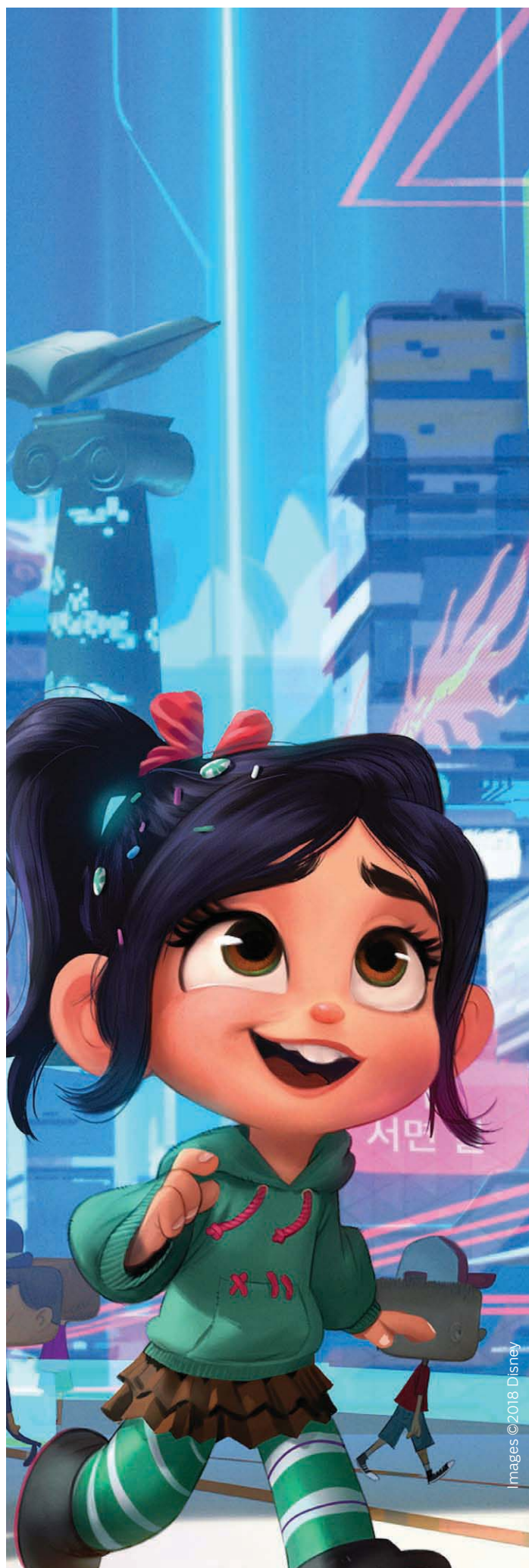


Internet Explorer

ARTISTS CREATE A VAST DIGITAL 'NET
UNIVERSE FOR *RALPH BREAKS THE INTERNET*

BY KAREN MOLTENBREY





It's hard to visualize the expansive digital world we call the Internet, a global system of interconnected computer networks that link people, places, and all things. But for the CG animated feature film *Ralph Breaks the Internet*, that is exactly what the artists at Walt Disney Animation Studios had to do. Then, they had to build it and bring this massive "invisible" world to life.

Ralph Breaks the Internet is a sequel to the 2012 film *Wreck-It Ralph*; in that film, the perpetual video-game antagonist Wreck-It Ralph sheds his villainous reputation by redeeming himself among his fellow game characters, who socialize outside their game roles when Litwak's arcade closes at night. During that quest, he befriends Princess Vanellope von Schweetz, a little girl with a big penchant for high-octane racing in *Sugar Rush*, a candy-themed kart racing game. *Ralph Breaks the Internet* picks up six years later in the arcade, as Vanellope finds herself on the verge of losing her game unless a difficult-to-find part for *Sugar Rush* can be located.

Where can a person find such an item? On the Internet, of course. So Ralph and Vanellope travel to this mysterious place via a newly installed Wi-Fi router in the arcade to locate the obsolete steering wheel and prevent *Sugar Rush* from becoming permanently unplugged.

Ralph Breaks the Internet is Disney's 57th animated feature, directed by Rich Moore and Phil Johnston, who shares writing credit with Pamela Ribon. Moore directed the original *Ralph* as well as the Oscar-winning *Zootopia* (2016), with Johnston also serving as a writer on those films.

