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**The science behind
special effects**

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With today's technology, imagination is the only limit to what can be created on a movie screen. And nowhere in the world is the imagination more unlimited than at New Zealand's own WETA Workshop and WETA Digital. Weta Workshop makes models, props and miniatures, whereas Weta Digital creates virtual characters and computer generated special effects. Audiences around the world were awestruck when the Lord of the Rings trilogy hit the big screen. Trees walked, massive armies of men and elves battled evil Orcs, and through it all marched an unlikely fellowship of brave little hobbits, a tall wizard, brave men, an elf and a dwarf and of course the lurking Gollum (aka Smeagol). The special effects were quite simply amazing, and creating them is not only an art but an exact science.



Gothmog, Richard Taylor and Peter Jackson on set

Weta Digital is an Academy Award® winning visual effects facility based in Wellington, New Zealand. The company was formed in 1997 by a number of directors – including Academy Award winners Peter Jackson, Jamie Selkirk and Richard Taylor.

Weta Digital offers world class visual effects for international feature films and commercials. The company is best known for its visual effects work on *The Lord of the Rings* trilogy (New Line Cinema), and more recently for its work on *King Kong* (Universal) all of which were directed by Peter Jackson.

Most recently, Weta Digital has completed work on the Theatrical Film and Extended DVD Version of *King Kong* (Universal) and has completed visual effects work for *I, Robot* (20th Century Fox) and *X-Men – The Last Stand* (20th Century Fox).

Weta Digital is now in production for the films *The Waterhorse* (Walden Media), *Bridge to Terabithia* (Walden Media), *Eragon* (Fox 2000 Pictures), *Halo* (20th Century Fox) and *Avatar* (20th Century Fox).

Computer Science

The character of Gollum, for example, was a 3D computer animation, which was inserted into the film with real actors. To create Gollum, staff at WETA Workshop first sketched the character out on paper and then created a detailed plasticine 3D sculpture, also known as a maquette. The sculpture was then scanned by WETA Digital with a mobile hand-held 3D scanner developed in Christchurch, which feeds directly to a computer every bump and feature of the model. Interestingly, the scanner was first developed for measuring size and space of meat carcasses for New Zealand's meat industry. Special animation software then produces a 3D computer animation. The software, controlled by the animator, is used to refine colour, texture, lighting, shadows, reflections, shine etc.

Although the computer at this stage has captured a still likeness of Gollum, he needs to be brought to life. Here WETA Digital broke new ground with new modelling, skin and muscle codes. The computer animators managed to create realistic movements for the computer generated character by creating a skeleton (like a stick figure) and muscle structure inside the animation of Gollum. Anchor points are assigned to the stick figure which correspond to key points and joint positions on the animation. For each key frame of film the computer needs to have start and finish coordinates for these anchor points, for example, Gollum's wrist, ankle or top of his head. Key frames can be any specified number of frames apart and the software fills in coordinates for in-between frames using a process called tweening. Each scene containing Gollum was shot three times, once with actor Andy Serkis standing in for Gollum, then again without any Gollum at all, and then finally with Andy wearing a motion capture suit.

Andy's motion capture suit has sensors at key points over his body which match the same points on Gollum's computer generated skeleton and muscles. Around 20 cameras capture the movement information from a number of angles and feed it back to the computer which duplicates the motion, giving life to the computer animation. Some things can be generated automatically by the software, such as Gollum's toes splaying as he walks.



Rob Gillies and Joe Dunkley dress an Orc on set.

In some cases it wasn't possible to use Andy in a motion capture suit, such as when Gollum jumps on one of the hobbits and bites him. In this case, animators had to painstakingly create all the action coordinates on the computer.

Many people who saw the Lord of the Rings movies were astounded by Gollum's complex facial expressions. Gollum's face was altered when he was originally created to closely match the facial features of Andy. This allowed a facial animation system, developed by Bay Raitt, to be used whereby dozens of digital prosthetics were placed on Andy's face. These captured any slight movement of the actor's face and fed the information back to the animation computer. The information was used to drive the virtual facial muscles of the animation. The result was facial features rivalling the complexity of real humans.

