Over the last 100 years, the art and technology of special effects has been tirelessly improved until, as the cinema enters its second century, few creative barriers remain to be broken. With the extraordinary advancements that have been made in computer-generated imagery, it is now possible to produce artificially any image that the human mind can conceive. Most future developments in special effects production are likely only to be refinements of current technology – allowing imagery to be created more efficiently and cheaply.

Future technological developments are likely, therefore, to concentrate less on the type of images that we create, and more on the way we consume them. Now, as in the past, we pay to sit in rows and watch an oblong image displayed on a flat screen. But an array of alternative methods of consuming filmed images are now being developed.

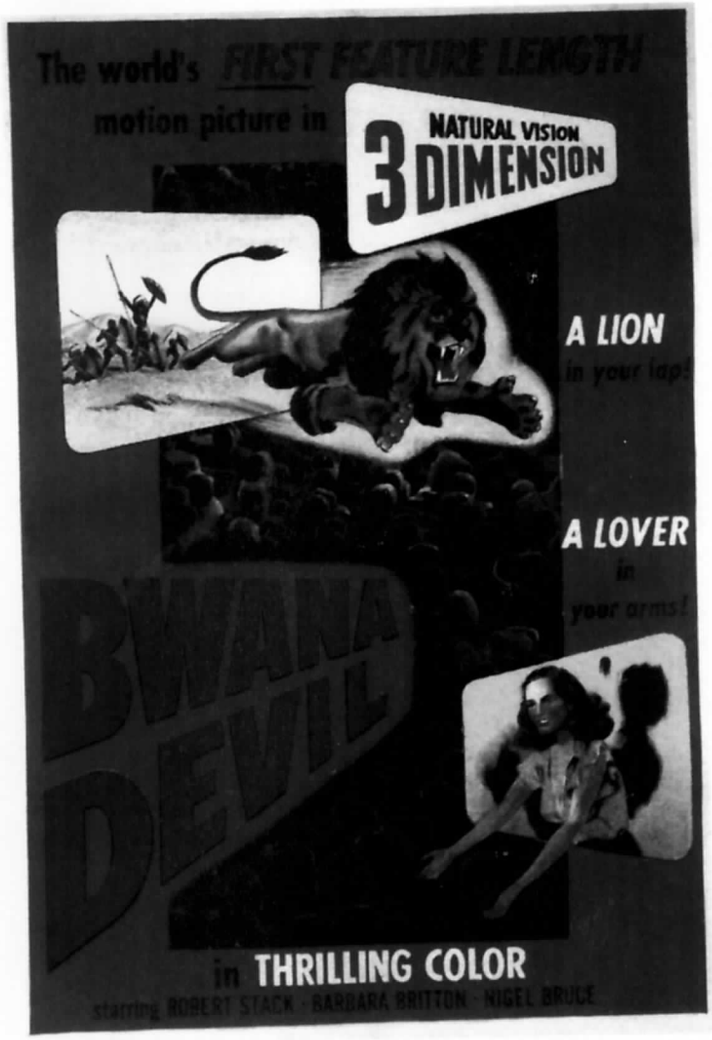
The cinema stands on the threshold of one of the most revolutionary eras since its invention. Some of the technology now being explored, with its emphasis on increased interaction between image and viewer, looks set to revolutionize the way we perceive visual entertainment for generations to come.

3-D

Since the invention of moving pictures, there have been many experiments in film presentation technology. Few ideas got any further than the drawing board since, during the first half of the century, cinema was the dominant entertainment medium of the world – and Hollywood saw no reason to tinker with a formula that worked. However, the idea of finding new ways to present films was taken more seriously in the 50s, when television began to steal huge audiences from the cinema. Desperate to halt the decline in movie-going, the Hollywood studios showed themselves willing to try anything that might distinguish cinema from television and tempt audiences away from their living rooms. Some ideas – such as widening the shape of a cinema screen – were both practical and popular, and remain in use to this day. Other ideas were more hare-brained, often seeing the light in only a few movies before fading into obscurity.