"We wondered if there was more to the story [of *Wreck-It Ralph*]," says Moore, who, along with the rest of the team, transported the lumbering Ralph (John C. Reilly) and feisty Vanellope (Sarah Silverman) from the arcade to the Internet. Joining the pair are some characters from the previous film as well as many new ones, including Yesss (Taraji P. Henson), an entrepreneur and head of the media site BuzzTube, and Shank (Gal Gadot), a tough-as-nails avatar from the online racing game *Slaughter Race*.

Throughout the film, Ralph and Vanellope are put to the test. The same can be said of the entire production team on this film.

Building the Internet

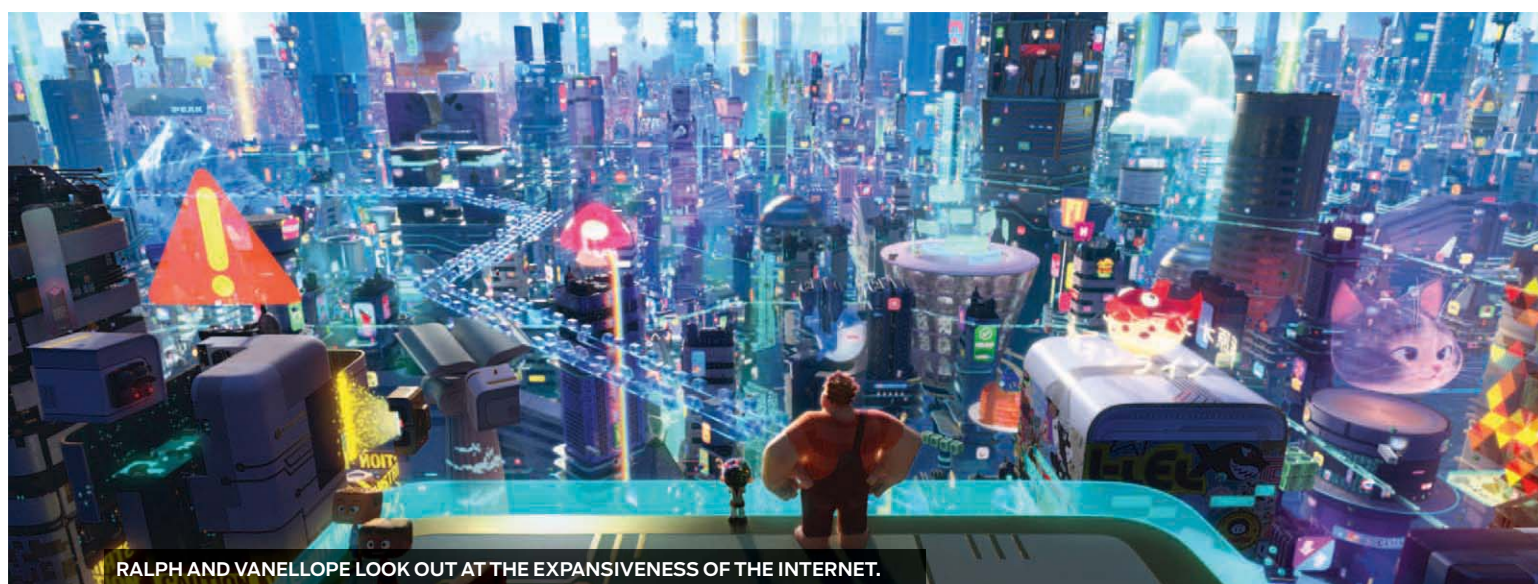
Where does one even begin when it comes to conceptualizing and bringing the Internet to life on the big screen? After all, it is a gigantic, complex world – one that creates awe when Ralph and Vanellope first see it. The artists wanted that same reaction from audiences.

Before anything, the team had to understand how the Internet and websites work, and then translate that concept from something akin to a board grid to a land with hubs. "We wanted a metropolis feel, but sort of abstract," says Ernie Petti, technical supervisor, who interfaced with all the departments on solving the technical challenges that would arise. The design team conceptualized the Internet as a cityscape – "the biggest city you've ever seen," says Petti. It is filled with wires and boxes and districts, and teeming with brands (some real, some not) from all over the world.

To keep their vision current during the four years of production while the actual Internet continually changed, the group focused on its main pillars – shopping, online gaming, and so forth.

New Steps in Worldbuilding

"We came away from *Zootopia* with the ability to build a world as big as that city – with distinct districts that were all fully realized and uniquely populated on a scale that was mind-blowing," Moore says. "The technology here has taken a huge step forward in the last few years, and we



RALPH AND VANELLOPE LOOK OUT AT THE EXPANSIVENESS OF THE INTERNET.

wanted to keep that going with *Ralph Breaks the Internet*. The Internet is not only big, it's dense with characters and places to go. This is probably the most complex animated film we've ever made in terms of locations, characters, heavy design, and assets."

