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Animated Movies on the 2250's

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Functions which change in time are often difficult to understand and vizualize, when they are expressed mathematically, or even shown as a series of "snapshots" at different times. The 2250 display consoles can be programmed to display a changing function of one or two position variables. Especially if parameters can be changed from the keyboard and the display started again, the 2250 is good for getting the "feeling" of a function.

Andy Hanson, of the Theoretical Physics Group, and I have produced a program using the Unified Graphics System to drive a 2250. Andy's problem had two parts. First, he had a physical theory which resulted in a function of position and time, and of several parameters which were fixed in any particular case. We wrote a program to show the function on the 2250, with parameters which could be set and reset from the keyboard. This turned out to be very valuable, and allowed him to investigate the theory in ways which the "snapshot" method and batch processing would never have allowed.

The second part of the problem was to present his work in a lecture. The best way to transfer the displays from the 2250 screen to the lecture hall was to make a movie showing selected cases.

The First Time

When you try to reproduce on film something which is happening on a 2250 screen, you discover that movie cameras and human eyes are different. Eyes are open most of the time, and they register changes fairly slowly. The camera shutter, on the other hand, is open only half of the time. The other half is taken for moving the film between frames, and if something happens while the shutter is closed, it is not recorded.

The 2250 display is retraced about 40 times in each second. This is too fast for the human eye to notice, and the display seems steady. However, if you just set your camera up in front of the screen and shoot, at the usual 24 frames/second, some frames will be exposed while the beam is drawing the picture, and some will only see the glow which stays on the screen after the beam has passed. If the display takes a relatively long time to draw, then one frame may show the afterglow for part of the picture and the trace itself for the rest. The resulting intensity variations from frame to frame produce a very annoying flicker. The effect cannot be eliminated in a system in which the 2250 and the camera are running independently of each other. The solution is somehow to synchronize the camera and the display so that each frame sees the same number of retraces.

An even more annoying problem is due to the hardware of the 2250s. As long as the display is not changed, the screen is controlled by a small computer which drives the retrace 40 times per second. But when a new picture is transmitted from the 370, it takes a certain length of time to transmit the new picture, and during this time the screen is blank. These pauses are sometimes several seconds long, which can be very irritating. The pauses are of course present in a film of the 2250, and in fact are even more bothersome in the film. (Perhaps we are used to different levels of technical perfection from Hollywood and Poughkeepsie, so we unconsciously smooth over the rough spots in the 2250 display.)

Andy and I decided to shoot the movie anyway, without synchronization, because the lecture date was approaching. We put the Comp Group's 16-mm movie camera on a tripod in front of the 2250 screen and fired away. The results were mediocre. The display changed about ten times a second, and each change resulted in an almost blank frame. A few times during the film, the display stopped for several seconds, and we had to edit those parts after the film was developed. The final result was flickery, but it was usable.

Technical Information

We used the Comp Group's Arriflex 16-mm movie camera, set on a tripod in front of the scope. (We used the portable tripod that cranks up and down, not the more stable wood one, which doesn't adjust easily.) Shooting in the normal room environment produces reflections of room lights and even the curious bystanders. Vern Smith of the Data Analysis Group removed the Polaroid camera from the black tunnel, which requires a Secret Tool. (Charlie Hoard should be able to do it too.) We taped the tunnel up and swathed the end and the camera with a black cloth to prevent all light leaks.

The camera itself is very easy to use. The eyepiece is open whenever the shutter is closed, and you see exactly what is going onto the film. The only controls are focus and aperture, on the lens, and off/on on the left side of the camera body. (Push down for on, right for off.)

The power supply is separate. We used the battery pack, which is a black plastic box about 3- by 5- by 6-inches, with a strap. It must be recharged after every 1500 feet of film by plugging into the wall overnight. Arriflex recommends a recharging time of 3 to 4 hours after a 400-foot load and 5 to 6 hours after an 800-foot load. They say it should <u>never</u> be charged more than 12 hours. There is also a power supply, but it is heavier than the battery and must be plugged into the wall. The power cables have a three-hole Cannon plug on one end, which fits the bottom socket on the camera, and a double banana-plug affair on the other which fits both the battery pack and the power supply. There are three cables of different lengths. Make sure you get the right polarity--red is positive and black is negative.

The 400-foot film magazines will take the standard 100- or 200-foot reels of fresh film just as they come from the store, and can be loaded in subdued light. I haven't tried a 400-foot load, which is wound on a core, and must be loaded in total darkness. Practice first with used film.

We use Tri-X Reversal Film, with an aperture of f/8. It came out a little dim, and f/5.6 would be better. Plus-X would have less "grain", but you would have to set the aperture to f/2.4, which would make the focusing more critical.

