

ILM - "Twister"

The visual effects work in "Twister" required the creation of various tornadoes that would interact with (and tear up) the ground, buildings, trees, cars, tankers, cows, tractors, farm equipment and other debris. Initially, it was my responsibility to execute a test for director Jan De Bont to show that it was possible to create the tornadoes. We wanted to give him full freedom on size, motion and structure. We chose to use particle simulation on the computer to create the tornado. This resolved the issue of fully integrating the many separate passes of debris and objects into the dust, allowing for seamless compositing and camera matching of the tornado.

Since this was a whole new territory, we created a 400 frame test showing a driver's POV of an F5 tornado shredding a barn as a tractor falls out of the sky, sending a tire into the windshield. Whether we could create a believable effect with the right amount of detail for film was unknown. Even if this were possible, how would we light the particles to shadow themselves like clouds do? And would the number of particles needed fit in the computers? Would the process be fast enough for us to deliver on time? The test was successful and the movie was green-lighted. The last 2 seconds of the shot were used in the "Twister" trailers. Once the project began, my role was to work with the software group to develop the particle renderer and implement the larger tornadoes, devise a technique to shred structures and train and supervise a group of 30 effects animators to execute the shots.

Shredding Barns and Structures

Numerous structures and debris were created in CG so that they could be rendered and composited seamlessly within the tornadoes, giving them the correct amount of dust to obscure them. If miniatures had been used we would have needed to roto each piece, in varying density mattes to cover each one, with the correct amount of dust based on its distance from the tornado. We typically generated 10 to 20 thousand pieces of debris, along with barn structures made of about 3000 pieces. I developed a method to release pieces of a barn or other structure where the animator would have full control of when each piece is set free, very similar to the "nail board" technique used in pyro explosions.

Entire sections could be released into the forces of the tornado at the same time, or piece-by-piece. Many larger pieces of "hero debris" were hand-animated to a specific direction. In addition to the broken barn parts, a dozen or so pyro charges of about 5000 tiny CG wood chips would be placed to go off at specific frames to add detail. A modified version of this was used to blow out the glass windows on the large barn at the end of the film.

The Making of an F5 Tornado

For tornado reference we studied hours of documentary footage of this phenomenon. The scientific F1-5 scale which measures the destructive power of a tornado is what we used to describe the size of the various tornadoes in the film (F5 is the most destructive). Together with Jan, we selected two references as the direction to work towards for the F5 tornado that would appear in several sequences at the film's end. These tornadoes had a dense inner layer shaped like the surface of a cauliflower or billowy cumulus clouds. The density of this structure decreases as you move away from the core. The larger the tornado, the slower it would turn and we made use of this to suggest scale.

F5 Structure

In order to retain the sense of structure seen in the reference footage, we generated invisible particles from the ground that would be affected by the physical forces present in the simulation, and would give birth to other smaller groups of invisible particles that would then generate the actual particles to be rendered. This technique gave us a lot of control on the cumulus structure and with the size and motion relationship between the various clumps. The color of the particles was varied to show more structure as in the reference. A matte was generated to darken the sky behind the twister in case there were any small gaps in the particle clumps.

All creation and positioning of the particles used variations on chaos theory techniques to randomize the structure so that it would look natural. It took a considerable amount of time to "grow" the basic shape of 5 to 10 million particles from the ground up. This simulated the action of a real tornado where big chunks of the ground are ripped out and then come apart as they move up. Because of the inherent properties of chaos, each time the slightest change was made to the forces or to the

population of particles, a different structure would result which still overall resembled the old one. Sometimes these initial shapes were saved as a starting point and hand-sculpted to modify their shape and add accents. Significant work was put into the level of detail of the outer layers since that characteristic helped achieve a sense of scale.

Particle Lighting

The most difficult aspect of the CG tornadoes was the lighting and rendering of the millions of particles. This was a totally new area of computer graphics since we were dealing with a volume as opposed to a surface. We created a new renderer dedicated to generating particles that can cast shadows onto themselves as well as onto other objects within them. The objects could also in turn cast shadows through the particles. We quickly found that this new area of volume rendering was very sensitive to the size of the dust particles. As the diameter of the particles would increase, the appearance would change from see-through thin dust to "ice-cream." Getting just the right size for the particles was the key to having the right density for the tornadoes. Particles were made to be smaller than a pixel to blend with each other into an amorphous mass. The particles could be backlit, and in some cases made semi-transparent, as in the case of the water twisters where the truck's headlights were matched in the computer and lit up the water mist.

Motion

We created an environment containing a series of forces, released particles into it, and watched what happened, similar to a virtual cloud tank. The difference was the ability to add and fine-tune as many invisible forces and to eliminate offending particles. We initially thought that once an overall rotation speed was determined for the tornado, we would be able to use that in all the shots. But we ended up tweaking that speed in every single shot, per Jan's direction, to maintain the same feeling of size.

Other forces such as upward suction, gravity and drag were in the mix, but turbulence was the most tricky to deal with. Calculating the motion of turbulence is so complex that it still defies the fastest supercomputers. With today's fastest computers it would take several thousand years to map out the air-flow of one second of a jet in flight. We, of course,

opted for a simpler approximation that looked good. It took us about 2 to 3 hours to run our simulation for a typical shot. This was too slow for trial and error evaluations, so we devised a fast way to preview the animation by only generating a fraction of the particles. In all there were over 200 separate controls that the tornado animators used to get the desired look.

Particle Clouds

Although many shots used 2D cloud replacement techniques, some of the shots (those that needed to show the tornado hooking up to the clouds surrounded by a rotating ring of dark clouds) used the same 3D particle rendering method used for the tornado itself. These structures frequently had elongated fibrous sections that lent themselves to the amorphous particle rendering.

Conclusion

I am fortunate to have participated in this project and play a key role in creating the central villain of the film. The challenge provided by "Twister" allowed us to venture into new areas of visual effects that will provide greater freedom to directors in their use of digital and practical effects.