



▲▲ CASE STUDY: PIXAR'S PRESTO



REAL-TIME ANIMATION WITH PRESTO

Pixar's new proprietary animation system harnesses the power of NVIDIA GPUs, enabling animators to work faster and be more creative



PROFILE

DIRK VAN GELDER

Van Gelder joined Pixar in 1997 as a software engineer working on subdivision surfaces. He has worked on software for each of the studio's movies since, and played a key role in the development of Presto, Pixar's new in-house animation system. pixar.com



PROFILE

BILL WATRAL

Watral is FX TD at Pixar, having joined the company from VFX facility Charlex. He has won two Visual Effects Society Awards, for his work on Pixar's CG features WALL-E and Brave. He was supervising TD on LAVA, Pixar's new short. pixar.com

As its name suggests, Presto – Pixar's proprietary GPU-accelerated animation system – is a seemingly magical tool for animators. Powered by NVIDIA's Quadro GPUs running on HP Z-Series workstations, Presto leverages the power of the card to drive an OpenGL 4.0 system capable of displaying fully animatable characters with tens of millions of poseable hairs, Ptex texture maps and real-time shadows. This means animators can view their animation in real time, making changes on the fly and enabling them to work faster and more effectively.

Originally developed for Brave, then used on Monsters University and every Pixar project since, the system brings a playful environment to the company's animators, giving them pretty much instant feedback.

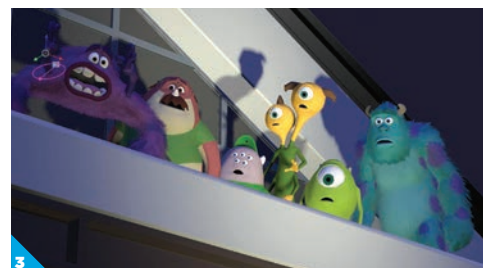
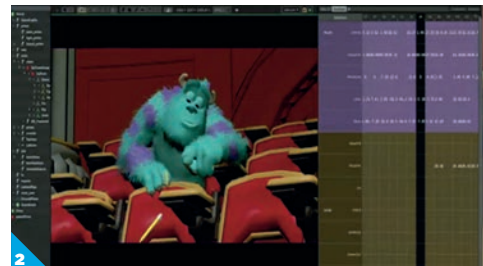
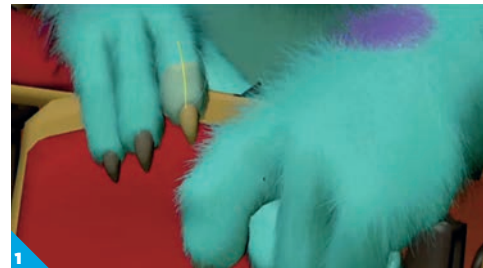
In 2014, at NVIDIA's GPU Technology Conference in San Jose, California, Pixar engineering lead Dirk Van Gelder entertained a crowd of more than 2,500 with a stunning demo of the tool's capabilities. Using everyone's favourite blue monster James P. Sullivan (Sully from Monsters, Inc. and Monsters University) as an example, Van Gelder revealed how Presto has empowered the movie's animators to see if an idea works without costly rendering iterations. From the subtle posing of a hand or even a single finger to dropping on new expressions, Presto gives animators a creative environment without traditional constraints.

For example, fur has always been a hairy subject for animators. Sullivan's fur, which is composed of 900,000 hairs, each with four CVs, can be controlled live within Presto. Animators now have a tremendous amount of control without any slowdown, where previously fur could never be seen and manipulated in this way.

Van Gelder used the example of Sullivan sitting in a lecture hall, emphasising the difference between a furry and fur-less monster. Without visible fur, animators had to make decisions on poses without seeing the whole picture, and shots may have had to be re-posed after rendering. With Presto, this guesswork is eliminated. "Every part of him is live and poseable in the system," said Van Gelder. "If we didn't have fast graphics, we wouldn't be able to make this happen."

