2005

Scanning photographic processes

Andrew Davidhazy

Scanning Photographic Processes

Andrew Davidhazy
Imaging and Photographic Technology
Rochester Institute of Technology
70 Lomb Memorial Drive
Rochester, NY 14623 USA
andpph@rit.edu

Key words: Scanning, imaging, peripheral, panoramic, photofinish and strip photography, cartography, cartographic projection.

Abstract

Photographs imply that they are representations of a particular scene in terms height, width and an instant in time. There are cameras that display time itself as a dimension of the final record. These are sometimes called "streak" or “strip” cameras. These cameras can be thought of as strip chart recorders where the subject information is gathered optically. This makes streak cameras powerful tools for non-contact measurement of subject changes over time. But they can also be used for other than purely technical applications.

In this presentation several improvised cameras of this type based on film and CCD or solid-state technology are presented and illustrated with applications. based the application of a linear CCD removed from an inexpensive hand-scanner and installed in the back of a 35mm camera body. I’ve used them to demonstrate a variety of applications where quantitative data about subject performance is desired and have also applied the camera for more aesthetically oriented purposes such as peripheral and panoramic photography. The cameras and their applications will be described in this presentation.

1. Scanning approach to photography

The process of scanning is becoming almost a household word in the field of imaging and indeed photography in general. This is due to the introduction of electronic scanning devices that approach imaging in a fundamentally different mode than the one normally associated with that of our own visual system.

We look at the world around us in an instantaneous fashion and perceive our surroundings all at the same time although we may concentrate on some aspect of a scene more closely than others. Standard photographic methods essentially duplicate our personal experience with remembering a slice of time, an instantaneous reality that presented itself to our eyes at some specific time.

Sometimes referred to or classified as 2-dimensional imaging, photography has assigned

to it the characteristic of being a “witness of reality” because it captures an instant in time and makes a faithful record of whatever appeared in front of the camera at the selected time. We assume that photographs are to a large extent a reflection of reality, However, there are a host of film-based as well as digital image acquisition processes that operate in a fundamentally different manner than standard camera and when the images produced by these systems are seen under conventional conditions our perception and understanding of these images becomes confused and our imaginations often stretch to the limit.

Fig. 1. Interaction between moving shutter slit and moving subject.

At the heart of this alternative approach to image making is the focal plane shutter.This consists of a narrow slit or slot that travels across the film plane of a camera during the course of making a record of the scene it is recording on film (or a digital array). When the rate at which this slot travels across the image plane is short in comparison o the rate that images might move at during the exposure process the final photograph looks very much like the original scene. However, if the images move significantly during the time the slot travels across the image then various types of distortion are introduced in the final photograph. This effect is appreciated by photographers as “focal plane shutter distortion”.

It is a type of distortion that is actually seldom seen. However, as shown in Figure 1., it can be made visible by altering the mechanical characteristics of a shutter or by chance as Henri Lartigue’s famous photograph of a race car appearing to lean forward in its direction of motion while the background shows bystanders and telephone poles leaning in the opposite direction demonstrates.

Generally we assume that there is no such thing as focal-plane shutter distortion. We assume that photographs are made instantaneously all over the surface of the film or of a solid state sensor in a digital camera. However, such instantaneity of recording , quite possible with standard cameras, is very difficult to achieve with electronic cameras when a truly high quality image are required. Instead, simultaneity of capture is sacrificed and a one dimensional array of CCDs (some call them pixels) is used and it is sequentially exposed to an image. Because the sensor is a 1-dimensional, not a 2-dimensional, sensor it is much cheaper to manufacture. In order to capture the full detail in a 3-dimensional scene and reproduce it as a 2-dimensional reproduction (as regular photographs do) the a single row of sensors is made to scan the image plane by mechanically moving it across the image. This means that large amounts of image bearing data can be extracted and stored. This leads to extremely high quality digital images.

This process of scanning a scene or the image of a subject has been known in earlier times and has been exploited by various specialized photographic technologies but has never gained the widespread acceptance that the electronic derivatives of these techniques will probably achieve.

The images recorded by slits or linear arrays can themselves be stationary in which case

the slit or array is moved or the slit or array may remain stationary and the image moved past it. In this manner current electronic imaging systems are related to traditional scanning techniques associated with strip cameras and to traditional cameras equipped with focal plane shutters.

2. Streak photographs made with stationary slits or CCD arrays

If we turn the “slit-scan” or focal plane shutter method of scanning images around so that instead of moving the slit or the array, instead we move the film or simply “dump” data from a stationary CCD linear array into computer memory, we have an imaging system often described as a “streak” camera system. These cameras, while not often used to capture real looking reproductions of subjects, provide time or timing information that is often crucial for a quantitative analysis of a particular subject.

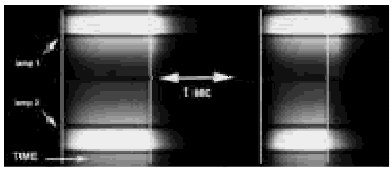

Fig 2. Two lamps, top and bottom, turned on and off at slightly different times can easily be timed with a streak camera.

For example, if two or more light sources are placed along the array and turned on and off at slightly different times the final record will be as shown in Fig. 2. The streaks associated with the lamp will differ slightly from each other in terms of length and position on the record. The difference in length of each record can be traced back to differences in “on” time and differences in placement on the record (along the “time” dimension) can be assigned to variations in the time at which one lamp was turned on with respect to the other.

