

A WORKSTATION APPROACH TO INTERACTIVE INTERPRETATION

H. Roice Nelson, Jr.

Landmark Graphics Corporation

ABSTRACT

Micro-computer technology developments have resulted in the ability to put the compute power of a base-line IBM 4300 or a VAX-11/780 size mini-computer in a users office or at a remote site. These capabilities have across-the-board application for geophysicists; especially since much of the work we do is so compute intensive. This paper reviews some philosophical implications of these developments and provides specific examples of how this evolution is presently being implemented by academia and industry.

In the book Megatrends, John Naisbitt presents ten trends that are changing our society, and by association our science. Four trends that have specific application in the image processing of geophysical data are discussed in some detail. Examples of how developments in the exploration industry relate to these trends are presented with slides, project design summaries, and video. Seismic interpretation, which is more image processing/image understanding than signal processing, will be affected most directly by the new developments in graphics processors and micro-computers. These developments are culminating with the development of high-compute-power workstations for interactive interpretation with application software packages tied to geophysical needs.

MEGATRENDS

Trends, like horses, are easier to ride in the direction they are already going (slide 2). This common sense statment comes from the introduction of John Naisbitt's book Megatrends. Just as there are structural and stratigraphic geologic trends, there are changes, transitions and trends in society, scientific study and technology. By "mapping" the direction of these changes, Naisbitt has provided one window for previewing the future. For the most part these "megatrends" are straight-forward concepts that, when verbalized, we see examples of in all aspects of our lives. Four of these trends have direct implications in the image processing/image understanding of the geophysical data used in exploring for hydrocarbons.

It is a widely accepted fact that we are in a "megashift" from an industrial to an information based society (slide 3). However, how has this fact been incorporated in exploration geophysics?

Seismic exploration results in large amounts of data or information. For the most part, this data is handled in a manufacturing mode rather than in an information processing manner. From an overall viewpoint, seismic acquisition, processing and interpretation are batch operations. Survey locations are given to a seismic crew, and they "manufacture" a set of seismic tapes. There is very little user involvement with the data, except for quality control. The same type of "manufacturing" procedure happens in processing a seismic survey. Batch processing procedures are established, and each section in the survey is processed with a slightly modified set of computer cards or card images. Interpreters receive the processed data and "manufacture" time maps. There is little opportunity for interactive evaluation of the data. Compare this with what MIT's David Birch has shown; almost 90% of the 19 million jobs created in the United States in the 1970's were not in the goods-producing sector. As Birch says, "We are working ourselves out of the manufacturing business and into the thinking business." (1) How many geophysicists are working with the data and not just acquiring, processing or interpreting it in a manufacturing mode?

One of the main reasons explorationists have not used available technology more (and we probably do use new technology more than most professions) is because the advancements often seem to be people remote. The second megatrend summarizes this concept: "for every high technology action, there is a high touch reaction or the technology will be rejected" (slide 4). This is another way of saying there must always be room for the human element. The fastest and most powerful computer in the world will not be widely used if it is hard to communicate with it. This is a major reason for the success of the VAX seismic processing systems. It is much easier for users to work with this computer system than many other similar sized systems, largely because of well tested and extensive documentation. Similarly this is why home computer systems like Apple's Lisa use tools like a "mouse" for easy user menu control. A user does not have to know how to type to be comfortable in working with the system. The human ease of use makes the system more user acceptable to a wider audience.

The fifth megatrend relates directly to basic business philosophy that is already set within many oil exploration companies. Naisbitt's premise is that our centralized structures are crumbling, that we are decentralizing and growing stronger from the bottom up (slide 5). An everyday example is the proliferation of specialized cable TV. Examples of this same trend in exploration geophysics include: distribution of recording instrumentation with sign-bit, wireline/radio telemetry systems, and cassette recording units; proliferation of mini-computers to distribute, support and replace mainframe seismic processing shops; and the development of workstations for interactive processing parameter selection and seismic interpretation. Telecommunications and the power of new micro/mini-computer systems allows explorationist to do virtually all of their work remote from the large central computer site.

