Digital Landscaping

by Gergely Vass

In recent years, panoramic images have become exceedingly popular among computer graphics professionals as well as photography enthusiasts. And it's no wonder. Such imagery as an exceptionally large field of view compared to conventional photographs or even to the human vision. With panoramic techniques, we can display the all-encompassing, 360-degree view around us with high detail across the entire image, making this the only method of truly capturing the image of wide-open vistas and landscapes.

The creation of panoramic imagery on personal computers has become easy. Digital photographs created by regular, low-cost cameras can be automatically "stitched" together using free or low-cost software. Yet, panoramic techniques are far from new; the first panoramas were created even before the invention of photography itself!

Before the era of motion pictures, artists had to depict series of events or multiple, simultaneous occurrences on a single picture. By arranging pictures next to each other - as seen on religious engravings decorating the royal tombs in Egypt - infinitely long and/or large historical events and journeys could be visualized.

The main problem (if it is a problem at all) with these tomb paintings is their lack of realism. The Chinese painter, Zhang Zeduan used the same trick of painting things next to each other - with superior technique - in the 12th century to depict the colorful life of a city on his famous handscroll, "Along the River During Qing Ming Festival". The artist used axonometric projection to reveal the depth of the scene, which makes the 3D structures look flat yet allows the extremely wide viewing angle. Such renderings of ancient times are very valuable for historians because they tell a lot about the life of average people: how they work, how they socialize, where they live, how they travel, and what tools and techniques they use.

Historical Research

During the Renaissance, artists and scientists conducted different types of experiments to uncover the secret behind realistic depiction of the three-dimensional environment around us on a flat sheet of canvas. Based on careful observations, the theory of perspective projection was born. Paintings and frescoes created using this fundamentally new technique are realistic, as they approximate the representation of an image on a flat surface, as it is perceived by the eye.

Due to the fact that the image plane (the canvas or the wall to be painted) is supposed to be flat, the perspective projection has a severe limitation: the theoretical limit of the viewing angle is 180 degrees; to avoid strong distortion, the field of view should roughly match the angle at which we view the final painting.

Trying to compensate for this, artists creating views of landscapes or city panoramas chose the viewpoint that is fairly far from the subject, and added an extreme amount of detail into the picture. This way - without using a very large viewing angle - complete cities or historical events, such as battles, could be illustrated realistically. This is analogous to current, conventional photographs cropped to a relatively wide aspect ratio.

London, engraving by Wenceslaus Hollar (1607–1677)

One good example of such pictures is the engraving of London by the Czech artist Wenceslaus Hollar. His works serve as great reference on how old London buildings, such as the famous Globe Theater, looked hundreds of years ago. While Hollar was able to create very wide images of landscapes, the limit of the perspective projection forced him to cheat on the real perspective and to focus on a limited viewing angle. Without introducing a new alternative to perspective projection, he was destined to fail creating "truly panoramic" depictions.

Panorama of Along the River During Ching Ming Festival,
18th century remake of a 12th century original by Chinese artist Zhang Zeduan

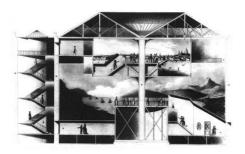*Panorama of Edinburgh from the top of St Giles Cathedral on the Royal Mile, Robert Barker.*

Panoramic Painting

Scottish artist and business man Robert Barker created the first "proper" panoramic paintings in the late 18th century. His "immersive" images depicted the entire surroundings on a single cylindrical canvas stretched all the way around the front of the viewer. The main contribution of his technique was to drop the idea of flat image-plane and perspective projection in favor of using a circular canvas and cylindrical projection. In his imagery, one can clearly see the curved outlines of buildings that otherwise are always straight on conventional perspective images. These curved lines are not some sort of defect, however; if viewed properly on a cylindrical surface, the illusion is perfect.

Cylindrical projection is just as accurate and precise as perspective projection, as long as we do not flatten the images that are supposed to surround us on a cylindrical wall.

