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Applications for an improvised digital streak camera

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This is a follow-up to my previous experiments related to the development of a low cost digital camera based on the partial dismantling of a hand-scanner and subsequent installation of the linear CCD array into the body of an old Minolta SLR camera. You can read about those by selecting [Improvised scanner based camera](#) and [Better scanner based camera](#). For a good background on what strip and streak cameras look like and operating and control features associated with strip cameras in particular, check out

[Basics of Strip Photography.](#)



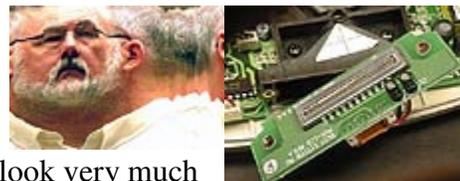
Over the years, while introducing the concept of what strip



and streak camera are all about, I relied on starting the discussion with the fundamental difference in the process by which leaf and focal plane shutters expose film in a camera. The point was to draw upon a clear understanding of the difference between an instantaneous and everywhere simultaneous exposure associated with a leaf shutter and the piecemeal, sequential, nature of an exposure associated with a focal plane shutter. The idea was that if one understood the fact that focal plane shutters may lead to focal plane shutter distortion it would be a simple step to extrapolate such thinking into a "new" system where the exposure is not made by a moving slit or slot but onto film moving past a slit past which an image of an object also moves.

This principle then leads one to examine systems where the slit in the camera remains stationary while the image of a subject also remains stationary and possibly simply changes in brightness or which moves along and over the slit while the film below is also in motion. This is the principle by which "streak" cameras operate. They make excellent image-based timing devices and function, essentially as "stopwatches", accurately indicating elapsed time and even changes in image (and thus subject) location over the slit vs. time.

Generally streak cameras are of very little interest to the average photographic audience and my major effort in the past was devoted to exploring situations where the image of the subject also moves across the exposing slit. When this is the case images that often look very much like the original subject can be recorded and in this application the cameras are called

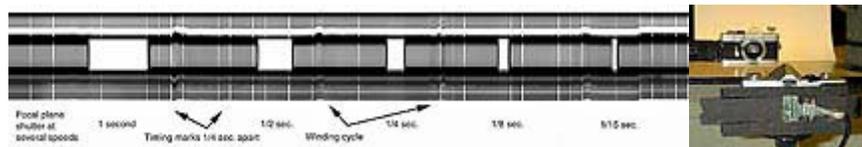


"strip" cameras. This system of exposure still yields images that along the direction of motion of the film are "time" records but because images are recorded sequentially yet viewed instantaneously we tend to forget how the records are made and simply concentrate on the unusual, or the seemingly unusual, capabilities of these strip photographs. Cameras such as these are used for photofinish photography at races, peripheral records of archeological objects such as vases or industrial records of pistons and cylinders (or human heads as shown here!), or for extreme wide angle photography based on panoramic cameras that "scan" a surrounding scene while the moving film behind the exposing slot memorizes the various views presented to the slit over time by the rotating camera.



In spite of the numerous applications for strip cameras, the streak version is often ignored because the images it delivers are not really pictures that look like a scene as perceived by a photographer or others. Streak records are simply records of the relationship over **time** of a subject that either is stationary in a given spot across which the slit or CCD array is placed or which move along it, but not across it because then a "strip" record would be secured. Streak cameras deliver just that. Streaks. These streaks stand for or are intimately related to time.

Examples of what these streak/strip cameras can do when used in the streak mode are not readily available and so I set out to make several examples of applications for streak cameras using an improvised digital camera into which I installed the linear array CCD from a cheap handscanner. The illustration to the left shows what the linear array looked like once installed into the camera body. As you can see it resembles a slit at the film plane of a film type camera. Further information about how such a camera was assembled and used for "strip" applications is described in other articles mentioned above.

