

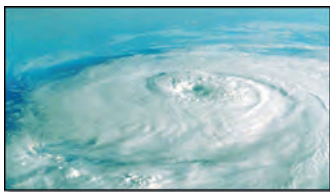
1 Visual Effects Today



Digital compositing is an essential part of visual effects, which are everywhere in the entertainment industry today—in feature films, television commercials, and even many TV shows. And it's growing. Even a non-effects film will have visual effects. It might be a love story or a comedy, but there will always be something that needs to be added or removed from the picture

to tell the story. And that is the short description of what visual effects are all about—adding elements to a picture that are not there, or removing something that you don't want to be there. And digital compositing plays a key role in all visual effects.

The things that are added to the picture can come from practically any source today. We might be adding an actor or a model from a piece of film or video tape. Or perhaps the mission is to add a spaceship or dinosaur that was created entirely in a computer, so it is referred to as a computer generated image (CGI). Maybe the element to be added is a matte painting done in Adobe Photoshop®. Some elements might even be created by the compositor himself.



It is the digital compositor that takes these disparate elements, no matter how they were created, and blends them together artistically into a seamless, photorealistic whole. The digital compositor's mission is to make them appear as if they were all shot together at the same time under the same lights with the same camera, and then give the

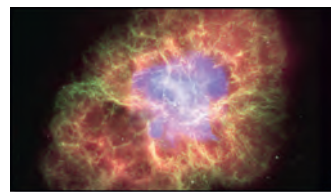
shot its final artistic polish with superb color correction. This is a non-trivial accomplishment artistically, and there are a variety of technical challenges that have to be met along the way. Digital compositing is both a technical and an artistic challenge.

The compositor is first and foremost an artist, and works with other artists such as matte painters, colorists, CGI artists, and art directors as a member of a visual effects team. This team must coordinate their efforts to produce technically sophisticated and artistically pleasing effects shots. The great irony here is that if we all do our jobs right, nobody can tell what we did because the visual effects blend seamlessly with the rest of the movie. If we don't, the viewer is pulled out of the movie experience and starts thinking, "Hey, look at those cheesy effects!"



So what is the difference between visual effects and special effects? Visual effects are the creation or modification of images, whereas special effects are things done on the set which are then photographed, such as pyrotechnics or miniatures. In other words, visual effects specifically manipulate images. And since manipulating images is best done with a computer, they are the tool of choice, and this is why the job is known as *digital compositing*.

I mentioned earlier that digital compositing is growing. There are two primary reasons for this. First is the steady increase in the use of CGI for visual effects, and every CGI element needs to be composited. The reason CGI is on the upswing is because of the steady improvement in technology which means that CGI can solve more visual problems every year, thus increasing the demand by movie makers for ever-more spectacular effects for their movies (or TV shows or television commercials). Furthermore, as the hardware gets cheaper and faster, and the software becomes more capable, it tends to lower the cost of creating CGI. However, any theoretical cost savings here are quickly overwhelmed by the insatiable appetite for more spectacular, complex, and expensive visual effects. In other words, the creative demands continuously expand to fill the capabilities of the technology.



The second reason for the increase in digital compositing is that the compositing software and hardware technologies are also advancing on their own track, separately from CGI. This means that visual effects shots can be done faster, more cost-effectively, and with higher quality. There has also been a general rise in the awareness of the film makers to what can be done with digital compositing, which makes them more sophisticated users. As a result, they demand ever-more effects be done for their movies.





In this chapter we take a wide-ranging tour of the incredible scope and scale of digital compositing in visual effects today. The first section describes digital compositing with CGI. A lot of our work is to composite CGI, so it warrants its own section. The second section reveals the many types of amazing visual effects that are done strictly with modern compositing software—no CGI required. The third section takes a brief look at the two types of compositing programs, node based and timeline based. From this point on I will refer to film in these examples, but I am also including video. It is just a bit too cumbersome to continuously refer to film (and videotape) or filming (and videotaping) or cinematographers (and videographers).