Barker begun his work on panoramic paintings of Old Edinburgh in 1796, and quickly filed a patent to protect his invention shortly thereafter. His system of representing an entire surround landscape through painting was so successful that he set up multiple buildings in which he showcased panoramas of old cities and historical events. These paintings were hosted in large, purpose-built structures to accommodate huge panoramas: which were more than 10m (40 feet) high and 26m (85 feet) in diameter.

Cross section of Robert Barker's Panorama, Leicester Square, London, 1789

Visitors reached the viewing platform by a short staircase in the darkness, to heighten the sensation of standing in front of the naturally lit circular rotunda. Without movie theaters or television at the time, these demonstrations were a big hit and proved to be the best attempts to make a realistic record of the world around us. People payed a considerable amount of money to be able to virtually experience a journey across time and place, and to be "in" some great historical event or distant place of natural beauty.

During the 19th century, panoramas became an early form of mass entertainment in European and American cities. To draw more audience into the shows, different versions of the illusion have emerged, including moving panoramas and dioramas. The latter is a partial or complete panoramic image displayed in a highly specialized theater utilizing moving layers of paintings, dynamic lighting, and real scenery and special effects to further enhance the realism. Before co-inventing daguerreotype (the first widely used method of photography) Louis Jacques Mandé Daguerre was the inventor and a master designer and painter of such theatrical stage illusions.

Daguerreotype, the first commercial photographic process, used silver-coated copper plates to produce highly detailed images. Shortly after its 1839 invention – when panoramas and dioramas were popular – photographers tried to create panoramas by placing two more daguerreotype plates side by side. Cameras using a point-like aperture and a flat light-sensitive plate (as do most cameras) produce perspectively projected images, so when the photos are placed next to each other, they will not produce a perfect panoramic effect. The edges of the images will be very apparent even if aligned perfectly.

San Francisco from Rincon Hill, 1851; (c1910 Martin Behrman)

To make panoramic photos that are not cropped perspective images, cameras first had to be modified. The first panoramic cameras with the crucial feature of panning with a relatively steady speed were rather difficult to build and use, thus original panoramic plates are very rare. With the invention of flexible film in 1888, a new wave of commercial panoramic cameras with a rotating lens or a rotating camera body were introduced.

Swing-lens cameras have a lens that rotates around the camera's rear nodal point as the photograph is taken, and a slit exposes the vertical strip of film that is aligned with the axis of the lens. These cameras are able to scan the viewing angle between 110 and 140 degrees. The entire exposition takes only a fraction of a second; however, due to the quick motion of the lens, the devices usually have fixed focus and a small aperture. This makes the technique ideal for outside work and less useful for low-light situations.

Nevertheless, rotating panoramic cameras are able to capture the entire 360-degree environment, since the whole camera body rotates, as opposed

Widelux and Noblex swing lens panoramic cameras.

Photograph of San Francisco in ruins from Lawrence Captive Airship,
2000 feet above San Francisco Bay...; 1906, Geo. R. Lawrence Co.

to just the lens. A sophisticated mechanism ensures that the film is pulled inside the camera so it matches the speed with which the image moves across the image plane. These cameras use a narrow slit for exposition, just like modern digital rotating line cameras.

Panorama Today

Creating panoramic photos requires advanced equipment and skills. As a result, this process had not become a mass-media focus until recently. However, advanced computer vision and image processing algorithms running on current PCs now allow us to "re-interpret" standard photographs and turn them into stitched panoramic images.

The first robust algorithms to match overlapping images pixel by pixel were first proposed in the 1980s for applications such as stereo vision and different optical-flow based methods. Robust matching and alignment of images means that the best match is found even if the input photos are not identical – in which, for instance, clouds or people are moving. The idea of representing a virtual environment using digital panoramas emerged in the computer graphics community

only around 1995, but today it has become a very popular technique among amateur photographers as well.

Browsing panoramic images appearing in online galleries is interesting, but it is even more fascinating to look at 100-year-old panoramic photographs, such as those from the "Panoramic Photograph Collection: Taking the Long View, 1851-1991." This can be found in the Library of Congress, where hundreds of high-res photos of cities, fires, floods, and more are displayed (http://memory.loc.gov/ammem/collections/panoramic_photo).

Stitched panorama where there is significant variation
between the input images.