ROCK SOLID

For LAVA – Pixar's new short, due to be screened alongside Inside Out in spring 2015 – the animators were running into problems when creating the expressions for its volcanic hero, Uku. "We had huge pieces of rock geometry that made up the mouth pieces of the characters sliding past each other," explains Bill Watral, the film's supervising technical director. "It was difficult for the animators to see what was happening and how much motion was going to be perceived by the viewer. We needed representation of rock textures on these characters in real time on the animation rig."



1. Presto gives animators unprecedented real-time feedback as they work, with hair, shadows and textures

2. The system harnesses the power of NVIDIA GPUs to give animators a free and playful environment in which to work

3. Presto can handle multiple characters, with real-time fur and shadows, providing a high quality preview of the final rendered image



Pixar's engineering lead, Dirk Van Gelder, captivated the audience at NVIDIA's annual GPU Technology Conference with a demo of Presto, the company's GPU-powered animation software

Uku's mouth consists of many rocks, each with their own texture, but when displayed as a smooth surface, the animators couldn't pick up the subtle movements. So Watral approached the GPU engineering team. "Typically you just slap a texture on there for characters," says Van Gelder, "but these characters were shaded procedurally so there wasn't a texture we could just grab, and [the mouth was] made up of many different rocks so there wasn't an individual mesh we could shade."

The team needed a way to drop on the textures without interrupting the shading and animation, and in a way that would stand up while the characters were being worked on. To solve the issue they went to Katana - The Foundry's lighting and look-dev system - and baked out textures from particular viewpoints. Custom GLSL shaders were then written to bake the CPU shader textures into the GPU textures, and place them on the character within Presto.

"If we didn't have fast graphics, we wouldn't be able to make this happen"

_Dirk Van Gelder | Pixar

LAVA's female character, Lele, provided her own problems, with mouth movements that could only be envisioned at render time.

"[Her] mouth is a hole carved into the surface of her face using a technique that we couldn't visualise in Presto," says Watral. "We had no way to visualise the expressions the animators were putting into her face."

"It was important that she had rocks for her lips and those rocks would slide around," he continues, "but you couldn't really see the angle that it was forming for her face; you couldn't get a read on her performance."

"We solved that using some code we'd written in the past to do reflections and mirrors. We do a multipass OpenGL thing, where we do one pass that draws a little cookie-cutter piece of geometry and then we use that as a feed to the second OpenGL pass, which uses that to establish



transparency, based on the animated mouth.”

Presto employs other GPU-accelerated effects, such as barrel lens distortion, which also came in useful during LAVA's production. “Our director was very clear that he didn't want to see the horizon warped on the edge of the frame,” says Watral, “yet he wanted to use fairly wide angles on some of the shots. Sometimes, as the camera moves down, the distortion on the horizon would change across the duration of the shot. So what we needed from the layout artist was a very specific visualisation of that lens distortion so he could go in and monkey with that value until he got the horizon flat again. Normally we don't do a full render cycle in layout, just first frame, last frame, so being able to see that in real time was huge.”

Although the GPU team often write their own code, Van Gelder comments that they also employ middleware like Silicon Studio's YEBIS, which is used to preview depth of field and other effects. “In Presto we have some things that are only for interactive use,” he explains, “where we take the camera parameters and feed them to YEBIS so that we get accurate depth of field representations. In the viewer we can show how deep the focal planes are, so you can see in real time how much depth of field you're going to get.”