The most influential of all 50s presentation experiments was 3-D, a technique that makes the normally flat images of a cinema screen appear to reach out towards the audience. Though there had been a number of earlier experiments, 3-D cinema only became widely popular with the release of the independently produced *Bwana Devil* in 1952. In fact, the 3-D effects in *Bwana Devil* were actually quite poor – spears waved towards the camera hardly threatened to poke the audience's eyes out, and the occasional encounters with skinny ex-circus lions were barely as thrilling as the 'lion in your lap' promised by the film's zealous marketing campaign. Despite this, and some appalling reviews, *Bwana Devil* was a box office hit. Thinking it had found a way to revive its ailing fortunes, Hollywood plunged into the production of 'stereoscopic' films. The trade began to think and talk in terms of 'depthies' and 'flatties' in much the way that 'silents' and 'talkies' had been distinguished on the arrival of sound. But all too often, 3-D was used as a substitute for other production values and some truly terrible films were produced, including *Robot Monster* (1953), a popular candidate for worst movie ever made. There were some more worthy attempts to use the method creatively, however, as in Hitchcock's *Dial M for Murder* (1954) – perhaps the subtlest expression of the technique. But 18 months after the release of *Bwana Devil*, and with the public already bored of the process, the production of stereoscopic movies dried up. The studios transferred their hopes to other technical innovations such as the widescreen process CinemaScope (<55).

Perhaps the greatest limitation of the 50s 3-D films was the varying quality of their stereoscopic effects. Images rarely 'leapt' from the screen as promised by the publicity and viewers had to wear uncomfortable red and



PRECEDING PAGES: **Leaping off the screen and 'into' the theatre, *Terminator 2: 3-D – Battle Across Time* wows visitors to the Universal Studios theme park. Could this be how all movies will look in the future?**

FAR LEFT: **A 50s audience wearing anaglyphic glasses enjoys the thrills of a 3-D movie.**

LEFT: ***Bwana Devil* (1952) was the first big 3-D hit, though its promises of 'A lion in your lap!' and a 'A lover in your arms!' were perhaps a little optimistic.**

ABOVE: **After the surprise success of *Bwana Devil* (1952), Hollywood plunged into the production of 3-D movies. *House of Wax* (1953) was the first 3-D production by a major studio.**

ABOVE RIGHT: **Gillman from *Creature from the Black Lagoon* (1954) was one of the most popular 50s monsters to lunge at the audience in stereoscopic glory.**

green spectacles that resulted in a murky-looking image and, in many cases, gave them a headache. Today, however, new technology allows 3-D films to be produced far more effectively than ever before. Anyone viewing a modern stereoscopic production will see images that appear to extend (and recede) from the screen so realistically that many people cannot resist the urge to reach out and 'touch' them. However, despite their sophistication, the new 3-D techniques still work on the same basic principles that were utilized in the 50s and before.

At the heart of all 3-D processes is the principle of binocular vision. The Greek mathematician Euclid (circa 325–265 BC), who was the first to note the phenomenon over 2,000 years ago, demonstrated that because our eyes are about $2^1/_2$ inches apart, each one sees a slightly different perspective of the same scene. By merging these two differing perspectives, our brains create the perception of depth. The phenomenon is easily demonstrated by holding one finger up at arm's length. Looking at it alternately with one eye and then the other, the finger will appear to shift in position because it is being viewed from two slightly different angles. Only by looking at the finger with both eyes at once will a real sense of three-dimensional depth be achieved. In order to replicate the way that our eyes work, all 3-D film techniques require a scene to be photographed in stereo – using two cameras to film the scene from slightly different angles. Each of these perspectives must then be presented to just one of our two eyes in order to simulate the impression of binocular vision and three-dimensional depth.

Historically, there have been three basic ways of ensuring that each of our eyes receives just one of the two perspectives necessary to create the 3-D experience. One, the anaglyphic process, uses coloured lenses either to transmit or block images of a certain colour. The polarized process, on the other hand, uses the principles of polarized light to separate each image, while the frame sequential process mechanically blocks the view from each eye intermittently. Today's 3-D systems apply new technology to maximize the potential of these processes.