Unlike the city in *Zootopia*, the Internet has a unique, layered pattern, wherein the streets are at different levels of verticality, as are the buildings, constructed with building blocks. Interconnecting these densely-packed buildings are streets and pathways, along with billboards, signage, videos, and more jam-packed throughout, all made from 3D geometry "to give the camera flexibility and for the light bounces and reflections. "We needed to populate the buildings with crowds and vehicles, which is easier when it's all in 3D," notes Petti.

The crew started out with a rough construction of a scene as a test. "The render never came back due to the sheer amount of geometry," Petti notes. So, a number of steps had to be taken. First, the crew needed an efficient way to construct the 3D buildings. Then, Disney Animation's in-house Hyperion renderer had to be reworked to make the rendering more efficient. In addition, the artists devised a new screen graphics pipeline for all the signage so they could be authored and organized efficiently.

The buildings differed in size and material (glass, steel, concrete), with an average height comparable to the Empire State Building (1,250 feet). "We wanted to include really big buildings that towered over the Netizens," says Larry Wu, head of environments. "Each building represents a website – the bigger the building, the bigger the site. And these buildings have floaty parts to them that give them a sense of

fluidity: The Internet is alive and changing."

To build the virtual city, the artists used Autodesk's Maya for modeling, along with in-house tools for texturing, including Paint 3D for painting and proprietary software for materials creation. Rendering was done using Hyperion. Each building was constructed of various subparts that were mixed and matched, and reused, yet each structure still had to look unique. While Hyperion has instanced buildings before, all the little pieces and parts here presented a problem.

"We were processing too much," Petti explains, noting that at peak, they were rendering equivalent to 1.9 million hours a day. "We had to rethink the entire instancing engine. So, instead of instancing a building, it would look at each piece inside and outside the building, and reuse that stored information."

Meanwhile, the newly developed screen graphics pipeline enabled the artists to track the plethora of screens and videos that are beside, below, and on top of the buildings. The art department created the signs, while the animation department created the videos, all of which had to be organized in an intuitive way so they could be populate across the cityscape. While placement of the hundreds of thousands of buildings and screens was done procedurally, that only provided a starting point for the artists; everything still had to be art directed quickly and easily from that point forward.

Popular Environments

There are approximately 150 master sets in the film, unique environments including the arcade from the original *Ralph*, which had to be revamped to work with the updated Hyperion. Then, those sets had to be fleshed out into individual locations within the Internet-scape. Different

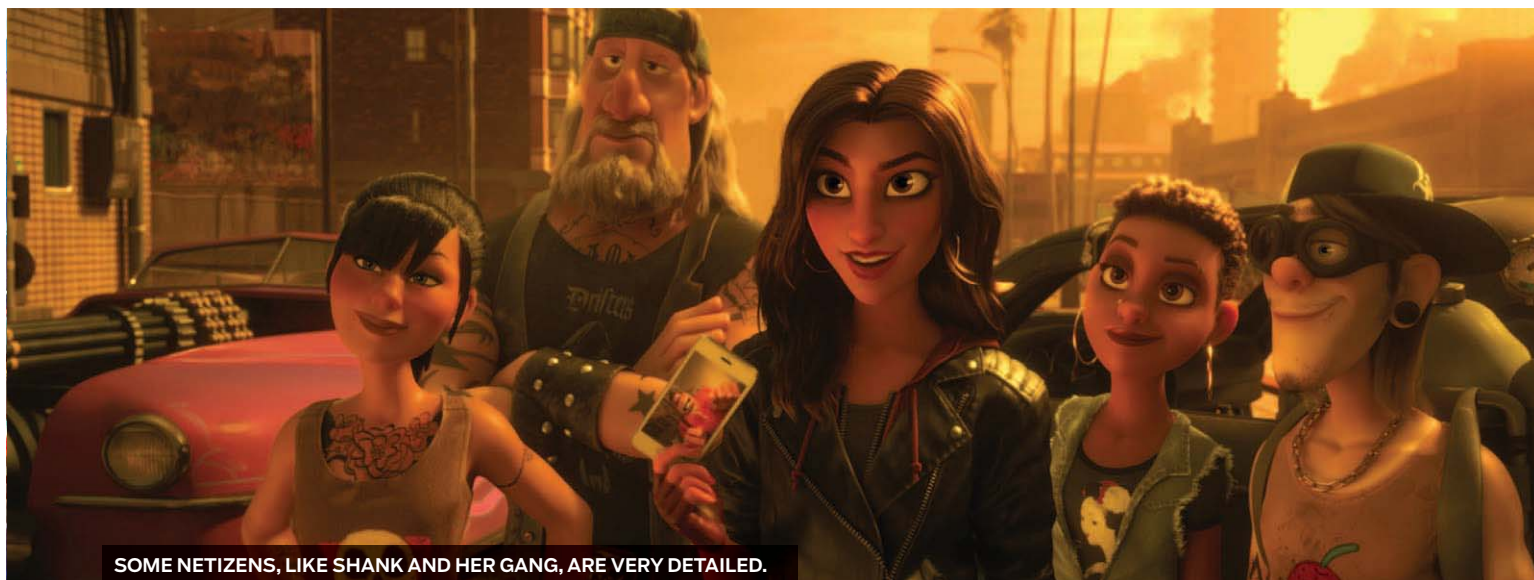
lighting styles help delineate among the many environments. "We also used film LUTs, which give the sense that you're using different film stock, bringing a more distinctive look to certain environments," says Petti. "For instance, the real world is a little more washed out, while the *Slaughter Race* environment has a really pushed look."