Compositing

The computer animation of Gollum was placed into the film using a technique called compositing. Compositing is when two separate pieces of film, usually foreground and background shots, are superimposed one on the other. To do this areas of the foreground have to be transparent for details

from the other film to show through. This is usually achieved by the foreground object being shot against a “blue screen”. A colour called Chroma Blue is usually used as human skin does not contain this shade of blue so no detail from foreground characters’ faces will be lost. The blue area is digitally erased from the frame making the area transparent. The background detail can now show through this blank area.

To composite Gollum into the scene, the animators had to ensure the camera angles which showed Gollum were the same as the camera angles which filmed the real actors, they then had to make sure that lighting in the computer-created environment matched that of the lighting on the real environment. Then Gollum was composited into each scene. Film painters then have to go through the frames one by one and add in any objects (such as rocks) where Gollum is standing behind something.

Other computer generated characters were produced in a similar fashion to Gollum. For Treebeard, from an ancient race of tree-like beings called Ents, and other Ents models were made and scanned, here the modellers relied on nature for the blueprints to create natural looking trees. To bring Treebeard to life, a 4.5-metre tall animatronic (large mechanical puppet) was created to interact with Merry and Pippin on set. The same motion capture technology that was used on the actor Andy Serkis was used on the animatronic to provide a library of movements,

techniques, and attacks for the virtual tree to portray in battle. Creature supervisor at WETA, Eric Sainden says that Ents were a particular challenge because there is so much interaction with branches and leaves and roots that grow into the ground as they walk. “There is also a lot of interaction with the live action characters. So, we have a lot of moving barks and bark colliding with itself on the cheeks and the eyes. Essentially, the tree must come to life.”

New software

Thousands of different programmes are used in the development of the special effects. For the Lord of the Rings trilogy Maya was used for the modelling and animation, Pixars Renderman was used for the rendering and Apple’s Shake was used for compositing the film. Perhaps most significant was the Massive programme developed by Massive Software’s Stephen Regelous. The software was used to create the Prologue from *The Fellowship of the Ring* and other large scale battle scenes throughout the trilogy. Massive created battle scenes by populating a battle field with hundreds, or indeed thousands, of virtual characters or ‘agents’. For example, in the battle of Helms Deep, thousands of computer generated Orcs fought against the stronghold of men and elves. Beginning with standard Orc characteristics, each Orc



Building Barad-dûr model

(agent) is randomly assigned personality traits, i.e. boldness, aggressiveness, cowardliness. Then they are assigned parameters such as how dirty they become during the course of fighting, how tall or short they are, and how weary they become. Each individual agent is then programmed using a pre decision-making process so that no two act in the same way at the same time. The 3D creatures can react, fight and make logical decisions based on inputted data which includes terrain, and responses to other agents, whether from the same species or from enemy species etc. Massive even had the ability to automatically compensate for some assigned features, such as if an agent was

shorter than other agents in the same species, he was automatically made to walk faster to keep up with his comrades. Each species also had its own unique fighting style, agents in a species can access a repertoire of movements previously performed by real actors wearing motion-capture suits.

The final step following Massive's simulation is the rendering of the image, which is done by a piece of hardware invented in New Zealand, called a Grunt. John Alitt created the Grunt to render computer generated images faster than any commercially available software. Out of the Massive simulation engine comes motion data for each individual agent. At this stage it is just a description of joint angles that belong to the skeleton of the agent. Grunt takes the motion data and file describing what the agent should look like, including armour and clothing he has on, shading ranges etc and actually constructs the visual effect.



Witch-king Application

In *The Fellowship of the Ring* there were approximately 560 computer generated visual effects shots. With the introduction of Gollum and Treebeard in the second film, *The Two Towers*, this increased to approximately 800 visual effects shots. In the final film, *The Return of the King*, there were over 1,000.