The anaglyphic process was first used for the projection of 3-D images in 1856 when J.C. d'Almeida gave a demonstration at the Académie des Sciences in Paris. Using a magic lantern, he alternately projected two images that had been photographed by two cameras whose lenses were the same distance apart as two eyes. The two images, one coloured red and one coloured green, were viewed by an audience wearing glasses which themselves held one red and one green lens. Each lens effectively obscured the image that was shown in its own colour and highlighted the image shown in the opposite colour. The result was that each eye received only the correct image, producing the illusion of a three-dimensional picture (fig. 1, 356>). The anaglyphic system, with its familiar red and green glasses, is the most widely known way of creating and viewing 3-D films, and it was the method widely used during the 50s. The images themselves can be projected from a single film that either has both the left and right, red and green images superimposed on each frame, or has the red and green images printed on alternate frames. Alternatively, two separate films can be shown simultaneously using two projectors.

FIGURE 1 **THE ANAGLYPHIC PROCESS**

The anaglyphic process works by using a red lens to block green (or blue, or cyan) light from one eye and a green lens to block red light from the other eye.

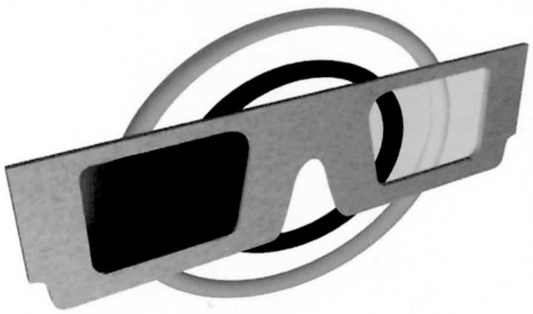
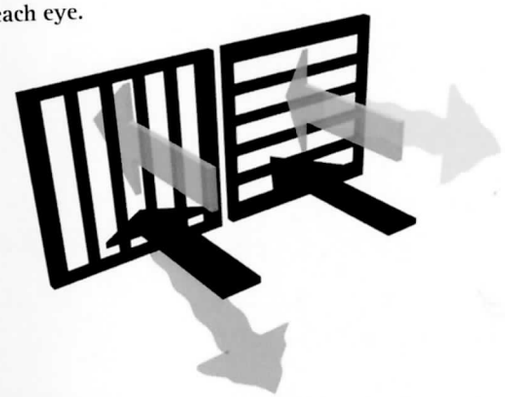


FIGURE 2 **THE POLARIZED LIGHT PROCESS**

Polarizing filters placed over each of the projectors showing a 3-D film make the light travel either horizontally or vertically. Polarizing glasses ensure that only one image reaches each eye.



The anaglyphic system can achieve good 3-D images but it certainly has its drawbacks. Audiences tend to tire of peering through the coloured spectacles for the duration of a whole film. The reliance on coloured pictures and spectacles also means that the anaglyphic system cannot be successfully used in full colour.

The polarized light process was discovered in the 1890s and applied experimentally to moving pictures as early as 1896. In the late 30s the innovations of Dr Edwin H. Land (1909–91), inventor of the Polaroid camera, made the use of polarized light a truly practical method of producing 3-D images.

Polarizing filters work rather like a grid that is made up of microscopic angled slots and bars. Only light that travels at exactly the right angle will pass between the bars, while that travelling at any other angle will hit them and bounce off. The polarization of light cannot be recorded on film during photography, so polarizing filters are placed over lenses during projection. Using two separate projectors, one image of a scene is projected through a polarizing filter with horizontally angled slots, and the other image through a filter with vertically angled slots. A viewer wearing glasses with one vertically slotted lens and one horizontally slotted lens will therefore see a separate image with each eye (fig. 2). Polarizing filters in themselves are neutrally coloured, and since colour is not used as a way to separate left and right images, the polarizing method can be successfully used to show 3-D films in natural-looking hues.

The Teleview process that was installed in New York's Selwyn Theatre in 1922 was the first to use the frame sequential method of creating 3-D images by using a mechanical means of presenting separate images to each eye. Each viewer looked through a device that contained left and right shutters, which were mechanically opened and closed in synchronization with left and right images that were alternately thrown from a single projector. Looking through a cumbersome contraption attached to the seat in front of them, viewers would be shown one image through the right eyepiece and then one through the left, in rapid succession, to create the impression of depth.