Slaughter Race contains a unique film perspective, with cameras attached to the vehicle to make it feel like an actual car chase was being filmed. The crew also extended the camera lens system to be more physically based, removing the CG edge from the camera for more accurate depth of field, to better ground certain scenes like this one in reality.

Another particularly interesting environment is eBay, where there are endless cubes with items being auctioned off, including some Easter eggs such as Aladdin's lamp. The items appear as holograms, to indicate these objects are not physically present in the space, and each has its own unique signage, auctioneer, and a bidding counter.

Ralph 2 contains a lot of holograms, for objects as well as signage and characters, resulting in a new hologram shader that allows rays to skip sets of geometry after light hits the outer surface and automatically finds the other side. An "edge glow" capability provided the necessary flexibility and user control for the effect.

For BuzzTube, animations were needed for all the screens. The crew even built the Deep Web, a dark, seedy sort of place at the depths of the Internet with characters whose faces are covered with hoodies and all sorts of viruses hanging around. But the one environment that is getting all the buzz is Oh My Disney, inspired by the actual website of the same name, where



all things Disney can be found, from Star Wars to Marvel, Pixar, and the Muppets – all of which had to be re-created to fit into this film. It is here where Vanellope meets the Disney princesses (see “Oh My Princesses,” page 29).

Cast of Characters

Once the Internet was built, it had to be populated. Like the original *Ralph*, this movie features a mishmash of environments and characters, only this time they span far beyond the video-game realm to include just about every genre. And, there would be many of them, far more than a Walt Disney Animation Studios film has ever had. So, every vertex would count.

The first test contained 150,000 characters. And, the number continued to increase from there.

To put the daunting task of character creation into perspective, consider these numbers: *Bolt* had 57 characters; *Wreck-It Ralph*, 233 (421 variants); *Zootopia*, 182 (687 variants); and *Ralph Breaks the Internet*, 434 characters with unique sculpts and 6,752 variants. Also, a new crowd system enabled some scenes with 500,000-plus unique characters, though the system was able to generate twice that number.

So, who are all these characters? Some are from the first *Ralph*, but mostly they are new ones, some with larger roles and some just faces in the crowd. “What I love about the *Ralph* series is that almost anything goes. We have characters that are all over the board appearance-wise,” notes Dave Komorowski, head of characters and technical animation. From a craft standpoint, there is every kind of keyframe animation style as

well, notes Kira Lehtomaki, head of animation. “But it all works together,” she adds.

Litwak's Pack

Although Ralph and Vanellope made their feature-film debut only six years ago, in animation, that can mean a lifetime. Time and technology marches on, requiring these characters to be reworked due to a number of advancements in the past few years, especially in terms of lighting and rendering. “A lot of our technology changed since the first *Ralph*, and our system couldn’t even open up the original Ralph because our simulation engine, rigging systems, and even our renderer have changed,” Komorowski says.

Ralph received some facial work, more hair, longer legs (for better performance), and wrinkles on his clothing. According to Komorowski, the group had difficulty with Ralph’s rigging on the first film due to his proportions – Ralph is an 8-bit game character whose legs are as long as they are wide, making it especially difficult to bend his legs and get an appealing pose.