1.1 DIGITAL COMPOSITING WITH CGI

Whenever someone makes a CGI element, someone else has to composite it. In this section we will look at three general areas where CGI elements are composited. First up is straightforward CGI compositing where a CGI object has been created and needs to be composited into the scene. Next we will take a look at set extension, a rapidly expanding technique in film making. Last we will look at the match move, where separate programs are used to analyze the live action and provide terrain and camera move data for the CGI programs.

1.1.1 CGI Compositing

By far the most common application of digital compositing is to composite CGI. Whether it is for a \$100,000 dollar commercial or a \$100 million dollar movie, the CGI is created in a computer and composited over some kind of a background image. The background image is very often live action, meaning it was shot on film or video, but it too could be CGI that was also created in a computer, or it might be a digital matte painting. Regardless of where the background comes from, the digital compositor puts it all together and gives it the final touch of photorealism. Figure 1-1 illustrates a basic CGI composite where the jet fighter was created in the computer, the background is live action footage, and the final composite puts the jet fighter into the background.



Figure 1-1 A CGI object composited over a live action background

Today, CGI goes far beyond jet fighters and dinosaurs. Recent advances in the technology have made it possible to create a very wide range of incredibly realistic synthetic objects for compositing. Beyond the obvious things such as cars, airplanes, and rampaging beasts, CGI has mastered the ability to create photorealistic hair, skin, cloth, clouds, fog, fire, and even water. It has even become common practice to use a “digital double” when you want the movie star to execute a daring stunt that is beyond even the expert stunt double. It will not be long before the first “cyber thespian” (an all-CGI character) stars in what would otherwise be a live action movie. However, after all the spaceships, beasts, water, and fire have been rendered, somebody has to composite them all together. And that somebody is the dauntless digital compositor.

1.1.2 Set Extension

If you wanted your actors to be seen standing in front of the Imperial Palace on the planet Mungo you may not want to spend the money to build the entire exterior of the Imperial Palace. Better to build a small piece of it on a movie set, place the talent in it, and then extend the set later using CGI when you need a wide shot. For this little piece of digital magic the film is digitized into the computer and the CGI folks build a 3D model of the Imperial Palace and line it up with the original film footage and its camera angle. There might even be a camera move in the live action which the CGI artists will carefully track and match. But eventually the live action and the CGI set extension must be composited and color corrected to match perfectly.

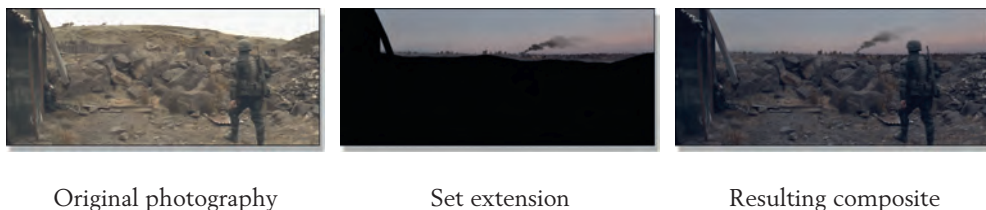


Figure 1-2 Set extension*

Figure 1-2 is a classic example of set extension that demonstrates how it can even be applied to an exterior location shot. The original photography captures the future soldier walking along an otherwise small and uninteresting rubble pit. The middle picture shows the set extension element that was an all-CGI city in the distance with smoke generated by a particle system and a matte painting for the sky. The resulting composite shows all of the elements composited together and color corrected to blend properly.

*Courtesy of Ruairi Robinson’s *Silent City*.

You can immediately see the enormous difficulty in trying to create this shot without using set extension and digital compositing. You would need to find a location that had the rubble pit the correct distance from a real city that had the right look and was (unhappily) on fire at the time. You would then have to wait for the right time of day to get the sunset sky, and in location shooting waiting is *very* expensive. If such a location could even be found you would then have to fly the entire crew out there. This amounts to a very expensive if not nearly impossible production plan.

