A stand-in actor was filmed during principal photography, with MPC implementing its CG Sean Young into the live action photography

DECONSTRUCTING DIGITAL HUMANS

Ian Failes discovers how far the art and tech has come for photoreal CG humans in film

Hollywood has been making phenomenal leaps and bounds in the creation of photoreal digital humans in recent times. Notable standouts include Digital Domain's *Benjamin Button* work, Weta Digital's resurrection of Paul Walker for *Furious 7* and Industrial Light & Magic's CG Grand Moff Tarkin in *Rogue One*.

Three films released in 2017 also greatly advanced the art, in different ways: *Blade Runner 2049* with its digital Rachael; *Logan* in creating CG digi-doubles of the main actors; and *Guardians of the Galaxy Vol 2* in de-ageing Kurt Russell. **3D Artist** caught up with the studios behind those digital humans – MPC, Image Engine and Lola VFX – to find out how they created the lifelike performances while managing to avoid the 'Uncanny Valley'.

RE-CREATING RACHAEL

Denis Villeneuve's *Blade Runner 2049*, a sequel to the 1982 sci-fi noir film, features a scene in which the retired Blade Runner Deckard (Harrison Ford) meets a clone of Rachael (Sean Young), the replicant he had previously fallen in

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> **Richard Clegg,**
> Visual effects supervisor, MPC

love with. This clone of Rachael was in fact a CG creation, from the shoulders up, by MPC, who matched the digital face to what Young looked like in the 1982 movie.

Young's performance in the original *Blade Runner* was an obvious source of reference, as were her roles in *Dune* (1984) and *Stripes* (1981). MPC then gathered a head scan of Young as she appears today in a Light Stage, a specialised lighting and capture rig built by University of Southern California Institute for Creative Technologies (USC ICT). The Light Stage is synonymous with so many virtual actors in filmmaking history.

"From that," says MPC visual effects supervisor Richard Clegg, "we built a skull so we could get key points on the face to understand the proportions a little better." This was married

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with 'best guesses' of camera focal lengths and lens information extrapolated from 1980s footage of Young.

A general head sculpt of digital Rachael started to take shape, but more detail was necessary. So stand-in actress Loren Peta, who performed the role of Rachael during principal photography with some tracking dots on her face, was also scanned in the Light Stage. Here, Peta and Young performed several FACS (Facial Action Coding System) poses, which would serve as the basis for blend shapes in animation.

In addition, Peta was captured with Dimensional Imaging's videogrammetry rig. "It's an array of around nine cameras with a very high frame rate," explains Clegg. "It's the same as photogrammetry, but you're just capturing multiple frames a second in video, and then you can get a mesh out of that. That gives us a 3D understanding of how the cheeks, and the lips,

and the skin, and all the flesh on the face moves around as the actor talks and performs."

MPC tested its approach on a couple of actual shots from the original film. One of the major challenges, in those tests and the final shots for *Blade Runner 2049*, was ensuring the Rachael's skin remained incredibly delicate. The studio used Pixar's RenderMan for rendering, and took advantage of a new model that utilised path traced subsurface scattering.

"It really helped with things like skin folds, and keeping detail on all the pores and all the minute details on the face," says Clegg. "I think if you don't get really nice photoreal eyes then that's when people start to say things like, 'You lose her soul,' or, 'You don't feel the emotion.'"

Animating digital Rachael was all about studying the reference and replicating particular moments that evoked the character. "We'd trawl back through the original movie, and find stuff where she has a little flicker under her eye, even," notes Clegg. "Or where she looks a certain way, or she expresses a certain emotion. Then we'd try and build facial shapes, and build into our facial rig enough diversity to be able to re-create, rebuild and reproduce what we were seeing from the original."