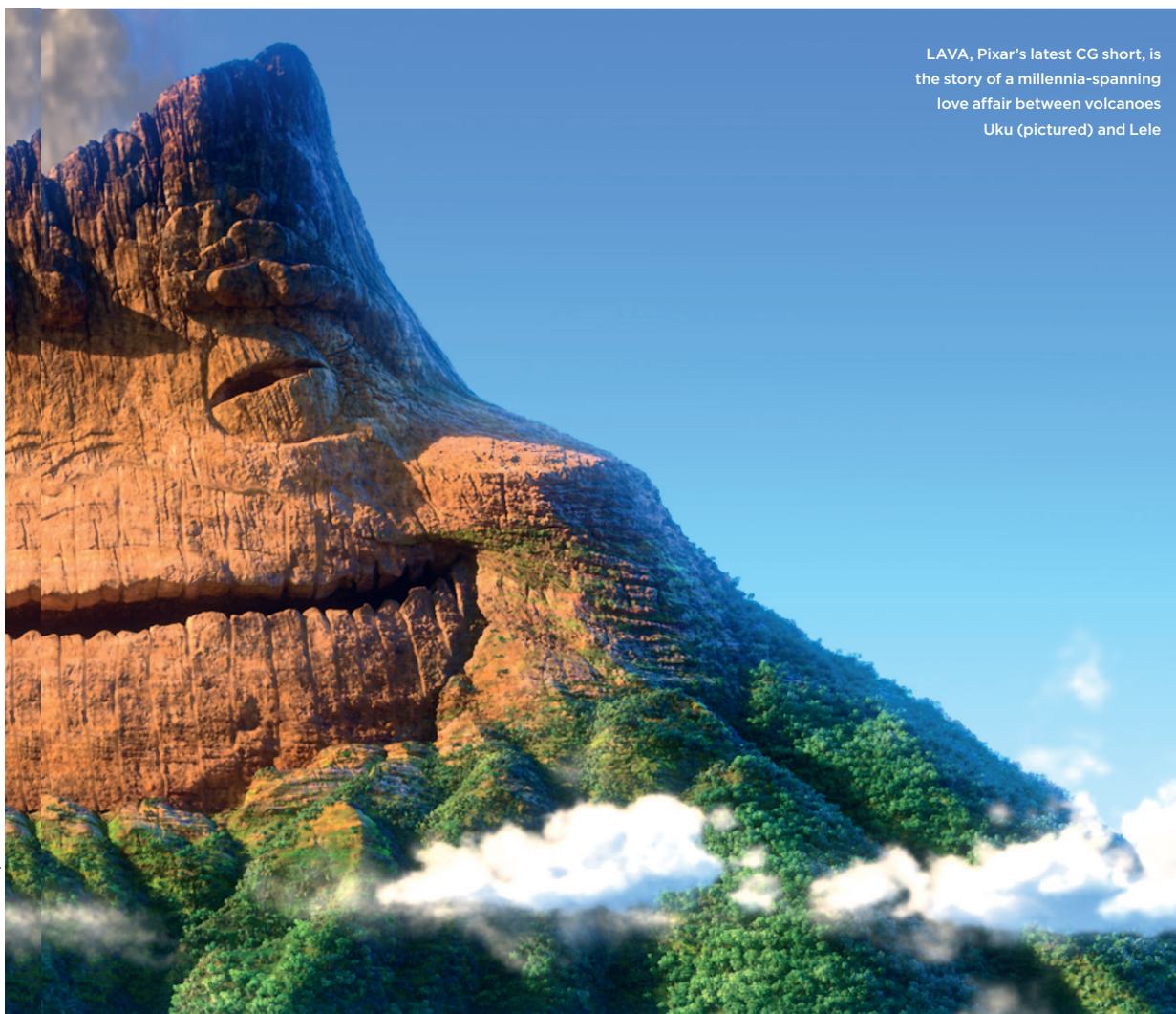
“The Presto viewer can show how deep the focal planes are, so you can see in real time how much depth of field you're going to get”

— Dirk Van Gelder | Pixar



A key development of Presto was the baking of procedural textures in to the OpenGL display, enabling the animators to visualise Uku's mouth movements. The real-time feedback in Presto (pictured right) closely matches that of the final rendered image (above).





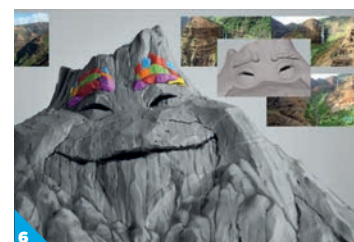
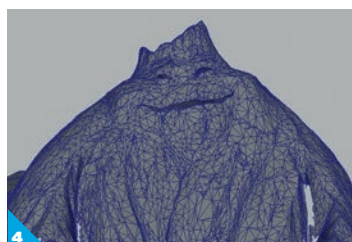
LAVA, Pixar's latest CG short, is the story of a millennia-spanning love affair between volcanoes Uku (pictured) and Lele

None of this functionality is just eye candy, asserts van Gelder; it all goes to help the animation process. For example, LAVA uses light and shadow to generate different moods, and by using Presto's real-time shadows, the layout artists were able to communicate any changes to the director early on in the process.

