BUILDING BIG HERO 6

The technology and the talent behind it are what make Disney’s latest animated movie its most complex ever. BY SOPHIA STUART
Big Hero 6, slated for release November 7 in the United States, is Walt Disney Animation Studios’ 54th film and the first to really be grounded in, and celebrate, tech culture. Following Disney’s acquisition of Marvel, the characters are drawn from the original comic book series of the same title (though, because this is Disney, they’re now younger, sweeter, and, well, less anatomically mature). *PC Magazine* was invited to the *Big Hero 6* Tech Day at the Roy E. Disney Animation Building, in Burbank, California, to learn more about the film—and the technology that made it possible.

**INVENTING HYPERION**

The movie centers on robotics prodigy Hiro Hamada (voiced by Ryan Potter), who’s growing up in San Fransokyo, a near-future mash-up of San Fran and Japan. He hangs out with his tech-savvy friends and a chubby, compassionate health-care robot called Baymax until they stumble upon a plot to destroy the city that involves a terrifying swarm of 20 million microbots controlled by neuro cranial transmitters.

In a nod to the Maker movement, Hiro gets busy in the lab, using whatever raw materials are lying around, doing some nifty programming on LED touch screens, and whipping up body shields, rocket thrusters, armor panels, and maglev discs on his 3D printer. After a montage depicting rapid prototyping and testing with much prepubescent despair, Hiro, Baymax, and their friends are tricked out into a band of high-tech heroes.

Behind the screen, *Big Hero 6* is four times more complex than *Frozen* in the scale of its animation, so Disney needed to ramp up massively. This is the first feature to utilize Hyperion, new state-of-the-art rendering software created by Walt Disney Animation Studios’ technology team, in collaboration with production artists. Hyperion has been in development since 2011 but draws on multiple research projects on
multi-bounce complex global illumination carried out at Disney’s Zurich research lab. Animators can now create frames containing highly accurate simulations of ten billion simultaneous rays of light as Hyperion calculates the illumination, bounce, shadows, and redirection of every single beam—something that would have been computationally impossible before Hyperion. It is able to do this efficiently even within massively complex scenes by using a novel streaming data architecture.

“We own every component of it; nothing was outsourced,” said Andy Hendrickson, CTO of Walt Disney Animation Studios. Hendrickson started his career at Skywalker Sound (Lucasfilm) and came to Disney after stints as head of technology at PDI/Dreamworks (where he worked on *Shrek* and *Madagascar*) and senior technology officer for Industrial Light & Magic (*Pearl Harbor*).

Hendrickson said that Disney had to build a supercomputing cluster capable of running Hyperion for *Big Hero 6*; it’s so big, in fact, that it would rank about 75 on the list of the world’s top 500 supercomputers. This cluster comprises more than 2,300 Linux workstations, each of which contains two 2.4GHz Intel Xeon E5-2695 v2 processors (for a total of 24 processing cores—and 48 threads—per machine), 256GB onboard memory, two 300GB solid-state drives...
in a RAID Level 0 array—serious hardware needed for the CPU-intensive Hyperion. The whole rig is capable of running 400,000 jobs (visualization, simulation, or rendering) in a 24-hour period, the equivalent of 1.1 million render hours. The storage system that holds the assets and archives of all 54 Disney Animation films has a capacity of 5 petabytes (or 5,000 terabytes).

For a system that runs at this mammoth scale all day, every day, for months on end, Hendrickson’s first problem was the size of the data center required. “It turns out that when you’re building a machine of this size there are significant power and cooling requirements—we didn’t have a data center within Disney that was local that could do that,” Hendrickson explained. So they had to co-locate across four centers, three in Los Angeles and one in San Francisco. “It had to be fairly close because of the amount of data that’s going back and forth as you’re rendering—we need millisecond latency.”

RESEARCH AND RENDERING
What’s impressive about Big Hero 6 is that the tech it depicts is grounded in solid research. The combined story, animation, special effects, and technology teams took several fact-finding trips to Japan and to visit both the Carnegie Mellon and MIT robotics teams. At MIT they discovered the inspiration for the film’s microbots. The Soft Machines Lab at Carnegie Mellon established ground rules for Baymax’s soft robotics functions.

Codirectors Don Hall and Chris Williams were both Marvel fans and Disney Animation veterans. Williams joined Disney in Florida’s animation studio as an
intern in 1994 and last directed *Bolt* in 2008. Hall, who has been at Disney since 1995, last directed *Winnie the Pooh* in 2011. During their research trips it became clear that *Big Hero 6* was going to be a love letter to both Japanese and geek culture.

Hall said that at every robotics lab they visited, the technicians said, “We want a robot hero for once, instead of a villain!” They got one. This movie is stuffed with pop culture references and even though the directors denied it, Baymax (voiced by Scott Adsit) does sound like a slightly less frustrated C-3PO.

The obsessive focus on research extended to the sets themselves. The tech team bought the actual assessor data for San Francisco to create an accurate digital construction of a working city, right down to lot size and the heights of buildings. In *Big Hero 6* there are 83,000 buildings, 260,000 trees, 215,000 street lamps (of six different styles), and 100,000 vehicles. “On every other film this would have been a painting,” Driskill said.

In the movie there are sequences where the camera zooms and swoops from a massive wide shot then dives deep into the immersive cityscape. As it flies past buildings you’ll suddenly see someone leaning out a tiny apartment window above a miniature air conditioning unit. “This is a level of detail never seen before in previous animated movies and is only possible because of Hyperion,” Driskill said.

Hendrickson’s team also created the software Denizen to enable nontechnical people to craft crowd characters, because they needed a lot of them—one shot alone has 6,000 individual characters. “We released the tool to everyone in
Disney Animation and told them to make a version of themselves,” Hendrickson said. “People keep watching clips to see if their virtual selves made the final cut.”

Zach Parrish, head of animation, explained the complexity for his team of the task at hand. “We created 701 unique characters with 1,324 animation cycles—how they walk, talk, interact—which adds up to 632,124 final animation cycles retargeted for various character variants.” Using the 3D animation tool Maya, each animator works with 200 controls to create individual poses and completes about 3 to 4 seconds of footage a week. Ninety animators worked on *Big Hero 6*, many for more than two years.

What Hendrickson’s team does is solve highly complex technical problems on a daily basis so the creative team can make magic on screen. This means hiring for a very broad range of people.

*NO ONE IS ALONE*

Top: Baymax explores the streets of San Fransokyo. Bottom: Aunt Cass (Maya Rudolph), Hiro’s guardian, provides support (and a home-cooked meal) for the heroes when they need it most.
“When we hire, we look to schools that focus on high-performance computing and have programs that are joint engineering combined with arts programs—there aren’t many—but we have to collaborate with people who are both left-brain and right-brain on projects,” Hendrickson said. “It’s hard for most people to understand that it’s not all equations and math. What we’re trying to do isn’t taught anywhere so we have to figure it out each time. We have plenty of healthy discussion and constant experimentation. We have a history of creating complex tools that have super artist-friendly user interfaces so we don’t have to have technology expert people to use them. No other studio does that.”

With *Big Hero 6* wrapped up, Hendrickson’s tech team is moving on to its next problem: fur.

“We’re in the middle of the next [film], *Zootopia*, now,” Hendrickson said, laughing, “so Hyperion is now rendering lots of fur. Fur is always difficult, especially at scale, and it’s not just one furry creature—it’s *Zootopia*! This is a whole world of fur!”