Stephen Hines, one of a number of people who specialize in the increasingly popular field of modern stereography, says that while the basic methods of viewing 3-D films haven't changed, modern equipment does allow far more control over the actual production of spectacular three-dimensional images. 'Today there are several ways of capturing images for a 3-D film,' explains Hines. 'Some systems use a single camera with a special double lens that records two slightly different views next to each other on the same piece of film. But the best way is to use two separate cameras on a platform that allows the cameras to be moved independently to produce different effects. Once you have those images on two separate reels of film, you can print them and filter them in any way you want depending on how they are going to be shown.'

Hines has invented a camera system that gives film-makers total control over the way their 3-D images will look. 'There are several factors that affect the characteristics of a 3-D image,' he explains. 'Our eyes are about two and a half inches apart. Reproducing this gap, known as interocular distance, will produce images that match our normal perception of images. However, if the distance between the two camera lenses is increased or decreased, it has startling visual implications.' By moving the two lenses farther apart, the final 3-D image looks very small. This phenomenon, called perceptual miniaturization, can often be seen in the popular View-Master 3-D binocular toys. 'View-Master-type pictures are often photographed by using two standard 35 mm still cameras that have been bolted side by side,' says Hines. 'Frequently, the result is that the lenses used to take the pictures are twice as far apart as the eyes that we use to view them. As a result, everything looks like it is somehow miniaturized. The reverse happens if the lenses are too close.'

The other major factor that affects 3-D images is the convergence distance of the two lenses. 'Imagine a line that comes from the centre of each of the two lenses being used for 3-D filming. If the lenses are angled very slightly inwards, these lines will eventually intersect. This is known as the convergence point,' explains Hines. 'When a 3-D film is projected, any object that was beyond the convergence point during filming will appear to be behind the plane of the theatre screen, objects that are at the convergence point will appear to be on the screen, and objects that are in front of the point will appear to be sticking out towards the audience.'

The rig that Hines has built, called the 'StereoCam', is a platform that can hold two standard 35 mm or 65 mm motion picture cameras or high-definition video cameras. One camera is mounted vertically aiming downwards, while the other is horizontal. Both cameras point at a 45° beam-splitting mirror, which makes it possible for each to film exactly the same scene (fig. 3). However, during operation, the horizontal camera can be moved so that it records a slightly different image to the vertical camera. Moving the horizontal camera can affect both the interocular distance between the two lenses, and their point of convergence, in order to make objects in different parts of a scene appear to leap off the screen. Small video cameras attached to the rig transmit images to a special viewing device which enables the director and camera operator to see a 3-D video image of the scene being filmed.

Once the two separate films have been developed, they can be treated according to the method by which they are to be presented. 'Some films are still shown using the red-blue/green anaglyphic process,' explains Hines. 'I've managed to find an optimum balance of coloured filters so that the effect of muddy colours and fringing is minimal. But there is always some fringing when using the anaglyph technique – objects that are in front of the convergence point will have red fringing to their right and objects beyond it will have their fringe to the left. Polarization remains the most practical and satisfactory method of separating the images,' says Hines. 'Polarizing filters are put on each of the two projectors and audiences wear polarized glasses, which present each eye with the correct picture and which have no adverse effect on the quality of the images being projected.' Another system, similar in principle to the Teleview system of the 20s, uses liquid crystal glasses that react to a beam of infrared light from the projector that causes them to flicker at around 50 hertz (times per second) and give each eye alternate views of the synchronized pictures on the screen. This system is used by IMAX (358>), which projects its large-format 3-D films at twice the regular speed so that each eye can see a different image in turn.

Using up-to-date filming and projection techniques, modern 3-D is hugely superior to the gimmicky process that once produced murky images of varying quality. Creating the convincing illusion that objects and environments on the screen do actually exist in three dimensions, modern 3-D is now a powerful entertainment medium with considerable potential.

In the 50s a downturn in audience numbers led the Hollywood studios to seek presentation technologies, including 3-D, that might encourage people back into theatres. 2005 saw a 6 per cent fall in US box office returns and was the third year in a row to see a decline in cinema-going. It is perhaps no coincidence, therefore, that the studios have shown a marked resurgence of interest in 3-D as a method of presenting mainstream movies.

In 2005 Disney released its animated CG movie *Chicken Little* in 3-D. Because, like all CG movies, *Chicken Little* was created and animated using 3-D models and environments, the final version could be released as a normal 2-D movie and re-rendered from the point of view of two virtual cameras (<233) for release in stereographic 3-D. The 3-D version was rendered by ILM and presented in theatres equipped with digital projectors (359>) using glasses, screens and software technology developed by a company called Real D.