To deal with the gigabytes of data, Weta Digital have 125 SGI Octane systems; 220 Linux systems; 35 NT systems; 15 Mac systems; a rendering system of 192 Dual Pentium 1 GHz and 448 Dual 2.2 GHz processors. In all a total of 1280 processors running at approximately 2,355 GHz fill the Weta Digital building.

Material science at Weta Workshop

Not all the special effects in the *Lord of the Rings* were created on the computer. Modellers at WETA Workshop had to create 48,000 separate items, including 1,000 suits of armour, 2,000 stunt weapons and 2,200 pairs of prosthetic Hobbit feet. Prosthetics are artificial limbs or other body parts. Other prosthetics used in the trilogy include Orc teeth, Lurtz's facial prosthetic, and the contact lenses used to give the Orcs their scary red/orange eyes.

So many hobbit feet were needed because each pair of feet only lasted two shooting days. The prosthetic feet took one hour to apply to actors Elijah Wood, Sean Astin, Dominic Monaghan and Billy Boyd.

WETA Workshop employed blacksmiths, leather-workers, sculptors and experts in medieval armour. A special foam latexing oven was running 24 hours a day, seven days a week to churn out Hobbit ears and feet, Uruk-Hai arms and legs, among other prosthetics.



Swordsmith Peter Lyon working on a hero steel blade.

Mass-produced moulds were used for making 200 latex foam silicone Orc masks. To make each Orc different and achieve a wide variety of characters, a number of prosthetics were applied to each mould. The finished mask was then implanted with yak hair, woven strand by strand for different hair styles. WETA also forged blue-tinged prosthetic feet, with long, curving claws, to stick out from the Orcs' knee-high boots. The look was completed with layers of Middle-earth mud.

It was a challenge for WETA Workshop to make chain mail that looks and moves



Lurtz Application

a mixture of paint, dye, water, and shellac (e.g. to represent mud on hems or wear on collars). Suede was roughed up using a kitchen grater and sandpaper was used on some other fabrics. Other processes that can be used include bleaching to accelerate the effect that sunlight and washing have on fabric, and acetone for making holes in rayon and acetate fabrics. Tea and coffee can stain old pages for an ancient parchment look. Mixed with water, they can give fabric 'perspiration' stains. To provide metallic rust effects sand is mixed with red oxide paint.

Locations

Many miniatures (small scale models) of characters and locations were created in painstaking detail. Richard Taylor, the Director of WETA, says that they had to create almost everything at least twice in different scales. "The mathematics alone was a staggering challenge. But it was the only way to stay true to what Tolkien created in his imagination: a world of many different sizes."

Before building a set on a real landscape, the film-makers created a miniature working model as a blue print. The film-makers used a miniature 'lipstick' camera, to conceptualize what would eventually be shot in live action on full-size sets. They then built the sets in real size. After filming, they had to take apart and remove all the structures so that the environment could return to its original condition.

In some cases it simply wasn't possible to create a life size set, such as the ethereal Lothlorien waters, because of limited space, the impossibility of the terrain, time, money, labour, materials, and the need for building approval from

like real chain mail, especially in close-up shots, and it had to be light enough for the actors to wear for long periods. It also had to be mass-producible. They solved the problem by using slices of narrow PVC piping. Every second ring was cut so that cut and uncut rings could be linked together to form large sheets. The cuts were sealed with a hot knife and then the sheets of plastic piping were metal-plated. A department of four full-time chain mail technicians assembled more than 12 million circular links to make up the suits featured in the trilogy.

Props and costumes

Typically three versions of a prop might be created for different filming situations. In the case of a sword, for example, a 'hero' version, using materials with the look and feel of the real thing and with authentic details, is made for close-up shots; a 'stunt' version, using materials that can be handled roughly without breaking, is made for action shots; and a 'background' version, using light materials that look like the real thing from a distance, is made for background shots.