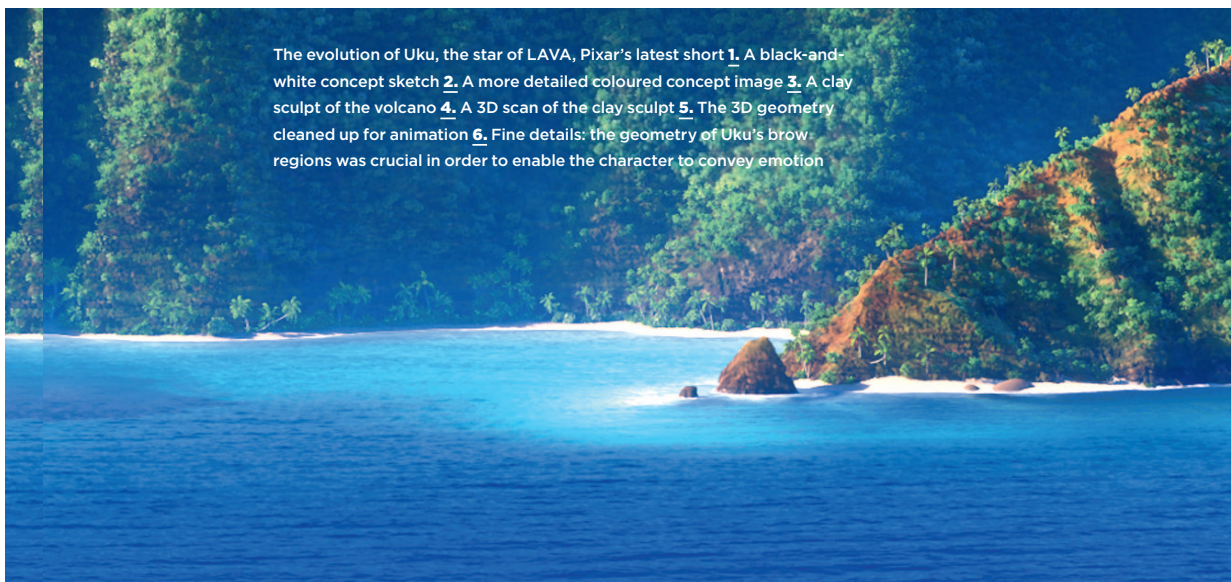
CUDA POWER

Presto is continually under active development, driven by the needs of Pixar's animators to view their work as near to final quality as possible. The system already utilises Pixar's OpenSubdiv system, which uses massively parallel CPU and GPU architectures to display subdivided meshes so the animators can view limit surfaces "within a pixel of final render". Previously, animators could only work with unsubdivided geometry as refresh speeds were too slow. "Now the trick is to be able to keep that same speed," says van Gelder, "but amp up the visual quality to give more accurate visual cues to the animators."

Using the power of OpenGL and CUDA acceleration with NVIDIA's GPUs, Pixar's Presto is able to deliver better texturing, better reflections, real-time fur and faster geometry drawing - but there's more yet to come. "As we stress our OpenGL pipeline more and more we realise some of our



The evolution of Uku, the star of LAVA, Pixar's latest short **1**. A black-and-white concept sketch **2**. A more detailed coloured concept image **3**. A clay sculpt of the volcano **4**. A 3D scan of the clay sculpt **5**. The 3D geometry cleaned up for animation **6**. Fine details: the geometry of Uku's brow regions was crucial in order to enable the character to convey emotion



infrastructure around imaging is a little old," admits van Gelder. "So we're in the process of rewriting it. We have a new OpenGL drawing engine called Hydra and that's part of the Universal Scene Description project. Our next step is to take Hydra and integrate that in Presto."

At some point toward the end of 2014, the next version of Presto will deliver faster OpenGL performance, with multiple shadow passes, high-performance, low-overhead drawing and the ability to handle "lots and lots of geometry." And all this with the help of NVIDIA GPUs.

FYI Watch Dirk Van Gelder's Presto presentation at GTC by directing your browser to: bit.ly/presto-gtc.