an impact. The dust was rendered with RGB lighting, a rendering technique for volumes that uses a red key, blue fill, and green rim light, giving compositors the ability to control the color of the volume in composite.

Another important aspect of underwater dust is that it doesn't dissipate as softly underwater as it does on land. Underwater dust would form tiny grain like particles and then settle back on the surface of the ocean. To recreate this type of effect within the dust, a particle simulation was advected by the dust velocity to give the particles flowing in the dust cloud organic free flowing

movement. This style of advecting particles gives motion and detail to the particle. It is hard to achieve similar detail and motion using only forces. Combining the particle simulation with dust simulation produced an effect that mimicked the phenomena that was seen in the reference footage of an underwater impact.

The dust tool allowed the artist to control the degree of an impact and the vertical force, as well as the gentle settling of the dust back to the bottom. The underwater simulation interface can be seen in 5.5.

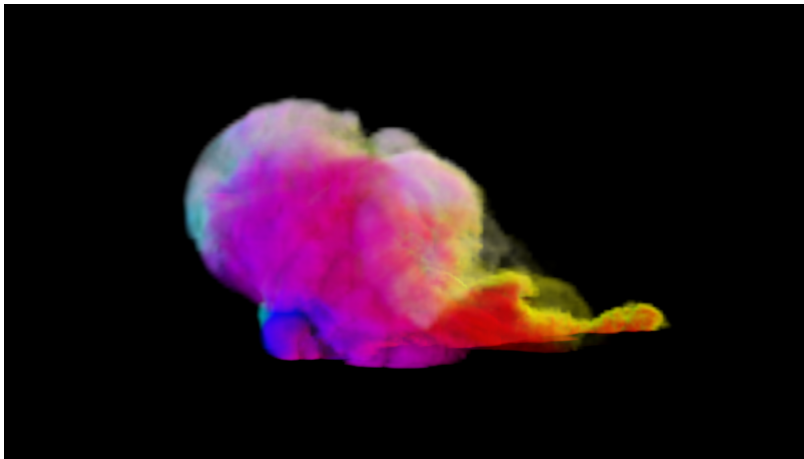


Figure 5.3: Frame 14 of the underwater dust, rising after the initial impact by the cannonball.



Figure 5.4: Frame 44 of the underwater dust, gently gliding down after the initial impact energy has dissipated.

There are several methods to create collision geometry in Houdini. The three main methods

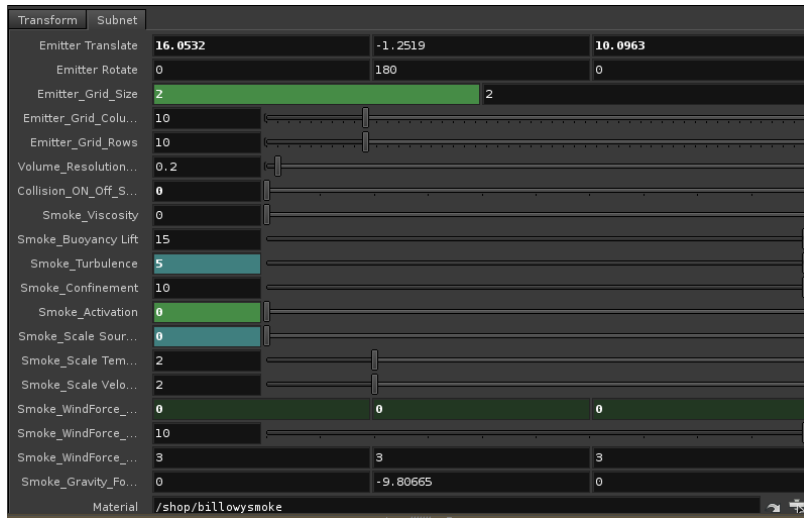


Figure 5.5: The interface and controls for the Underwater dust OTL, given to the artists.