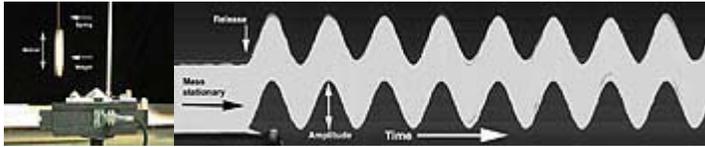


To demonstrate the timing capability of streak cameras, for the first example I chose to show how the exposure time of a camera shutter's can be measured. These times, generally less than a second in duration, are difficult to measure without specialized equipment. A plain stop-watch will not do as the times are less than one second in duration.

Absolute timing is only possible if some sort of reference timing signal is introduced into the scanner program or is included in the data gathering process from an external source. I chose this latter method as it was the most direct and intuitive way to do it. I simply arranged for the light of a stroboscope flashing at a calibrated and known time interval to "blast" the CCD with light every so often. This left a line on the output image which could then be easily identified in terms of record length as the time that had elapsed

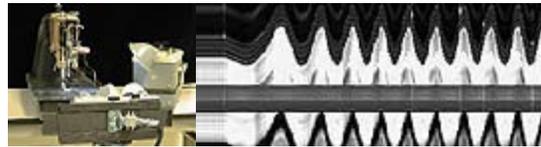
between flashes. The external light flashes provided the "time base" for the ultimate streak record.

The linear CCD array was lined up vertically and a light background was placed behind the shutter. When the shutter opened this would cause a local rise in light level that would be detected by the array. Since it was displaying what the light level at the subject was and this was in turn controlled by the shutter, in the final display, the duration of operation of the shutter at 1, 1/2, 1/4, 1/8 and 1/15th second could be easily visualized. As the exposure time was halved so was the length of each light streak caused by the operation of the shutter.

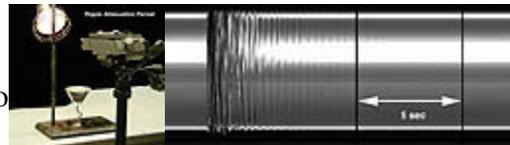


Next I decided to demonstrate how one can get an estimate of oscillation rate of a mass attached to a spring. For this a weight was attached to a spring and the CCD lined up with the vertical path that the weight would cover as it was allowed to freely bounce up and down once released. The scanner was turned on and its data transfer rate was adjusted to a high value by making the chopper wheel turn as fast as the software in the program running the scanner would allow without going into the "too fast" zone. Once the scanner started to transfer data the weight was released and started to oscillate up and down and this was clearly seen, even as the record was being acquired, as a sinewave pattern displayed on the monitor.

The third experiment consisted of aiming the linear array of the scanner across the face of some moving and stationary parts of a sewing machine. The idea here was that one might be able to track the direction of motion of various levers and mechanical parts associated with the stitching process. Once the scanner started to acquire data the machine was turned on and, indeed, parts did move in repeatable and cyclic fashion just as was expected. Although nothing unusual was observed the image obtained was a simple visual confirmation of how a sewing machine operates.

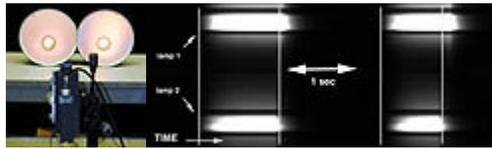


Next, an experiment was conducted to determine how long it would take a liquid surface to come to rest after being disturbed by something. For this measurement, which could have been done by simply using a stopwatch (but, of course, no actual "proof" would thus be obtained), the linear array was lined up across the diameter of the top of a vessel and a light source was set up in such manner that the light was reflected from its surface directly and specularly into the camera lens.



Once the scanner was turned on, the surface was touched and, as expected, ripples formed which then disturbed the light reflected to the camera and the CCD array. Eventually they settled down and a smooth surface was reestablished. The streak-record

thus obtained was a visual proof of the length of time that it took for the vibrations to settle down.



The next experiment was designed to show whether two events such as lights being turned on and off and that look very similar to the eye in terms of simultaneity, are, in fact, simultaneous and identical in duration or not. For this I chose two floodlamps that I turned on and off by hand trying to perform the action simultaneously. The linear array extended across the scene and cut through the middle of each of the light bulbs.