Film is available off-the-shelf from Keeble and Shuchat (2323 Birch in Palo Alto, just off California Ave.), and costs $7 for 100 feet of Tri-X. Cine-Chrome Labs (4075 Transport Ave., Palo Alto, near Bayshore at San Antonio Road) will do same-day developing if you hit their schedule right, or it may take 48 hours. The cost is 4¢ per foot, with a $5.50 minumum. Both places have resale-number cards made out in the name of Stanford Linear Accelerator Center. The number is G-1337.

Synch or Swim

The problem came up again of course--Andy had more theories and more lectures to give, so off we went, this time to do it with synchronization.

The Arriflex movie camera has an "animation" motor which allows the camera to take one frame at a time, in response to an external signal. What is needed, ideally, is an interface between the computer and the camera which would allow communication in both directions, so that the computer could read the camera status and control the camera action and/or the screen display accordingly. The simplest system would allow the computer to trigger the camera to take one frame. A time delay could then ensure that the display remained while the frame was being taken.

Since our entire operation so far was financed from petty cash, and since once again we didn't have the time to develop even a simple system, we resorted to button-pushing. The program was written so that each attention from the 2250 keyboard would cause the picture for the next frame to be displayed. To make the film, one person sat with a finger on the keyboard and a finger on the camera trigger, and alternated buttons at about two cycles per second. The end of each film sequence was signalled by the 2250 beeper, so it wasn't even necessary to watch the screen. To shoot 350 feet of film (about 14,000 frames) took six hours, including stops for changing film, reprogramming a few sequences, and about an hour break when the computer was down. We were lucky in that the computer service was consistently good. We were never bothered by the pauses which sometimes occur when a new picture is sent to the screen driver, and which would have caused blank frames.

This method of synchronizing camera and computer is obviously not the easiest, but it worked. We would have spent more than six hours in designing and debugging an eletronic interface. If we were planning to make many more films with the 2250's, an interface would certainly be worth making.

The rest of this note is a description of the animation motor and some information about exposure times.

The Animation Motor

There are two motors for the camera. The first simply turns on or off, and drives the film and shutter at the usual 24 frames per second. Each frame is exposed about 1/50 sec. The second is the animation motor, which allows the film to be exposed one frame at a time. Exposure time can be set to 1/8, 1/4, or 1/2 second, with a maximum picture taking rate of 4, 2, or 1 frames per second. The motor controller, called an "intervallometer", is triggered by pushing a button. The switch labeled "CONT/STOP" selects continuous (free-running at 4, 2, or 1 frames per second) or stopped (but triggerable, one frame at a time). The switch labeled "REG/ALT" selects regular mode (one trigger per frame) or alternating mode (one trigger opens the shutter, and the next closes it).

Pull the controller from the rack in the GIF room by unplugging the power cord and the computer interface cable, and unscrewing the four bolts that hold it to the rack. Cart it down to the 2250's and plug it in. Hook up the cable from the controller to the motor. This is the 20-foot cable with the round green plug on one end and the rectangular black one on the other. (The "shutter" cable is irrelevant and can be left off.) There is a power supply in the controller, so you don't need anything else. Put the switches on "ON", "FWD", "REG", and "STOP". Push the trigger button a few times. This does two things. First, it shows you that the motor works, and, second, it positions the motor. Turn off the controller, and don't rotate the motor shaft again until it is in the camera.

Take the regular motor off the camera, by loosening the clamp (bottom rear of the right side) and gently working the motor straight back. Take off the lens or the front dust-cover, open the eyepiece cover, and make sure the top dust-cover is in place, where the film magazine goes. Now when you look through the front opening you will see a rectangle of light if the shutter is closed, and no light if the shutter is open.

Put your finger in the opening where the motor was, and find the rubber coupling that the motor shaft was in. <u>Don't touch the mirror.</u> Turn the coupling with your finger and watch through the front opening to see the shutter turning. Run it through a few cycles, just to get an idea of what goes on in there, and finally leave it with the shutter closed. (That's when you can see the rectangle of light, remember?) About halfway between opening and closing is nice.

Now put in the motor. The frame counter goes up and the cylinder containing the motor itself goes to the camera's right. The motor goes all the way in so there is no silver showing. Tighten the clamp and you're all done. Turn the motor by hand and watch the shutter move.

Changing Exposure Time

To change exposure times, turn the intervallometer OFF. Push the slide switch on the motor, not hard but a little more than gently, in the direction you want it to move. It will move a little and then hang up. Now if you rotate the motor gently with the knurled knob (counter-clockwise works the best) you will reach a spot where the slide switch moves to the next position. Don't force it.

Exposure Guide

We used Tri-X film again, with an exposure time of 1/8 second and the aperture at f/11. The following table gives the corresponding apertures for different films and exposure times.

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f-Stop vs. Film Speed and Shutter Speed

Exposure (sec)	1/8	1/4	1/2
Tri-x (ASA 200)	f/11	16	(22)
Plus-X (ASA 50)	f/5.6	8	11