are to create the collision geometry as a rigid body object, a static object, or convert the object to a volume that has its own density, temperature and velocity field. After trying each of these methods, converting the collision object to a volume yielded the best results for the cannonball colliding with the dust. The volume method, allowed for the dust volume to be pulled along the volume of the cannonball based on the heat of the two densities. This meant that lighter cooler dust would follow the trail of the cannonball giving the sense that the dust was being pulled by the water current trailing the ball. This was the type of effect that the director was looking for, as it matched both the director’s artistic vision and the reference footage closely. The dust followed the cannon ball trail just as the underwater dust followed the trail of the object passing through it. In figure 5.6, the light wispy dust that was affected by the collision with the ball object at the top of the dust cloud can be seen. The dust is being pulled in the direction of cannon ball. figure 5.7, shows a frame from the ”Peanut Butter and Jelly” Film.

This particular method has both advantages and disadvantages. The main disadvantages are that setting up the collision object requires a mid-level understanding of Houdini in order to set it up correctly. This was overcome by the creation of detailed tutorials and documentation that depicted the exact sequence of steps necessary to set up this part of the simulation. The main reason why this is necessary is because when importing a new piece of collision geometry into Houdini via the alembic file system, the act of rebuilding the geometry, erases everything that was already set



up for the collision, in order to bring in the new geometry. So it was necessary to explain how to set this up.



Figure 5.6: The dust hit with fine wispy detail.



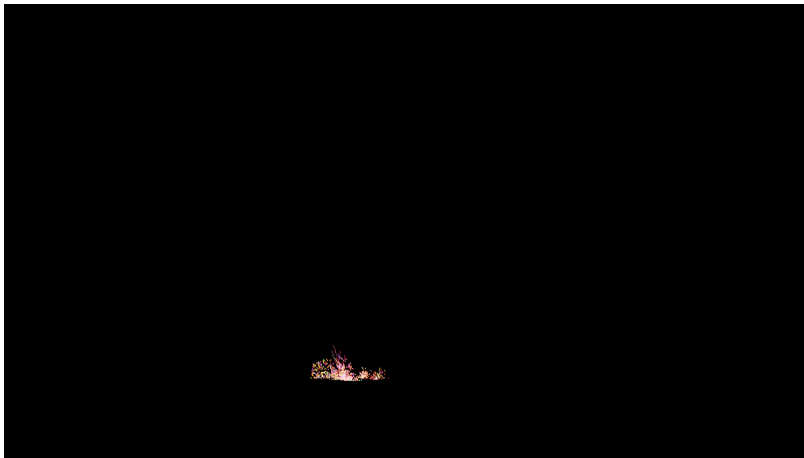
Figure 5.7: A dust shot from the Peanut Butter and Jelly film

The main advantage of using a volume is that it has access to all the velocity and motion that it generates from its animation. Extra curl noise was added to the volume object, to stir the area where the object collided with the dust even further than animating the turbulence of the whole simulation. This means that the artist could control how much turbulence is produced when the collision object impacts with the dust. A high value of turbulence or amplitude will cause a large disturbance, producing more swirling, and dust will be swept up in the wake of the ball moving through the water. Giving that amount of control over the volume-based simulation alone is more than worth the trouble of setting up the collision geometry correctly one time. Once set up, an artist could duplicate the initial underwater dust node, and use it for several collisions of that same

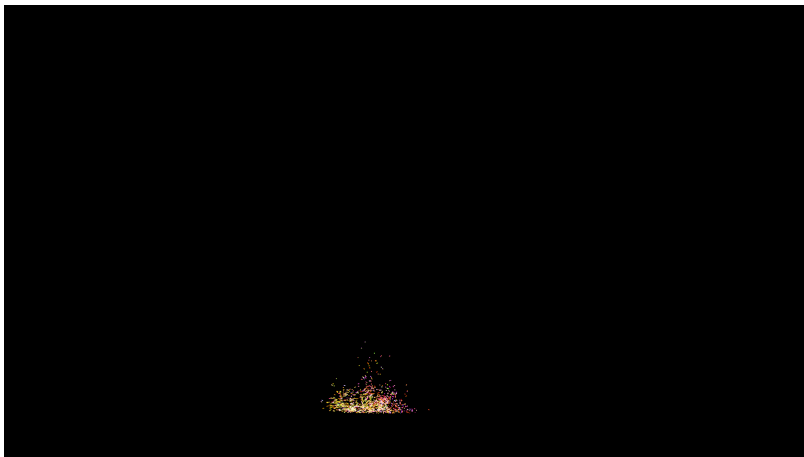
object. In the example shown, the cannon ball collided with the ground three times. After setting up the collisions for the simulation for the initial contact once, the artist could quickly replicate another impact with varying parameters and appearance.