MORE THAN JUST CG STUNT DOUBLES

CG humans are perhaps most widely used as digi-doubles or for stunt or face-replacement
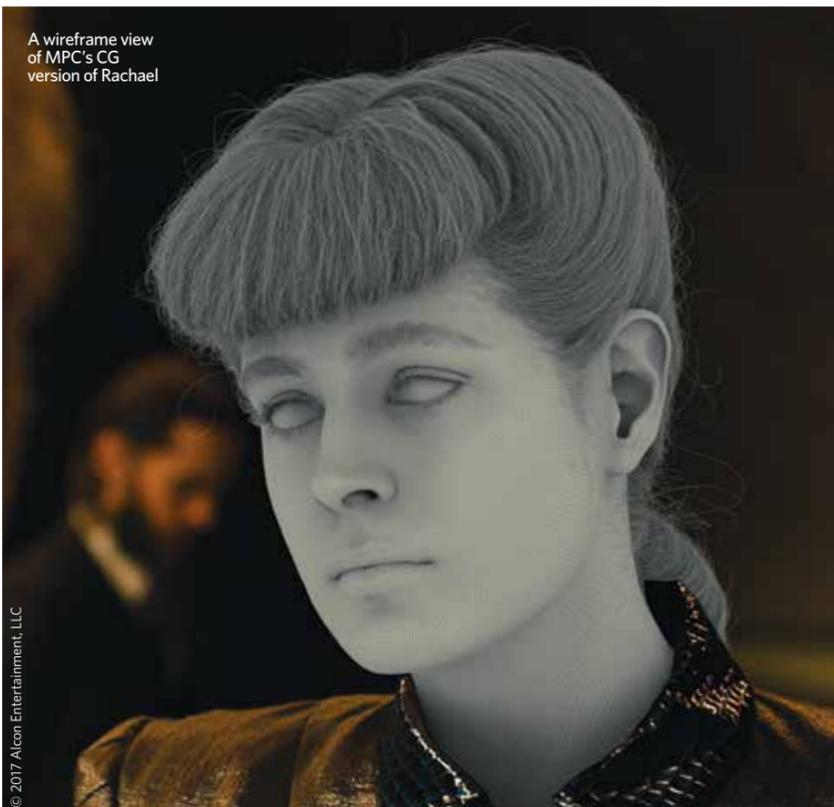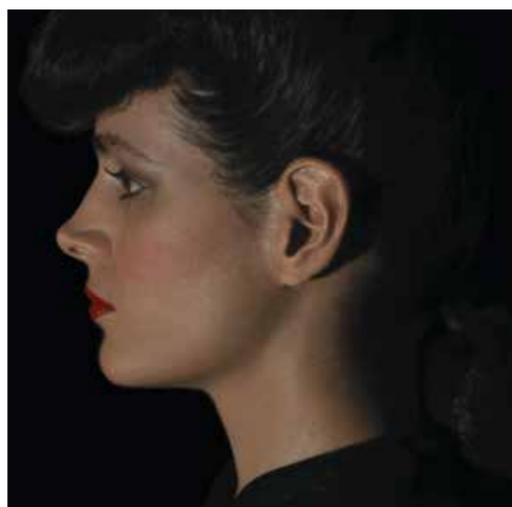
A wireframe view of MPC's CG version of Rachael

HOW TO REPLICATE A REPLICANT

In crafting a digital Rachael for *Blade Runner 2049*, MPC had several facial feature challenges to overcome

GROWING HAIR
Although the on-set stand-in actor did wear a matching hair style to Rachael, MPC replaced the hair and generated eyelashes, eyebrows and peach hair fuzz completely digitally with its proprietary hair and groom toolset called Furtility.

LIGHT RIG COPY
On set, a unique rotating disc of light was used by cinematographer Roger Deakins for the scene. MPC rebuilt that rig in its CG lighting setup. "We had a scan of the light rig," says senior lighter Ian Cooke-Grimes. "We used this light rig to position all the lights, which was also tricky shot-by-shot because the lighting was always moving."

EYE REALISM
Often referred to as the 'window into the soul,' the eyes of digital actors are perhaps the most important. MPC also paid close attention to digital Rachael's eyelashes, noticing that widening them ever so slightly could produce some distracting heavy-set shadows.

THE LITTLE DETAILS
Rachael's soft and subtle features, including her dimples, were challenging components of the face to replicate. A new subsurface scattering model implemented into Pixar's RenderMan helped the team achieve the necessary detail.

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>
> **Martyn Culpitt,**
> Visual effects supervisor, Image Engine

work. But these are typically fleeting shots and rarely for close-ups. In James Mangold's *Logan*, the continuation and, possibly, ending of the story of *X-Men's* Wolverine (Hugh Jackman), stunt doubles got a major boost.

Several scenes of the film made use of a completely digital double Hugh Jackman face for fast action moments, but there were also a number of fully-digital CG human shots for both Wolverine and his clone, X-24, that were seen in incredible close-ups. Image Engine handled the work, and the studio simultaneously delivered a CG human for the Laura/X-23 character played by Dafne Keen.

