ADVANCED IMAGING

A customized world in bullet time: the Oscar Winners on machine vision and visualization for F/X imaging.(Manex Visual Effects)

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Manex Visual Effects, the Oscar-winning house behind The Matrix and What Dreams May Come, looks at **effects** imaging capabilities and needs now. Did you figure that machine vision, LIDAR & photogrammetry are all involved?

Special **effects** are the growth hormone that spurs the evolution of film experience. But after the virtual sparks fly and smoke clears and the lights in the theater go up, audiences may find themselves asking, "What happened to the story?"

Visual effects can enrich and expand the director's vision to bring storytelling to new, previously unimaginable planes. This synergy of science and art is why **Manex Visual Effects** (Alameda, CA) won the 1999 Oscar for Special **Effects** for What Dreams May Come, and why it continues to innovate with films like The Matrix and Deep Blue Sea.

The challenge is the same for any imaging professional. When a Hollywood "Picard" states, "Make it so," the **visual effects** designer draws on what's available and what needs to be invented in order to execute, and often transcend, the order.

Joel Hynek, Senior **Visual Effects** Supervisor at **Manex** and the direct recipient of that Oscar, recently shared with Advanced Imaging his perspective on **visual effects** processes, tools and techniques that are involved in meeting movie making challenges now.

The **Manex** way draws from a rich heritage of machine vision, motion analysis and tracking, adds solid 3-D processes and techniques, then caps it with the **Manex** spin that pulls it together to provide what Hynek calls "customized innovation" for clients - working with the known to take leaps into the unknown to create something new.

"**Manex** has embraced pre-visualization wholeheartedly. It's a way to control **visual effects** production," Hynek told us. At **Manex**, "previz" is more of a dynamic, circular process - not linear - with all departments accessing a central database throughout an entire production. (See [ILLUSTRATION FOR DIAGRAM OMITTED] above of the "Unified World Environment".) This system is the foundation for constant feedback and monitoring from initial design through compositing among all contributors, from the director to animator.

The **Manex** tool kit is now a mix of traditional tools and customized inventions:

* For 3-D CG: SoftImage and Alias Wavefront's Maya for animation, set-up and building.

* For rendering: Renderman, Mental Ray.

* For compositing: Kodak Cineon.

* Avid Matador for painting, special **effects**, rotoscoping, tracking and multi-layered 2-D animation.

* **Manex** proprietary software for the bullet-time ("flo-mo") shots in The Matrix or the immersive paint **effects** in What Dreams May Come.

Where dreams came from

Manex claimed the **Visual Effects** Oscar for the Polygram/Interscope film What Dreams May Come, a fantasy/drama about the eternal power of love through life, death and beyond. It starred Robin Williams as a soul on a quest to reclaim his wife - an artist who is lost in the underworld.

"The challenge with What Dreams May Come was very exciting," says Hynek. "The director wanted to bring a painting alive and in fact wanted to show what it was like to be inside an oil painting. If there ever was a project that was all about art direction, this was it."

As with any film, the director worked from the script and hundreds of storyboards to provided varied conceptual references, including pictures by Van Gogh and Caspar David Friedrich.

Still, says Hynek, it was a conceptual and technical leap to interpret 2-D paintings as 3-D worlds: "Do you want to have a world where literally everything looks like it has fresh oil paint on it? Well, that could look nothing like a painting."

The usual mode for a **visual effects** production is to search for reference. What Dreams May Come

was particularly demanding in that respect.

"We tried everything we could think of: ink and water to oil on bizarre materials, exploring physical attributes of paint and researching people who painted from photographs," says Hynek. "But you can only get so far with that when there's something you're doing that hasn't been done before. That's where establishing a relationship with the director is critical, where he will trust you and say, 'Let's go down this road,' and then have the faith in you to convince his producers to give their support."

The director wanted Monet in the foreground and Caspar David Friedrich in the background. Says Hynek, "He had an amazing amount of tear sheets and **visual** reference, and would point to something and say, 'I like the light quality there and the brush strokes here.' He left it up to us at **Manex** to digest all this different information.

Machine vision delivers

But there was still the technical challenge of creating a moving 3-D world from 2-D reference.

After long sessions of intense, collaborative brainstorming, the **Manex** team realized that they had to come up with a way to attach paint strokes to every feature of an image so that the strokes would move smoothly with each action. Traditional paint programs, they'd found, have been both two-dimensional and "too noisy."