Instead, the producer wisely chose to do a set extension. The rubble pit was easy to find and close at hand. The crew drove to the location in only half an hour. Once the film was digitized the CGI department took over and created the background city and smoke animation while the digital matte painter made the sky painting. When all was ready the digital compositor took all four elements—original photography, CGI set extension, smoke animation, and matte painting—and then composited them together and color corrected them to blend naturally. Not only was this far less expensive, but (and this is the punchline) the director got exactly the shot he wanted. What CGI and digital compositing bring to the table is creative control—the ability to make exactly the shot you want. Not just what is practical or affordable.

1.1.3 Match Move

Directors and cinematographers hate to lock off the camera. They love to swoop the camera through the scene, boom it up over a crowd, or swing it around the heroic character. This is fine if the shot is all live action, but it wreaks havoc if the shot requires CGI to be mixed with the live action. If the live action camera is moving then the CGI camera must also move so that the CGI will match the changing perspective of the live action. Not only must the CGI camera move, but it must move in perfect sync with the live action camera or the CGI element will drift and squirm in the frame and not appear to be locked to the rest of the shot. Special *match move* programs are needed to pull off this bit of cinematic magic. An example of a match move shot is shown in Figure 1-3 where the camera orbits around the live action soldier. The soldier is in an all-CGI environment.

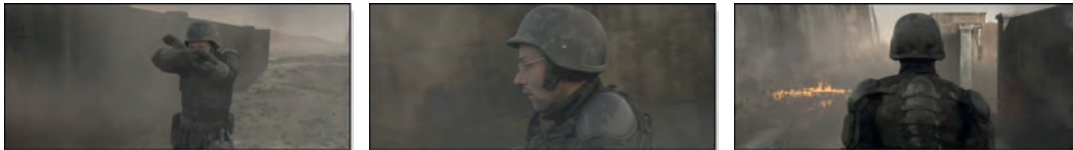


Figure 1-3 Match move sequence

Match move is a two-step process. First, the live action plate is analyzed by the match move program. A *plate* is simply a shot that is intended to be composited with another shot. The match move program correlates as many features as it can between frames and tracks them over the length of the shot. This produces a low-detail 3D model of the terrain in the scene along with camera move data. The terrain model is low detail and incomplete, but it does provide enough information for the next step.

The second step is to give the 3D terrain information and the camera move data to the 3D animators. They use the terrain information as a guide to where to place their 3D objects. The camera move data is used by the computer camera to match the move of the live action camera in order to render the 3D objects with a matching perspective that changes over the length of the shot. If the terrain information or camera move data is off in any significant way the 3D objects will scoot and squirm rather than appear to be firmly planted on the ground.

After all the 3D elements are rendered the live action plate and the CGI come to the digital compositor for final color correction and compositing. Of course, the compositor is expected to fix any small (or large) lineup problems in the CGI or live action. There are two fundamental ways the match move game can be played. Live action can be placed in a CGI environment (like the example in Figure 1-3) or CGI can be placed in a live action environment, like King Kong in New York City. Either way you work it, match move is truly one of the great wonders of visual effects.

1.2 COMPOSITING VISUAL EFFECTS

Now we will take a look at the many diverse applications of visual effects that are done with the modern compositing program alone. None of these require any CGI. The steady advances in compositing software tools and algorithms have continuously added new capabilities for the digital compositor, which must be mastered both technically and artistically.

1.2.1 Bluescreen Compositing

There are many situations where placing an actor or actress in a scene for real would be too expensive, too dangerous, or even physically impossible. In these situations you would want to film the talent in an inexpensive and safe environment, and then later composite them into the actual expensive, dangerous, or impossible background. This is what *bluescreen compositing* is all about. The talent is filmed in front of a solid blue background to make it easier for the computer to isolate then composite them into the actual background like the example in Figure 1-4.



Figure 1-4 A basic bluescreen composite

Bluescreen compositing offers a completely different set of challenges to CGI compositing because the compositor must first isolate the talent from the backing color by creating a high-quality matte. This matte is then used to perform the composite, whereas with CGI a perfect matte is automatically generated by the computer and comes with the CGI image.