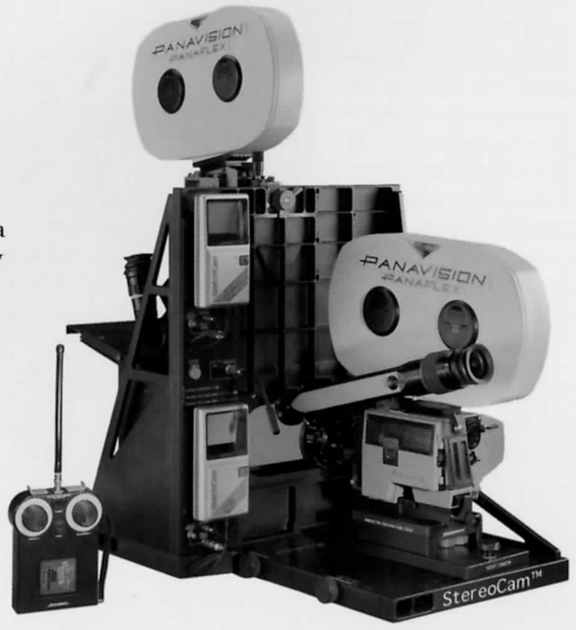
3-D works well in theatres equipped with digital projectors because they are capable of displaying far more than the 24 frames per second shown by normal projectors. The system developed by Real D and used for *Chicken Little* displays 144 fps. These frames are divided between left and right views so that when polarized glasses are worn each eye receives 72 fps. A special silvered screen also helps to ensure high-quality viewing.

Chicken Little was a notable success in 3-D, earning considerably more per 3-D screen than it did in 2-D venues. Importantly, audiences and critics commented that watching the film felt quite natural, and was unlike the 'gimmicky' experience normally associated with traditional 3-D

ABOVE: **Disney's *Chicken Little* (2005) was the first computer-animated movie to be widely distributed in a 3-D format. Computer-animated films are ideal for release in 3-D because a second, stereographic version of the film is easily rendered using an additional virtual camera.**

FIGURE 3 **THE HINESLAB STEREOCAM**

A beam-splitting mirror allows a vertically mounted camera and a horizontally mounted camera to film from almost identical perspectives. The horizontal camera can be moved to change the quality of the 3-D image achieved.



presentations. Such reaction augurs well for those who hope stereographic film can break away from its widely held perception as a gimmick to become a viable alternative method of consuming films.

When *Chicken Little* was released in November 2005, just 84 screens in the US were equipped to show the film in 3-D. It was planned that 500 screens would be available for the release of Disney's second stereographic CG film *Meet the Robinsons* (2006). Disney has announced that all of its future CG animated films will be released in a 3-D version, and other studios look set to follow.

Other film-makers are showing interest in 3-D as a method of making mainstream films. James Cameron has announced that he will make all of his future movies in 3-D, saying that he believes 3-D could change movies in the way that sound and colour did when first introduced. He has already directed the stereographic special-venue film *Terminator 2 3-D* (1996) as well as producing the documentaries *Ghosts of the Abyss* (2003) and *Aliens of the Deep* (2005) in IMAX 3-D. He has developed a new system of filming in high-definition 3-D which will be used to shoot his feature film *Avatar* (2008).

There is now even a way to create films for presentation in 3-D without having to film stereographically during initial production. A Californian company called In-Three has developed a complex and closely guarded system that can take normal 2-D images and convert them into 3-D. In this process the left-eye image remains the same while the right-eye image is altered to create the impression of 3-D. The technique is intensive and requires trained operators to selectively apply a series of differing digital processes to each shot in order to add depth information that is not present in the original frame, a process they call 'Dimensionalization'. In-Three has persuaded a number of Hollywood studios to convert classic films for re-release in 3-D. The system has been endorsed by directors including Peter Jackson (<44), Robert Rodriguez, Robert Zemeckis (<43) and George Lucas (<39), who is planning to convert all of his *Star Wars* films into 3-D for future re-release.

It remains to be seen whether such high-profile enthusiasm for 3-D will this time be reflected at the box office.