Also, Ralph’s clothing is more detailed and moves better now. There are a lot of subtle wrinkles. Plus, there is a lot of cloth sliding thanks to the use of Marvelous Designer’s 3D tool for a more realistic, natural result. The same can be said about the detail and simulation of Vanellope’s clothing. “If you look on the inside of her hoodie, you can see the pilling that we’ve added,” Komorowski points out.

In contrast to Ralph, Vanellope is not from the 8-bit world and has a lot of S curves to her posing. Her motion is fluid and zippy. One of the bigger adjustments to Vanellope was her hair, specifically her ponytail. The technology six years ago didn’t provide a way for the animators to run a hair from her

scalp to her ponytail. Now, the groom reacts like an actual person’s hair would.

In fact, the artists devised a new way of designing hair across the board in this film, employing a solution developed for *Zootopia* and also used on *Moana*, whereby look dev and technical animation define hair grooms using a hierarchy of strands that allow for improved art direction while still maintaining a believable feel when simulation is added.

New Main Characters

There are many new characters that help Ralph and Vanellope navigate the Internet, including Yesss, the trend-predicting head algorithm at BuzzTube. Yesss’ poses and movements are big, snappy, and exaggerated. She changes hairstyles and clothing often, and her outfits are quite a spectacle – after all, she is a trendsetter. Her clothes are very defined and have very sharp angles “because she’s a very sharp and quick-witted character,” Lehtomaki says. The ultimate creator of cool, Yesss sometimes sports a large faux-fur jacket made out of fiber-optic cables whose tips light up, changing constantly based on her data intake. Code, meanwhile, moves through her hair.

Shank is another complex avatar, who fits hand-in-racing glove into the dark, gritty urban environment of her edgy online game, *Slaughter Race*. “There is a subtlety to her acting and performances,” says Komorowski. Through Shank and her posse, the artists pay homage to the various car racing games that use lower-level motion capture whereby their foot contact is not always perfect to the ground. “We do this purposefully in the film because we wanted to evoke the fun in some of those games,” Lehtomaki says.

Shank wears layered clothing: a hoodie



THE TRENDSETTER YESSS IS CONSTANTLY CHANGING HAIRSTYLES AND CLOTHING.

on top of a T-shirt, and a leather jacket over that. “We ran a simulation and then art directed her long, flowing brown hair,” says Komorowski of this fearless driver whose hair often blows in the wind.

On the gross side of the scale is Double Dan (Alfred Molina), a grouchy, slug-like shifty sort of guy so named because of a conjoined little twin brother, named Little Dan, tucked into the folds of his neck. Double Dan is the proprietor of the Dark Net’s apothecary, where he whips up various viruses. Far from a subtle character, Double Dan’s animation does, in fact, have a subtleness, which adds to his intimidation factor.

In *Zootopia*, the crew used a lot of muscle simulation to really sell the scale of the larger animals. Here, they applied that technology to Double Dan, giving him jiggle as he moves. “His little brother is right there on his neck, which presented us with even more of a challenge,” says Komorowski.

The basic sculpt for these and the other main characters were created in Pixologic’s ZBrush, and then the models were ported over to Maya, where they were rigged and simulated using mostly proprietary tools written inside of Maya. The animators employed a newer, faster rigging system on this film, called Parade, enabling the animators to scrub back and forth to a nearly real-time result. The models were textured using the studio’s Paint 3D and Adobe’s Photoshop. Hyperion, again, was used for the shaders.

Using the Hyperion renderer devised for *Big Hero 6*, the artists were able to make colors in this film more vibrant. “It’s a level of sophistication we just didn’t have on the first *Ralph*, and we really wanted to plus them in this world,” says Komorowski.

With Hyperion, the subsurface shading models were changed to a path-traced

subsurface shader, presenting some surprising results. On the first *Ralph*, the subsurface solution tended to wash out fine detail, so the artists would amp up those shapes to get them to read better once the subsurface was applied. “When we used the path-traced subsurfacing, suddenly all those details were standing out. Ralph looked a bit like a Neanderthal, and we had to tone back some of that detail,” says Komorowski.

Netizens & Net Users

Another fun and interesting character is KnowsMore, an outdated, clunky digital academic running the search bar. A search engine personified, he was inspired by the 1950s/’60s style of animation that is simplistic yet elegant. Like the other characters, he was created in Maya, but his cartoony eyes and the reflection in his glasses were crafted in Meander, in-house software first used in the short “Paperman.” In fact, the Internet is filled with these native avatars called Netizens, who call the Internet “home.”