For various props and costumes to look authentic it was important that they looked used or aged, rather than brand new. Some clothing and fabrics were sprayed with



Gothmog Application

authorities. In these instances detailed miniature sets were digitally combined with live action and real landscapes. In all, WETA Workshop constructed 68 miniatures that were sculpted and moulded with excruciating detail. Barad-dûr was built in 1/166 scale. For reference, miniatures as small as a 1/3000 scale Orthanc Chamber were also built. A ¼ scale miniature was built for foreground shots in which Helm's Deep was to appear in the distance, which took over four months to construct. Another 1/35 scale miniature was also built. Weta Workshop built a 1/72 scale miniature of Minas Tirith to represent the 212-metre, seven-tiered city, with over 1,000 architectural houses dotting the streets. Sections of the city were built at a



Minas Tirith

larger 1/14 scale, enabling the film producers to actually walk through the streets. "The colours, the little plantings and washing lines ultimately add the fine edge of reality that will allow the city of Minas Tirith to come to life and feel as though it's been populated for thousands of years," describes Richard Taylor. "One of the greatest benefits of building a miniature is that it will capture the textural surfaces that capture the reality of our own world. You can create these architectural structures, these organic places, these mountainsides, at a level of reality that is still sometimes difficult to create digitally. But ultimately, it is a combined effort because the digital department then takes those elements and seamlessly places them in the picture plane."

Miniature cameras shoot much slower than standard film cameras. The cameras used on *The Two Towers*, called Mitchells, were originally developed for aerial photography during World War Two. This, combined with new technology from German-based Arri, were mounted on cherry pickers to twist and turn through tiny model corridors. Actors are added (composited) last to the scene.



Miniatures DOP Chuck Schuman inspects the Corsair mini.

short compared to men, elves and Gandalf the wizard. In part this is achieved by using very short actors to stand in for hobbits in shots of taller races, and very tall actors to stand in for elves and men in shots of hobbits. Scaling is also achieved by having the actors stand at different distances from the camera and composing the shot so that they look as if they're beside each other. In some cases, the scene was shot twice with different-sized sets and props (e.g. the small character in the large set and the large character in the small set) and then combining the shots. Our brains do the work in creating this illusion as we expect objects to be a certain size. For example, a tall wizard in a small house appears taller, than if he were standing in a normal size house, or a short hobbit in a big bed appears

Other sets such as Hobbiton were very real, some of the actors commented that Hobbiton wasn't really a set at all, but a real village. To help achieve this look, the film makers employed a team of horticulturist to move in and plant out fields, flower beds and create grassy knolls at least a year before filming even started at the site, so that it looked and felt like an old village that had been there for generations.

Scaling

Throughout the Lord of the Rings trilogy, many scenes rely heavily on relativity. That is all motion is relative, as is the size of something. For example, the film producer, Peter Jackson, wanted the hobbits to look

smaller, because our brains don't believe the bed is bigger than a normal size bed. And sometimes scaling was simply achieved by getting actors that needed to be shorter to kneel down.

The special effects team at WETA Workshop and WETA Digital have won numerous awards, including four Oscars, for their work on The Lord of the Rings Trilogy. This international recognition has catapulted WETA onto the world stage of special effects. Recent films include *The Last Samurai*, *Master and Commander*, and *King Kong*.

About Weta Workshop

Weta Workshop is situated in Wellington, New Zealand and is a comprehensive film and television effects facility that houses a large and varied skill base of creative technicians. Best known for their work on 'The Lord of the Rings' trilogy, Weta Workshop is a five time Academy Award® winning company that offers services to all aspects of the creative industry including design, special make-up effects and prosthetics, creatures, armour, weapons, miniatures, prop building, large scale sculpture, display work and costuming.

Weta Workshop is closely associated with Weta Digital (four time Academy Award® winning company) and their complimentary relationship is reflected in their integrated approach towards solving specific film making issues and challenges. Weta Workshop is only a few minutes from Wellington's largest studio complex (and affiliate business Stone Street Studios) and other associated film production services, including Weta Digital and Park Road Post.

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