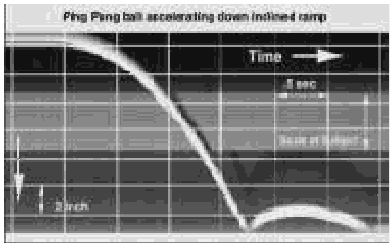

Fig. 3. A "streak" record of a falling ball

As shown in Fig. 3, a rolling ball whose image travels along the slit, or array, over time will leave a curved path on the final record in which the slope of the curve at any point can be assigned a particular velocity and the curve itself is a visual representation of acceleration.

As shown in Fig. 3a, right, something as simple as several objects rotating on a turntable when "continuously" sampled by a streak camera across their axis of rotation record as a series of intertwined curved traces whose slope is a direct indication of their location away from the axis of rotation. Phase shift or location around the turntable of the objects can also be deduced based on straightforward mathematical analysis.

Streak cameras are what might be called “magnificent time machines”. They allow the visualization of time itself as an integral component of a photograph.

3. Applications of strip or scanning photography

When a camera equipped with a slit shutter past which film moves and over which an

image moves or a CCD linear array across which an image of a subject moves, it is possible to make more or less faithful reproductions of the original subjects by matching the film velocity to that of the image or adjusting the sampling rate of the CCD so that proper aspect ratio of the image is maintained in the final record. When images move across the slit or the CCD array they are called generically “strip” cameras. They also have a wide variety of applications.

Listed below are but a few of the most basic ones that have enabled photographers to solve visual and technical problems that standard camera systems are simply incapable of dealing with effectively.

2.1 Linear strip photography. Linear strip photography comes in two different "flavors". In the most common example, the strip camera, fitted with a narrow slit past which film can be moved, is aimed at a subject that moves across the field of view of the camera. The image of the subject passes over the slit in the camera at about the same speed as the film moves under the slit.

Fig. 4. A film-type strip camera was used for this variation on a photofinish photograph. The film in the camera was moving at about the rate that the images of the runners were moving at past the slit.

Two widespread applications of this technique are the production of photofinish pictures at races, such as Fig. 4, and the making of synchroballistic photographs in the analysis of rocket performance.

Conversely, the camera can be placed in a moving vehicle such as a plane or a car and moved with respect to a stationary subject. In this way a long swath of subject can be recorded over time. One of the foremost applications of this technique is its use as an aerial camera system in photogrammetry, reconnaisance and remote sensing.

2.2 Peripheral photography. A variation of the above methods is to rotate a subject in front of the camera. In this case the slit is typically lined up with the center of rotation of the subject and with each revolution a complete 360 degree view of the subject's surface features is recorded onto the moving film. The process is called peripheral photography.

Fig. 5. Film based and CCD Linear Array Digital peripheral portraits.

Fig. 6. Peripheral portrait made of rotating subject onto moving film and while also panning the camera!.

2.3 Panoramic photography. The last common example of the application of these cameras is in the use of the scanning principle for the making of ultra-wide angle panoramic photographs. Scanning panoramic cameras able to cover angles of view extending to a full 360 degree record. This is accomplished by rotating the strip camera. The film moving beneath the slit (or across the CCD array) then records various locations around the camera at different times and eventually a complete photograph of the scene surrounding the camera is secured.

Fig. 7. Panoramic photograph of my lab made with an improvised digital panoramic camera utilizing a linear CCD array removed from a simple hand scanner and installed in the back of a regular camera. The camera was rotated slightly over a full turn to cover about 375 degrees surrounding the camera.

2.4 Conical Peripheral and Panoramic Photography. A seldom seen development in the area of peripheral and panoramic photography is the use of film moving in circular rather than linear fashion behind the slit of a specially constructed strip camera. The design allows for the making of undistorted reproductions of subjects that have a conical shape and for the making of panoramic photographs that resemble conical projection techniques used in cartography.

Fig. 8a) sketch of layout of a novel camera designed to move film past a narrow radially cut, tapered, slot located in front of a turntable-carrying film. 8b) when the camera is tipped backwards to take in tall subjects or if one simply wants a higher angle of coverage, the back of the camera describes a conical path in space and this requires the film within to move in circular, rather than linear (as is the case in standard panoramic cameras) fashion. 8c) the same camera can accurately make peripheral reproductions of the surface of subjects that have a conical rather than a cylindrical shape.

The process of making images by the scanning method is full of potential for a myriad of applications. Hopefully, with the development of electronic imaging processes and greater access to linear arrays this method of image making will flourish and become an integral imaging process in art, science and technology and achieve a level of recognition in the photographic and imaging community in general that the forerunners of these devices never accomplished.

References

[1] A. Davidhazy, How I Broke the Reality Barrier, Popular Photography, October 1970, volume 67, number 4, pp.75-77.
[2] A. Davidhazy, Looking at Life Through a Slit, Milwaukee Journal, June 27, 1971.
[3] A. Davidhazy, Davidhazy adds a Twist to Photography, Democrat and Chronicle Upstate Magazine, November 14, 1971.
[4] A.Davidhazy, Improvised Scanning Digital Panoramic Camera, Panorama, the journal of the International Panoramic PhotographersAssociation , Fall 2001,Volume 18, Number 3, pp 4-6.