SPECIAL-VENUE FILMS

In addition to 3-D, there are a number of other systems that use unusual techniques to achieve a spectacular result. So-called 'special-venue films', in which the film itself is the star, are found in theme parks, major museums and science parks, or as stand-alone sites in city centres. Special-venue films normally use an unusual film format to produce a particularly high-quality image, while in theme parks the images are often accompanied by motion, smoke, lighting effects and even performers who interact with the on-screen action.

A system called 'Showscan' invented by the effects pioneer Douglas Trumbull uses 65 mm film that runs vertically through the camera and projector at 60 fps to produce images that are brighter and sharper than with any other system. Looking at a Showscan film really does feel like looking through a window into the real world. Showscan is normally combined with motion platforms that are programmed to move in response to the images seen on screen in order to immerse the audience in the action.

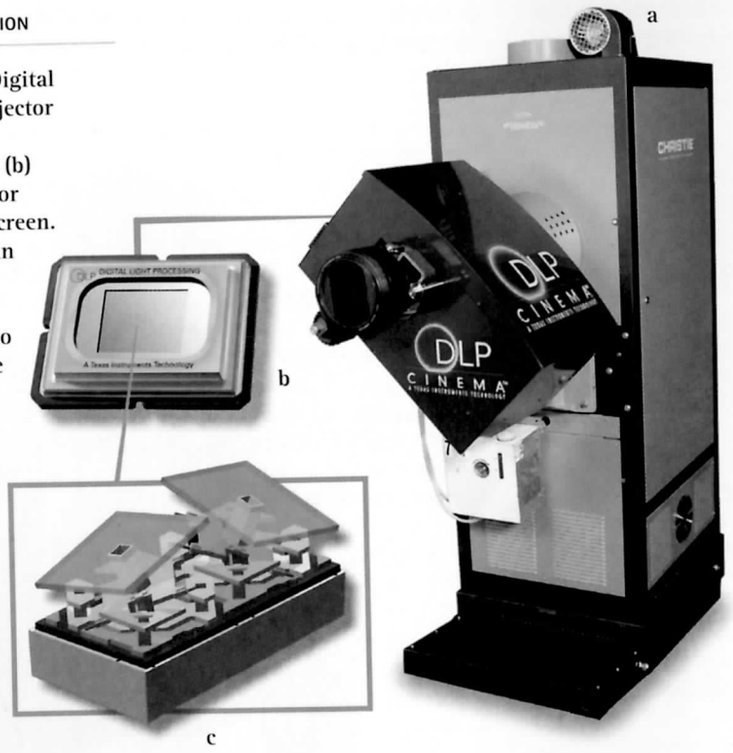
The most commonly used special-venue system is IMAX, which runs 65 mm film horizontally through the camera at 24 fps (the 65 mm equivalent of VistaVision, <55). IMAX films are projected onto enormous screens up to eight storeys high that completely fill the viewer's field of vision.

IMAX films have traditionally tended to be documentaries set in impressive landscapes such as the Rocky Mountains or the Arctic. IMAX cameras have even been used by NASA to film breathtaking views of the Earth from space.

Though IMAX has been available since the 60s, it has only recently become widely popular, resulting in an explosion of production using the format. This includes, for the first time, fictional films such as the dramatic 40-minute feature *T-Rex – Back to the Cretaceous* (1998) – a spectacular 3-D movie featuring computer-generated dinosaurs. IMAX is also starting to show digitally remastered giant-screen versions of selected Hollywood

FIGURE 4 **DIGITAL PROJECTION**

Texas Instruments' Digital Light Processing projector (a) uses three semiconductor chips (b) to reflect red, green or blue light onto the screen. Each chip contains an array of 1.3 million microscopic hinged mirrors (c) that tilt to reflect light onto the theatre screen.



ABOVE RIGHT: **Computer-generated characters leap from the screen in this promotional still from *Terminator 2: 3-D – Battle Across Time*.**

BELOW RIGHT: **The enormous size of an IMAX screen fills the viewer's field of vision, making it the most spectacular way of viewing filmed images.**

blockbusters at around the same time as their general release. These have included the *Star Wars* prequels, *Poseidon* (2006) and the *Harry Potter* films. The company's 3-D technology has also been applied to films such as *The Polar Express* (2004), which took a considerable portion of its initial box office returns from stereoscopic screenings in IMAX theatres.