The process began with the live action shoot in which stunt actors (who would be replaced with CG human faces for Jackman and Keen) would wear orange markers for tracking and rotomating. "There were also multiple witness cameras for every take," says Image Engine visual effects supervisor Martyn Culpitt, "so we could also lock down the motion of the actors and really sit our CG humans into the action, whether it be a face or full body replacement."

Image Engine's approach to modelling started with a series of photos of one of its own crew members delivering FACS poses. "That gave us a base to start working on our facial shapes library and also to kickstart the whole process of ingesting scan data and adapting it to our generic topology," outlines lead character modeller Marco Menco.

Jackman and Keen then went through Light Stage scans, and Image Engine used the resulting data to build rigs for the characters of Logan, X-24 and Laura. "In order to rig the heads we have developed a new face system to accommodate a FACS-based approach," says senior rigger Andrea Arghinenti. "For each facial expression, split areas have been defined to give animators the level of control needed to compose the performance. Layered corrective shapes and on-face free form deformers have then been used to refine the overall deformations created by the muscle shapes. The face rig has been treated as a separate asset, loaded only when needed, and in order to improve the playback performance we have been supporting three different resolutions."

Image Engine's lookdev and lighting is done using its own proprietary Gaffer toolset, and the studio adopted Solid Angle's Arnold for rendering. "For shading," details R&D lead Andrew Kaufman, "we used a combination of shaders from Solid Angle, alShaders and in-house OSL shaders, all combined together in Gaffer. At the time, both the subsurface model and the caustics available with alSurface were definitely a game changer for us, both in terms of look/plausibility and performance. [Also], the hair shading performance offered by Arnold… impressed us."

The development of these hero CG faces for *Logan* was a big undertaking for Image Engine, but the team were confident of achieving high-quality results. "We all know what Hugh Jackman looks like and so there is really no wiggle room in getting it right," notes Culpitt. "I remember [overall visual effects supervisor] Chas Jarrett saying to me once that he didn't really believe in the Uncanny Valley and I agree with him; it either works or it doesn't. We definitely went through phases where it was not Hugh and we had to figure out what was not working, but we spent the time and the final heads are fantastic."

Keen's stunt double performed fighting scenes, with her face replaced with Image Engine's CG one

reference | cg render
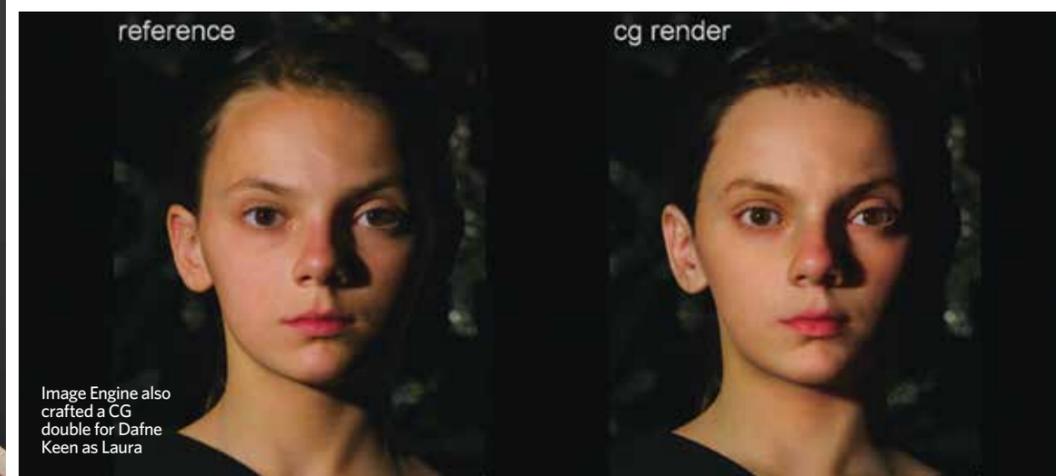
Image Engine also crafted a CG double for Dafne Keen as Laura

Image Engine's *Logan* lookdev had scars, skin blemishes and trademark beard

THE LOOKDEV BEHIND LOGAN

A step-by-step look at how Image Engine approached the task of creating the lookdev for a digital Hugh Jackman, using USC ICT's Light Stage system, not only for the Logan character, but also the X-24 clone

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The process began with scanning Jackman in USC ICT's Light Stage. "The OLAT (one light at a time) from ICT was great reference," notes Image Engine senior lookdev artist Adrien Flanquart. "The OLAT light rig triggers a flash of light from a different position across a 360-degree sphere around the actor. Each image represents a single light source and the combined result represents nearly all possible real world lighting of the actor."