Netizens are colorful bits of characters of various sizes and shapes branded to their website – sort of ghosts in the machine that perform actions on the Internet. Mostly they look cartoony, and their actions are more fluid than the Net Users’. “They’re meant to be digitally constructed. Their skin has a super-soft silicon feel. Their hair is a bit metallic, and if you look at their specular highlights, you’ll see little circuit board types of textures,” says Komorowski. Some Netizens, though, like Shank, Yesss, and Double Dan, have larger roles in the film, and are extremely detailed.

In addition, there are Net Users, mechanical representations of us inside the Internet. Non-natives, Net Users do not show a lot of emotion; they have iconic expressions that kind of snap or pop from one extreme to another. They have limited, somewhat

robotic body motion (with their heads leading the action, as if directed by a computer mouse). They have block-shaped heads and are rather uniform in size. But everything else about them – from their clothes to their hairstyles – are unique from all the other Net Users, thanks to a mix-and-match creation system that included facial sculpt and so forth for the most variety possible. The animators then used a crowd rig for these characters, which is not as robust as the rig used for the main characters, but rather a simplified version of the standard rig.

To account for some deviation in body type, a system called Refitters used the base simulation setup to retrofit the clothing to different shapes by using specific landmarks on the bodies, saving all the rigging and simulation procedures. The artists just clean it up.

...But Who’s Counting?

Disney Animation is known for pushing the state of the art in technology and creativity. And *Ralph Breaks the Internet* is no exception.

In this case, though, the challenge did not rest with a unique, singular advancement; rather, it was about expanding the scale and scope of previous advancements. In *Frozen*, all the characters were simulated. In *Big Hero 6*, the team wrote a new shader. In *Zootopia*, they dealt with massive scales of crowds and hair, and on *Moana*, they tackled wind in the hair and water. Without any of those steps, *Ralph Breaks the Internet* would not have been possible. Or, it would have been “less” in every way: fewer buildings, fewer characters, painted backdrops, static signs....

Petti sums up the work perfectly: “Everything here was just more.” ■

Karen Moltenbrey is the chief editor of CGW.

Oh My Princesses

In *Ralph Breaks the Internet*, Ralph and Vanellope decide to make a viral video to pay for an eBay bid gone awry. And the subject of this video? The Disney princesses in the Oh My Disney realm of the Internet.

The sequence uses a tongue-in-cheek approach to lovingly poking light fun at Disney and its beloved princesses. The idea was made on the fly during production and presented at a story meeting, not knowing how it would be received. Disney and the directors loved it.

The first order of business was to research the characters – 14 of the officially coronated Disney Animation princesses, including Merida “from the other studio.” This was done by accessing the Disney Animation Research Library, which houses all the original drawings from the films, to study expressions and movements. They also consulted many of the original animation supervisors.

The biggest challenge was converting the characters from their original 2D form to CGI; the textures of their original outfits as well as new, contemporary clothing also had to be made in CG. Even the more recent 3D characters needed re-stylized to fit into the *Ralph 2* visual universe. “Some are more cartoony, some are more realistic. And their eye sizes can be drastically different,” says Kira Lehtomaki, head of animation.

Hair often became challenging as well – how would they make Ariel’s hair, which was always voluminous and flowing

underwater? Or translate Aurora’s (*Sleeping Beauty*’s) stylized, art-deco curls and cinnamon bun-like bangs? “The artists [back then] were making choices based on what angle they were drawing them from, so while they could move lines in a drawing to accommodate that, in CG, we actually have real strands of hair growing from their head, so the hairdo has to make sense,” says Lehtomaki. Together, the animators and simulation team figured out how to move each strand of hair to achieve a particular curl.

Rebuilding the princesses in the *Ralph* style required modelers, riggers, the hair simulation team, texturers, and lighters all working together with animation in what was informally dubbed the Princess Palooza Lab. The process was collaborative and iterative, not linear – and not just for the hair, but for the movement as well. Lending insight were some of the original animators and the voice actress who were live-action models for their particular princess; they also voiced the princesses in this film. Each princesses’ performance had to be specific to that character in substance and movement.

“There are little homages to really iconic scenes from the original films that are peppered throughout the background in the sequences, so even if a princess is not the center of focus in a scene, there’s still intricate character movement happening in the background,” says Lehtomaki.

Is this sequence iconic enough to go viral? Quite possibly.



ANIMATORS RESTYLED THE PRINCESSES TO FIT INTO THE *RALPH* WORLD.