There are now over 250 IMAX screens worldwide and many more are planned for major cities. While they can only ever represent a small percentage of the tickets sold to see a mainstream film, Hollywood is starting to see IMAX as an important additional source of income for selected 'event' movies.

DIGITAL DEVELOPMENTS AND VIRTUAL REALMS

While the reproduction of sound has evolved significantly in the digital age, the projection of images that are recorded and stored on 35 mm film has remained essentially unchanged for decades.

However, digital projectors are now able to project film-quality images onto large screens using millions of microscopic mirrors (fig. 4). Digital projection is attractive to studios and film distributors because it will reduce the huge costs currently involved in manufacturing, transporting and ultimately destroying thousands of prints of each new film. Using digital projection, cinemas will receive films on disks, download them via the internet, or have them relayed by satellite. It is hoped such methods will help cut the risk of piracy from stolen film prints and make it easier and quicker for a theatre to adjust the number of screens that are showing a film according to its popularity. Film prints become progressively dusty and degraded with each showing; digital projection, however, means that a film will look as good for its hundredth screening as it does at its first.

The first digitally projected public screenings of a major movie were of *Star Wars*: Episode I *The Phantom Menace* (1999), for which four US theatres were equipped with the new projectors. Later the same year *Toy Story 2* (1999) became the first feature film to be entirely created, mastered and exhibited digitally, with digital theatres projecting copies of the movie that had come directly from the computers at Pixar Animation Studios.

The entirely digital production and distribution of movies is set to increase as more movies are both filmed and finished digitally. At the time of publication over 1,000 screens worldwide were

equipped for digital projection but this number is expected to rise rapidly. The future, for major theatre chains at least, will undoubtedly be the exhibition of movies without film.

The continued use of a large screen to communally view the newest films is by no means a certainty. Falling box office revenues are in part due to many people's increasing preference for consuming movies and other entertainment at a time and place most convenient to them. DVD and home cinema systems have contributed to falling theatre attendance by making movie-watching at home a more enjoyable experience. In an attempt to find new business models in response to the digital revolution, Hollywood studios are even contemplating a service that will send, for a premium fee, latest releases directly into homes while they are still on theatrical release.

Even viewing movies on a screen could become a thing of the past. A technology that dispenses with any form of screen by projecting images directly onto the retina of the eye is already available. The system, called Virtual Retinal Display (VRD), was originally developed for military, medical and industrial applications – but its potential for entertainment purposes is being explored. The system requires the user to wear a headset which rapidly scans high-resolution images through the pupil and directly onto the retina. To the viewer, these images seem just like ordinary vision – exactly as if they are being seen directly through the eyes and without the black boundaries that we see around the edge of a cinema screen. By linking such a headset to a powerful computer, the viewer's head and eye movements can be tracked so that as the head is turned, they are able to 'look around' within the virtual environment. In the future it is conceivable that, rather than being rendered out as a 2-D final product, computer-generated movies may be released – perhaps via the internet – in an unrendered 3-D state. A viewer wearing a VRD headset could then act as their own virtual camera – as they move their head to see another area of the action, the movement will be measured and used to render, in real time, their own individual view of the pre-orchestrated action. Furthermore, because the system is binocular, it can send a slightly different view of a scene to each eye – making it ideal for viewing films in 3-D.

In the future, new technologies such as VRD will undoubtedly see widespread use in gaming applications – giving participants a highly interactive relationship with the game they are playing. However, the impact of such 'virtual reality' technology on cinema-going is more open to speculation. 'In the future, there will undoubtedly be many more ways to receive visual entertainment,' the cinematic visionary Douglas Trumbull believes. 'The scope for our increased interaction with such entertainment is huge – individuals will be able to choose what they see and even make decisions about how on-screen characters behave. But how that will affect the cinema is hard to tell. I believe that some new form of entertainment that uses computer-generated characters and environments will evolve. This will probably be a highly interactive mixture of the computer game and the cinema as we know it. People may go to the future equivalent of the multiplex to participate in this type of entertainment or, more likely, plug in through the internet. Ultimately such entertainment may even plug directly into our brain, supplying images and sound and even stimulating certain nerves to control our feelings and emotions. However, despite the increased opportunity for direct interaction with our entertainment, we shouldn't forget the power of the traditional cinema. People do actually enjoy sitting with hundreds of other people in a theatre – where they can laugh and scream in response to a piece of filmed entertainment over which they have no control. Whatever additional new forms of entertainment we create, they will probably exist alongside the old method. There are many entertainment marvels ahead, but the cinema as we know it will be hard to beat, and I believe it will still be around for some time to come.'