The backing color can also be green, in which case it is called a *greenscreen*, but the principle is the same in either case. The computer detects where the backing color is in each frame and generates a matte that is used to composite the actor (or actress, spaceship, animal, dazzling new consumer product, or whatever) into the background. Here is where the artistic and technical challenges for the compositor skyrocket. Not only because of the difficulty of creating a good matte but also because the various elements will not visually match the background very well so they must be heavily color corrected and processed by the digital compositor to blend them properly.

1.2.2 Motion Tracking

Motion tracking is the little brother to match move. With match move the CGI artist is tracking hundreds, sometime thousands, of points in a scene and using that data to build 3D models and a matching 3D camera move. Motion tracking usually only tracks a few points and its data is used to track one two-dimensional image onto another two-dimensional image.



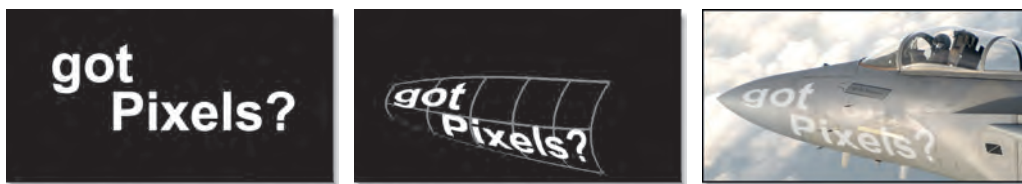
Figure 1-5 Motion tracking

Let's say that you have been given a graphic element such as a corporate logo and the mission is to attach it to the wing of a supersonic jet fighter like the one in Figure 1-5. The motion tracking program locks onto key points on the wing of the fighter and tracks them over the length of the shot. That two-dimensional tracking data is then applied to the graphic element so it will move in perfect sync with the fighter's wing when composited. Of course, even though the graphic element now moves with the fighter correctly but does not change its lighting as the fighter moves through the shot, this and other photo-realism issues will have to be addressed by the compositor.

Motion tracking has many applications beyond tracking logos to jet fighters. One of the most common applications is monitor replacement where a new image is tracked and composited over the face of a monitor or TV screen. When a digital matte painting is added to a shot that has a camera move, the matte painting will have to be motion tracked to lock it to the shot. Another common use is to create a mask to isolate some object in the frame, and then motion track the mask to stay on top of the object over the length of the shot. Any time one image needs to be locked onto another moving image, motion tracking is the technology that makes it possible.

1.2.3 Warping and Morphing

Warping is one of those magical things that only a computer can do. Imagine it as attaching an image to a sheet of rubber, then pulling and stretching only those parts of the rubber sheet that you want to deform. This especially allows you to push and pull on the interior parts of the image to deform it any way you want. When is this used? Any time you want to fit one image over another but you can't make it fit just by pulling on its corners. Figure 1-6 shows an example of warping a graphic element to fit over a curved surface. These warps can also be animated over time to maintain their warped shape over a moving surface.



Element to warp

Warped element

Warped element composited

Figure 1-6 Warping an element

Morphs are the big brother to warps. It takes two warps and a dissolve to create a morph, but we will have to wait until Chapter 8 to see how this is actually done. For now, we can simply admire the fact that in the hands of a digital artist the computer

can seamlessly transform one face into another, as if by magic. And it is magic—digital magic. But all magic requires a magician, and that’s the digital compositor. Most compositing software today comes with warping and morphing capabilities. There are also separate dedicated programs available that just do warping and morphing in case your compositing software doesn’t.

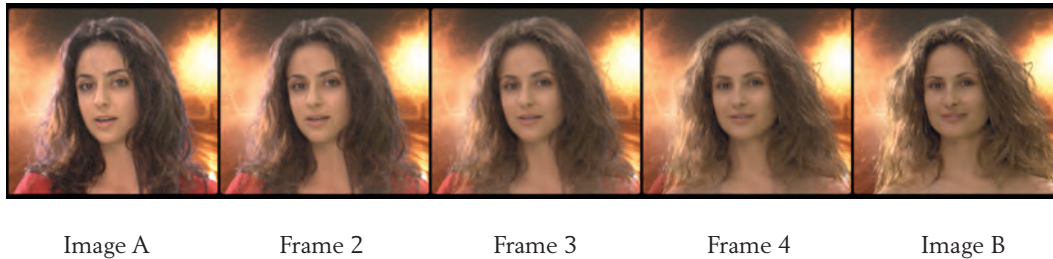


Figure 1-7 Morph sequence

Figure 1-7 illustrates a morph between image A and image B. What is not obvious from this example of a morph is that the two morphing images must be shot on bluescreen or isolated from their backgrounds in some other manner, such as a *roto*. The morph is performed on these isolated images, and then the results are composited over the background.