"The big leap came through when we realized we could use 'optical flow', or motion analysis technology, which came out of the machine-vision world and is used as an aid to the manufacturing process," says Hynek. The process created a file of motion vectors of every pixel in the frame. Then they used a particle system (by Pierre Jasmine) to attach paint strokes to these motion vectors and arrange the vectors in an algorithmically-determined sequence that simulated relative distance and depth perception.

"The same way you can learn about space by moving your head back and forth, like a cat does before it jumps," explains Hynek, "is the same way we use information to tell the particle system what was in front of what." The **Manex** team had to develop a lot of special tools to smooth the process.

Motion analysis + LIDAR + 3-D equalization = 3-D control

"This was just a theory in the beginning, just an 'I-bet-we-could' type of thing," says Hynek. So they set out to demonstrate the theory "because no one could truly understand the **visual** concepts we were presenting."

It was autumn and the leaves were brightest in North Carolina - a good spot for the test shoot. The premise was that the director could shoot with a regular camera, without motion control, and through tracking and motion analysis, the **Manex** team could attach paint strokes to everything. In addition to motion analysis, the 3-D bag of tricks also included LIDAR (Light Detection and Ranging, which scans a set to produce a three-dimensional database representation) and traditional camera tracking with 3-D equalization that surveys orange balls placed around the set with a laser transit and deduces camera motion.

These laser range-finding surveys provided data that enabled the **Manex** team to reconstruct the camera's motions and lens characteristics. From that, they were able to reconstruct a 3-D computer-generated wire form of the scene on a field of orange balls that were used as a reference for the scanners that recorded the live action.

That theory tested out to produce a startling, beautiful image of a 3-D painted world. Motion analysis extracted the important signal from the noise, "which is just what an artist does when he paints a painting by throwing away all the junk and incongruent stuff and leaving you with this beautifully arranged image," says Hynek. "We had to prove it, and so we did. And that's how we got the job!"

Matrix: VR

Right on Oscar's heels last April was the release of another attention-grabbing feature with the **Manex** touch: The Matrix, starring Keanu Reeves as a millennial Everyman with a disturbing ability to simultaneously grok multiple realities. (Some of which are disturbing themselves!) The challenge to **Manex** was to help the audience share that experience.

Visual Effects Supervisor John Gaeta headed the **Manex** team for the project, which was planned in storyboard detail much like the story's comic-book roots.

"It worked very smoothly," says Hynek, "because the pre-viz is really just a storyboard that's moving through time."

What resulted was yet another **Manex** innovation: a cinematographic technique, dubbed "Flo-Mo", which simulates a new experience called "bullet time."

Says Hynek, "You're not using just one camera, you're using 122 of them, but you are moving a camera in an impossible path through time." Unlike the "frozen time" effect seen in the Rolling Stones video and several TV commercials, which is shooting all the cameras at once, "bullet time" is sequencing the cameras through time so that your virtual camera keeps progressing forward.

"It's another good example of an idea whose time was absolutely right," says Hynek. When the directors presented **Manex** with the idea of bullet time, most other people had thought about moving cameras around on rocket sleds and similar approaches.

Manex's bullet time is, in practice, largely based on the work done at University of California (Berkeley) by **Manex** Virtual Cinematography Technical Designer George Borshukov.

Borshukov used image-based rendering to produce photo-realistic animation. He then utilized photogrammetry techniques to extract the shapes of objects from photographic images and projective texture mapping to render the final frames of the animation. For the foreground elements, all the camera moves were pre-visualized in SoftImage 3D using a set of **Manex** custom plug-ins to position the still cameras along the trajectory.

It is a huge job to correlate and stabilize the vast amount of camera data involved in bullet-time shots, but once those data points are recorded, they can be reused and recombined in endless ways.

What this means is that bullet-time backgrounds can be created for film without a complex on-set rig, and that the virtual camera can follow trajectories not feasible in the physical world.

"You can go to a location with one still camera and shoot about twelve stills in roughly the path that you think the cameras will do or the shot you're trying to do," says Hynek, and then construct the 3-D geometry of the set with photogrammetry. The potential for creating a huge library of virtual sets is enormous.

The next demonstration of the work of **Manex Visual Effects** is in the Warner Brothers movie Deep Blue Sea, scheduled for release this summer.

"What motivates me," says Hynek, "is creating new images that you just couldn't see or experience any other way. It's particularly more exciting when that new world is integral to the film...when it's totally involved and conceptually integrated into the film as in 'Dreams' and 'Matrix'. The director's relying on the **visual effects** team to create the world that's in his head and it's just all the more exciting when it's a world you've never been in before.