It may be decades before the techniques now being developed for the display and consumption of moving images settle into established new forms of mass entertainment. However, the incredible advances of the last two decades mean that the actual images that these technologies will display are not likely to change vastly; given enough time and money, any image imaginable can now be conjured with the computer. ILM's senior visual effects supervisor Dennis Muren believes that anything film-makers want to see is possible. 'We can now create pretty much anything anyone asks of us,' Muren states. 'That's not to say that things aren't a challenge any more, but I rarely lie awake at night worrying whether or not we can pull something off. For me the big challenge in digital effects is now about getting things done faster. I want to see results more quickly and I want individual artists to be able to have much more control over their own shots rather than being just part of a pipeline.'

For some, however, there remains one goal: the creation of 'virtual performers' – digital actors indistinguishable from the real thing. Such characters would be the wholly owned property of entertainment companies and would never have to be paid salaries or royalties, nor would they need an expensive entourage of assistants, drivers and make-up artists. Such performers would become cross-media stars, appearing in both films and computer games.

Amazingly lifelike digital characters currently appear in many films, but these are often nonhuman characters such as aliens and dinosaurs whose unfamiliarity helps to disguise their artificial origins. Computer-generated humans tend to be used only very briefly, or in long shot, so that detailed scrutiny is impossible. They certainly aren't yet capable of giving a completely naturalistic performance. There is no doubt that a totally convincing computer-generated human can and will be created, but in the near future, perfect virtual actors will be so time-consuming and expensive to produce that, other than the publicity gained by the film that features the first virtual cast, the advantages of creating artificial performers are debatable. As Muren says: 'I just don't see the point of virtual performers. If you want great performances, then hire great actors – there are plenty out there. Visual effects are all about creating what doesn't already exist.'

The most frequently cited attraction of so-called 'synthespians' is the possibility of making new films with the stars of the past. Humphrey Bogart and Marilyn Monroe are two personalities commonly tipped for a comeback. The creation of convincing-looking Bogart and Monroe replicas is already a possibility, but aside from an appropriately hard-boiled face or accurately rendered curves, whether any animator could re-create their glamour, or indefinable on-screen presence, remains debatable. Nevertheless, some enterprising companies have already negotiated for the rights to resurrect certain deceased icons in future movie productions.

Hollywood has always sought to provide ever more spectacular images in order to keep audiences coming back for more. But the advent of digital effects has started to challenge the old rules. In 1993, cinema-goers lined up around the block to see the computer-generated wonders of *Jurassic Park*. Just a few years later such images were almost commonplace and certainly didn't warrant lining up to see. In the future, film-makers will find it increasingly difficult to impress audiences with outstanding images and will instead have to work even harder to create entertainment in which audiences are genuinely swept up by the drama and intrigued by well-observed characters.

A century ago, Georges Méliès was the first film-maker to discover that sheer spectacle was not enough to keep audiences coming back, and when he failed to offer anything more than tricks, his films began to lose their popular appeal. Visual effects artists will continue to perfect the creation of whatever wonders are asked of them. But in a new century, where films can be made without film, and where dramas may not need actors, the challenge for film-makers will be to find new ways of using moving pictures to awe, inspire and entertain us.

RIGHT: **Lifelike CG characters are already possible, but will the silicone chip replace the need for real actors in the future? Many believe the computer is best used only for the creation of fantasy characters, such as the giant green star of *Hulk* (2003).**

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FRONTISPIECE: *King Kong* (2005), Weta's extraordinary creation.

BELOW: Special effects have played a prominent part in many movies during cinema's first century: *Santa Claus* (1898), *T2: 3-D – Battle across Time* (1996), *Manslaughter* (1922), *When Worlds Collide* (1951), *The Living Daylights* (1987), *The Godfather* (1972).