1.2.4 Bullet Time Shots

Ever since we were thrilled by the jaw-hanging spectacle of a camera flying around a suspended animation of Keanu Reeves in *The Matrix*, bullet time shots have become a permanent entry in the lexicon of visual effects. They present a never-before-seen view of a frozen moment in time using methods that defy imagination. Unless you are a digital compositor, of course, as this is an all-compositing effect—no CGI is required.

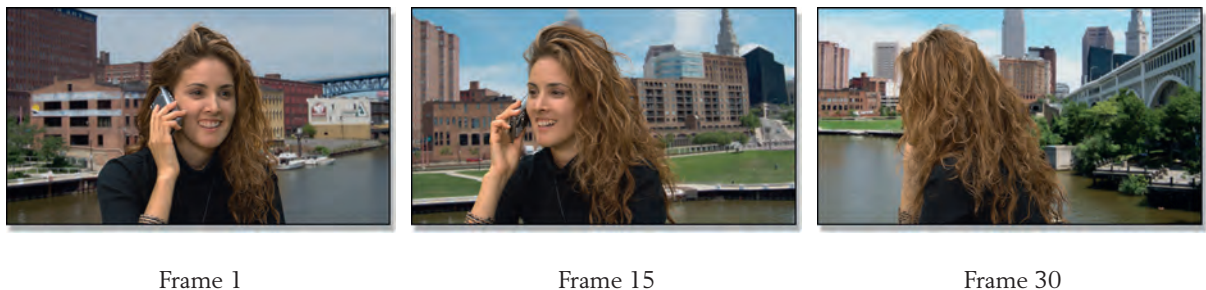


Figure 1-8 Bullet time shot

Figure 1-8 illustrates just three frames out of a bullet time shot. The setup is that a number of still cameras are arrayed in an arc around the target character like the top view diagram in Figure 1-9; they are then all triggered electronically. If they are triggered at the same instant the character is frozen in time. If they are triggered a fraction of a second apart the character moves in slow motion. Either way, the result of the photography shoot is a series of still frames, each taken from a slightly different point of view since each camera is in a different position around the character.



Figure 1-9 Bullet time rig of still cameras

Now, enter the compositor. The first issue to be dealt with is that while the cameras were all pointing at the character, the alignment is not perfect, so each camera is off-center a bit. As a result, when the frames are played at speed there is some jitter, which has to be removed using image stabilization techniques. Next, each camera will have taken a slightly different exposure due to the natural variation in the cameras, lenses, and film stock (or digital sensor), so each frame must be precisely color corrected so that they all match and there is no flicker in the shot when played at speed.

Last, the shot needs to get a digital speed change—what we call *retiming*. Here's why; let's say we want to end up with a 4-second shot. Since film plays at 24 frames per second, we will need 4×24 , or 96 pictures. Setting up, aligning, and triggering 96 still cameras is an arduous task. Instead, we will just set up half that many (48 cameras), and then do a speed change to "stretch" the 48 frames to 96. The technology to do this is called *optical flow*—more digital compositing wizardry. We will learn all about optical flow in Chapter 7, but suffice it to say that it can create beautifully interpolated in-between frames to stretch a shot.

1.2.5 Crowd Duplication

If the director wants an attacking army of 50,000 Orks, he will open his checkbook and turn to the CGI artists. They will use what is called *flocking* software to avoid having to personally choreograph the behavior of 50,000 angry Orks. However, if the director wants to fill a baseball stadium with cheering fans he will either have to hire 50,000 excitable extras, or you, the dauntless digital compositor.