"Those images," continues Flanquart, "give us perfect insight of how light scatters through hair and skin, how eyes react to light direction and how specular highlights roll over the face of the actor." This is just another reason why the Light Stage is often sought out by visual effects studios to aid in the creation of photoreal digital doubles; it's had a role in the making of some of the most well-known CG actors in VFX history.

"We also use the OLAT to build any kind of 3D light rig based on those photos," explains Flanquart. "For example, combining a frontlit photo and a backlit one results in a nice studio rig, or turning all of them from northern hemisphere of the rig 'on' but with low intensity results in an overcast equivalent." The combinations echo the different kinds of indoor and outdoor lighting that might be encountered on a normal film set.

Image Engine's digi-double of Jackman came into play in several different scenes, including one where a stunt performer had carried out a driving stunt. Here, the 'stuntie' performs the action wearing orange and black tracking dots. The digi-double would be animated to match the action, and then rendered and composited to match, as closely as possible, the lighting of the original photography.

Then the final shot, complete with motion blur, was intercut directly with other live action scenes of Jackman. Visual effects supervisor Martyn Culpitt points out that every single detail was of importance, including the CG hair. "It is really like a fingerprint, each person has their own hair patterns," he explains. "It's pretty amazing getting down to dialling little curly hairs that would push the believability."

Lola de-aged Kurt Russell by referencing his look from films such as *Used Cars* (1980)

YOUNG AGAIN

A different type of digital actor stars in James Gunn's *Guardians of the Galaxy Vol 2* in the form of a young Kurt Russell. In the film, the actor performs the role of Ego at his current age but also in flashbacks that show him as a suave lover around 35 years younger. The resulting digital actor was made courtesy of the 'youthification' expertise of Lola VFX, the studio responsible for Skinny Steve in *Captain America: The First Avenger*, a young Michael Douglas in *Ant-Man* and a de-aged Robert Downey Jr in *Captain America: Civil War*.

For young Ego, Lola started with reference from Russell's films, especially *Escape From New York* (1981) and *Used Cars* (1980). "*Used Cars* was just about perfect," recounts Lola visual effects supervisor Trent Claus, "because not only did Kurt have kind of a goofy, lighthearted 80s sort of look and demeanour in the film, he was the right age, he smiled a lot and was charming, which were some of the same facial expressions we were looking for."

On set, Russell performed the role in make-up and with a wig, as well as a few tracking dots painted on his face. An age-correct actor double, Aaron Schwartz, performed the scene for the purposes of lighting reference. Lola was actually involved with production in casting that double.

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>
> **Trent Claus,**
> Visual effects supervisor, Lola VFX

"We don't necessarily look for someone that looks exactly like Kurt Russell," says Claus. "What we're really looking for is someone who has the key features of that actor when they were young, like a strong jawline, the same shape of chin with the little divot in the centre, laugh lines that flex and compress in the same way or roughly the same way that Kurt's do."

Schwartz was also photographed in Lola's custom lighting rig where he re-created some of the lines and looks from Russell's performance. It gave the studio hi-res skin textures, with no motion blur, to use in the de-ageing process.

Scans and CG models do form a part of Lola's approach to this work, but it is actually largely done via 2D compositing. Lola starts with typical 'beauty' work on the skin, from wrinkle removal to the adjustment of skin tone. Then more complicated effects begin, such as adjusting bone structure and re-creating skin (since skin tends to sag in the upper eyelids and other places over time). This was done mostly in Autodesk Flame, but it also involved matte painting and CG elements.

Ego's hair proved to be one of the trickiest parts of this de-ageing project, as well as having young Ego and his lover kiss. "That was a first for us, a de-aged kiss," says Claus. "When going into it, we weren't really sure how we were going to accomplish that at all, because of the interaction between the two faces. It has to compress like real skin does, it has to react to her, and has to look like Kurt kissing someone as a youth. That was something new and exciting."

THE AGE OF DIGITAL ACTORS

In addition to film work, some equally technically impressive work has been seen in games and real-time projects. But right now it remains in the movies where the most photoreal actors are on show. And it looks set to continue, with more superhero films requiring digi-doubles, and a number of CG human-centred projects in the works like *Alita: Battle Angel* and *Gemini Man*.

One thing is certain: the age of the digital actor is definitely upon us.