With the method chosen for collision objects, a tutorial was written to teach artists who have little Houdini knowledge how to modify collision geometry and manipulate the tool. This tutorial assisted the lead artist in the creation of the third dust impact.

To further drive the integration of the dust with the particles, deep compositing was used to blend the two effects together based on their depth away from the camera. Using this technique, allowed the artist compositing the effect to determine which individual clusters of particles were shown inside, outside, in front and behind the dust, and to increase the integration of the dust with objects in the scene. While the Underwater dust was rendered in Houdini, most of the other objects in the scene were rendered outside of Houdini. This made it difficult to place geometry in front of other geometry, and required the use of multiple holdout masks. With the use of deep images for the particles and dust, the artist could integrate in composition because these elements had a similar depth value. The dust, despite being rendered in Houdini, could be placed in front and behind of multiple generated objects at the same time by controlling where is was based off the depth, without needing holdout masks. figure 5.9 is a look development shot to show what the final film will look like. figure 5.10 is a shot currently being worked on that is much closer to the actual film.



(a) Frame 17 of the dust grain advected by the dust.



(b) Frame 33 of the dust grain advected by the dust.



(c) Frame 45 of the dust grain advected by the dust.

Figure 5.8: Sequence of dust grains with RGB lighting.



Figure 5.9: An example of what variety of impact the tool can create for a single cannonball impacting the dust three times.



Figure 5.10: shot 15 multiple cannon impact hits.

# Chapter 6

## Results

The four environmental effects for dust trails, snow, underwater dust, and mist were used in two productions. These tools were designed to be extensible and useful for future productions. While sometimes subtle, environmental effects can play a large role in the telling of a story or toward increasing the fidelity of environmental phenomena in film. Environmental effects can accentuate characters, set the tone or mood of a story, draw the viewers attention to certain actions or locations, and environmental effects can even provide the basis for the entire story in some cases. There are a multitude of environmental effects that can be used in the production of a film.

The mist and dust trail effects served to ground the robot character in the environment of Alien Oasis. The dust provided subtle cues for the viewer as to the type of terrain that the robot was driving on. The mist effect served to set the mood of the short film in its opening establishing shot and throughout the film. It also helped to give character to the waterfall and a sense of life, as the mist reacted to the waterfall movements. The Dust trail effect can be reused for any film that requires the traversal of a desert landscape, and the methods presented can guide Houdini artists to making similar types of effects.

For the Dragon Slayer film, the snow sets the scene with a quiet and serene environment. When the dragon creature emerges, the amount of snow falling transitions from a light flurry, to a blizzard. This sets the tone of the film and the sense of urgency throughout.

The Peanut Butter Jelly film benefited greatly from the use of the underwater dust tool. In one of the more dramatic shots of the film, an epic battle ensued where opposing sides fired cannon balls and bullets at one another. Using the underwater dust tool, the artist could create realistically

accurate underwater sand collisions at every single impact point. Using the tool, the artist was able to create multiple separate and unique collision bursts based on the cannonball object. The collision object geometry could also be interchanged, and the underwater dust tool adjusted to match the updated geometry.

To simulate real world effects, it is crucial to take reference from those effects. Obtaining reference footage or imagery of natural phenomena will serve to highlight minute details that may seem insignificant, but are in fact crucial to properly replicate the effect, and for it to seem believable to the viewers. Without the reference footage gathered from these effects, it is not possible to discern the subtle flow of the dust as it is lifted from the ground by a tire into the air. The reference footage obtained served as a basis for each of the created effect.

Each of these tools contributed to a Digital Production Arts film, and was designed to be used in future productions.

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