On-Line Movies

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... just mounted a field tape ... now typing the word "movie" ... watch the screen when I hit the carriage return ... a new world for seismic interpretation !

Movies of Field Tapes

The big news from the Stanford Exploration Project is the excitement of on-line movies. Eventually we will want to tell you about movies of wave propagation and data processing. But starting at the beginning, there is a lot of excitement about movies of raw seismic data. Even conventional reflection data is three dimensional (time, offset, and midpoint). So we can view the data by sweeping various planes through it to make a movie. By sweeping through the data fast enough, it is possible to get a better idea of what is on the data than you could by examining the still frames. The simplest movie is to look at the seismic profiles as they are collected in the field. But the successive common shot profiles are displayed at a rate of about 16 frames per second, that is, about 100 times the speed of the field recording.

You expect to see, and you do see, the familiar hyperbolic arrivals from quasi-planar reflectors inside the earth. You also see something which is hard to explain and quantify. You perceive lateral motion. As the ship moves forward, the texture of the wavefronts seems to move backwards. Viewed from the geophone cable, the earth moves backwards underneath you. The hyperboloids remain essentially fixed, because the reflectors are predominantly horizontal layers, but irregularities on the hyperboloids move toward increasing offsets. The irregularities themselves are not particularly describeable. It is like you are driving along the highway at night. There may be nothing particularly distinguishing about the road surface, but you have a well developed ability to perceive its motion. The occasional diffraction is like an occasional post you see along the road; it moves the same relative speed as everything else. This phenomena is not limited to the large clear events, but seems to apply to almost everything.

It is better to see these movies rather than to read about them. Instead of describing the many other movies we have made, I will leave you to see the video tape we plan to make.

From Cheap Graphics to Movies

On the face of it, it is not possible to make movies using the CRT graphics systems which cost less than about $100k. This is because they have small intrinsic memories, and can be downloaded by DMA (direct memory access) at a rate of only about one frame per second, along with a visually disturbing transient. What saves the day is that seismic data contains considerably less information than an ordinary picture. So it is mainly a question of being able to slice things up and move them around to appear where and when you wish.

I knew movies would be valuable. When Raul Estevez made his prism movie, we immediately recognized phenomena which we had never noticed or understood on the still frames. So although I always wanted on-line movies, I was afraid that the investment would be too heavy in cash and human time for our small group. As it happened, we came in the backdoor, for only about $15k and about 6 man months time.

We began by needing about 6 additional text terminals. We were accustomed to paying about $2-3k per terminal. But we discovered that for less than an additional $1k per terminal, we could get color graphics terminals. We purchased 9 GIGI terminals from the Digital Equipment Corporation. These terminals write text on a 384 by 240 dot matrix. But the dots may also be individually addressed. It is not particularly important that there are also 7 colors available. (Also the color "attribute field" is coarser than the dot matrix field.) I wrote the line drawing software and I am pleased to report that it has turned out to be the most frequently used plot program on our system. I also wrote a wiggle-trace-variable-area plot but it is slow, lacks resolution, and is not popular. The terminals also seemed to be very useful for making slides. We just photograph the screen. Then we got the idea that we would use the 9 cheap terminals for development but would get one good terminal for display of final results. Thus the good terminal would be justified whether or not we were able to make satisfactory movies.

What I didn't realize at first was that the better terminal was a lot more than just a larger color pallet and a 512 by 512 dot screen. The difference was like going from a two dimensional graphics device to a four dimensional device. The first dimension came from the ability to control intensity as well as color. The second dimension came from the ability to make movies. Movies are made by one of two methods. The easy method was to manipulate the bit mapping from video memory to the screen, thus giving us any movie which could be completely contained in the 512 by 512, 8-bit memory. The better method turned out to be the DMA from the VAX computer.

Vendor Selection

We selected the AED-512 manufactured by Advanced Electronics Design. It costs about $15k. Our reasons for selecting this product were: First, the salesman gave a good presentation in our lab and loaned us the demonstrator over a long weekend. Second, the company is nearby Stanford, facilitating consultation and repair. Third, we could afford a more expensive unit with more capability but companies selling more expensive units had sold far fewer of them, so we expected the AED unit (more than 500 sold) to be fairly well debugged. Fourth, we believed that AED had a working DMA interface to the VAX. Five minutes after we plugged in our new DMA interface, it started smoking, and for a long time the manufacturer seemed unable to repair or replace it. Happily, I can now report that the manufacturer can deliver a working DMA interface to the VAX.

Availability

We believe that our main contribution is in demonstrating what is possible. Naturally we also offer our plot software to those who can use it, but we can give no installation assistance. The software will be of little or no use on computers or operating systems which do not support the C language.

Credits

The main effort of developing the on-line movies was the work of four people. Jeff Thorson did most of the work at the product selection stage, and wrote prototype and low level programs. Chuck Sword did the DMA work. Rick Ottolini converted the prototypes into a set of production programs. Rob Clayton contributed by teaching Chuck. He also wrote the line drawing software for the AED. Alfonso Gonzales, Larry Morley, and I provided an eager user community. My main effort was in developing the line drawing programs on the GIGI terminals. These mimic the line drawing programs of Rob Clayton for other devices.

```
# Simple movie program, Laterally variable reflectivity.
# Produces convincing synthetic field tapes.

implicit undefined (a-z)                                                    implicit
integer kbyte,it,nt,ih,nh,is,ns,iz,nz,it0,iy
real p(512),b(512),refl(25,16),z(25),ranz(25),random
character*40 plot
data plot / "/scr/jon/plotfile"/
kbyte = 1

open(3,file=plot,status='new',access='direct',form='unformatted',recl=1)   open
close(3,status='delete')                                                    close
open(3,file=plot,status='new',access='direct',form='unformatted',recl=1)   open

nt = 512
nh = 48
ns = 10                          # Even ns=3 makes convincing movies.
nz = 25
do iz=1,nz                       # Reflector depth
        z(iz) =  nt*random()     # random() is interval (0,,1.)
do iz=1,nz                       # Reflector strength with depth.
        ranz(iz)=2.*random()-1.
do is = 1,ns                       # Prepare a random reflectivity (depth,midpoint)   do
        do iz = 1,nz
                refl(iz,is) = (1.+random())*ranz(iz)
z(1) = 0.
do is=1,ns
        refl(1,is) = 1.          # Direct arrivals are not random.
do it = 1,nt                                                # Prepare a wavelet
        b(it) = exp(-it*.08)*sin(.5*it-.5)
do is = 1,ns {                                              # Shots
        do ih = 1,nh {                                      # down cable h = (g-s)/2
                iy = (is-1)+(ih-1)                          # y = midpoint
                iy = 1+iy-ns*(iy/ns)                        # periodic
                do it = 1,nt
                        p(it) = 0.
                do iz = 1,nz {                              # layers
                        it0 = sqrt( z(iz)**2 + 100.*(ih-1)**2 )
                        do it = 1,nt-it0 {
                                p(it+it0) = p(it+it0) + refl(iz,iy)*b(it)
                                }
                        }
                write(3,rec=kbyte,err=20) (p(it),it=1,nt)
                kbyte = kbyte+nt*4
                }
        }
stop
20 write(6,30)
30 format('error')
stop
end
```