When the scanner started to gather data, I started the process of turning the lamps on and then off. The record shows that the lamps, while very similar in time that they turned on and off, are not exactly identical in terms of when they did so and there is also a slight discrepancy in the duration of one lamp's light emission vs that of the other.

Another experiment that I thought would be an interesting application for a streak system was to determine the rate at which dye was absorbed into some material such as absorbent paper. For this the CCD linear array was lined up vertically and along the paper that was going to be absorbing some ink. Once the scanner was recording data (in this case at a relatively low rate governed by the fact that the DC gearhead motor driving the chopper wheel in the scanner's data acquisition chamber) the ink was added to the bottom of the paper and it started the process of rising due to "wicking" action. To keep track and quantify the position of the dye vs time, I included on the paper two marks located 5 cm apart. In this case the "timing marks" were introduced by slowly passing a piece of black paper two times in front of the camera's lens at 1 minute intervals.

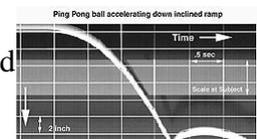


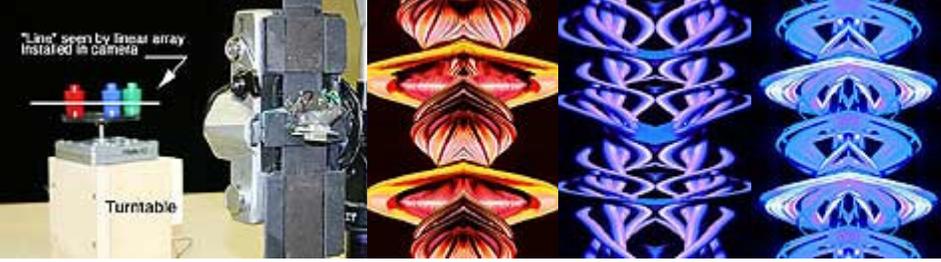
The image obtained clearly shows the significant change in velocity of the dye as it rises ever higher along the length of the hanging, absorbent, paper. At first there is significant acceleration of the ink upwards. With time, however, the rate of ascent slows down and eventually, in fact, it stops altogether as all the dye becomes absorbed by the paper or when evaporation plays a significant role in the dye transport process.

I also decided to make a record of the acceleration of a ping-pong ball as it runs down an inclined ramp. For this the linear array was lined up slightly above the edge of the channel along which the ball would be rolling. In order to be able to determine the distance that the ball moved on the track an object of known width was installed slightly behind the channel. Because this object would not move during the experiment it would leave a streak of constant width along the final record. This would serve to provide a scale of distance against which a graph of displacement vs time could be prepared.



Again, a stroboscope flashing at 4 flashes per second provided the "time base" for the event and after the





scanner started to acquire data the ping-pong ball was released from

the high point. It rolled down the ramp and there it hit a hard stop which caused it to rebound.

The visual or image data obtained from this experiment clearly shows the changes in subject position from rest vs. time. This can then be readily transformed into a mathematical expression for the performance of the ball as it accelerates down the inclined ramp.

In this case, from the graph of position vs. time the following data can be extracted: after a time of .5 second from time of release the ball had moved 1.4 inches, at 1 second it was at 4.6 inches, at 1.5 seconds it was 10.2 inches and at 1.7 seconds it had moved to 13 inches.

Finally, there also are applications of this linear array that are more geared to the artistic and creative sensibilities than to measurement and physical behavior of subjects and when used for this purpose the linear array can be used to produce images that often boggle the imagination. The array is simply lined up in such a manner that a subject translates across the array, such as by rotation, vibration or translation, and the resulting output can be a startling image as shown by the "mirrored" illustrations provided here.

I hope that you will agree that streak techniques, whether based on film or solid-state sensors, can be used to examine a wide variety of interesting applications.

If you'd like to communicate with me about this topic simply send me e-mail by clicking [HERE!](#)