This decentralization relates directly to Naisbitt's eighth megatrend, i.e. that we are moving from hierarchies to networking (slide 6). The computer is smashing the pyramid in that it allows knowledge networking, and the restructuring of businesses into smaller and smaller units that are more entrepreneurial and participatory. A network is not a thing, it is a process, a three-dimensional communication structure in which the constantly changing participants treat one another as peers because information has nothing to do with status in a hierarchy. (2) One of the reasons the Japanese have had very impressive productivity gains is because of implementing "network type" management procedures.

Each premise discussed above relates directly to a workstation approach to interactive interpretation. If an individual user has direct hands-on-access to the compute power of a mini-computer, it is easy to conceive of the ability to process, manipulate, reprocess and better understand (interpret) the information contained in the data. The three basic areas that are being attacked by academia and industry in order to provide exploration workstations are graphics processors, micro-computer based central processing units and application software.

GRAPHICS PROCESSORS

The developments in Landsat type image processing techniques provide an example of how to attack the problems of interacting with digital displays. It is technically feasible to sit down at a workstation, have your world displayed (slide 7), zoom in on areas of interest (sides 8-13), and specify data sets that are going to be interactively evaluated in order to understand the image. In oil exploration, these steps would include: (1) requesting a regional display; (2) defining a specific area of interest; (3) requesting a listing of the information in the digital data base; and (4) display the surface locations of the different data sets (slides 14 L&R). Even though this is technically feasible the problem has yet to be adequately solved. One problem is that there are cost effective limitations on working with these large data bases. Presently this data base handling is not possible on a stand alone graphics processor.

An example of an extensive image processing effort is the work under way by the movie industry, specifically for the purpose of creating dynamics. Digital Productions has interfaced a high resolution graphics processor to a Cray, which allows the creation of images with up to 250,000 polygons in 100 seconds. (3) This scale of image processing is not used with present geophysical display applications, although it is easy to come up with problems that require this much image processing. One way our industry will meet this scale of needs is by networking stand alone workstations to vector processors that have special application algorithms (slide 15L). This will allow the user to use the workstation for small jobs, and pass process-intensive

operations on to special purpose computers.

For seismic display, the display characteristics become the critical link. Vector graphics systems have been used in mapping and in seismic processing research shops. However, they do not allow the display of enough data for routine production seismic image evaluation. Because of the amount of data that must be worked with, the typical "workstation" for the past decade has been a storage tube system with some local intelligence (slide 15R). Because of recent developments in raster graphics technology, these storage tube systems are being replaced for seismic data evaluation.

1983 is seeing the introduction of raster graphics processors that can cost effectively handle 1280 x 1024 x 24-bit pixels non-interlaced at 60 Hz. Seismic sections can be effectively displayed in color with 5-bits of information for each pixel. This still leaves three overlay planes for interpretation information on an 8-bit pixel raster system. There are also "real time" 2D migration processing tests being run with 2000 x 2000 pixel monitors (4).

The most logical configuration for an interpretation system would be based around this type of graphics processor, a powerful CPU, a true three-dimensional display device, hardcopy capabilities, as well as a large screen display device (slide 16). Large screen devices that can be selectively rewritten provide a computer controlled softcopy of full scale wiggle seismic sections. One of the most advanced of these systems is the IBM 8,000 x 8,000 pixel Large Scale Information Display (LCID) device (slides 17 L&R). This system is based on a projection liquid crystal display (5). The picture is written by sweeping 32 micro-sized lasers across the liquid crystal. It takes about one minute to draw a complete 64 million pixel image.

CENTRAL PROCESSING UNIT

Interactively processing and developing an understanding of the information on seismic sections requires a fast CPU that is easy to use and closely coupled to the graphics processor. There are many ways to accomplish this, ranging from the direct Cray connection described above to having no processing capabilities outside the graphics processor. For normal geophysical display applications there is a need for either image processing or signal processing. Both of these operations require that extensive compute power be available to the user.

A major premise of this paper is that a user is better able to attack interactive processing parameter selection or interactive interpretation only if there is sufficient local CPU intelligence and memory. Furthermore, if this distributed computer power is networked, it allows geophysical users to communicate rapidly on related subjects, to share resources, and to leave a centralized host available for processing a queue of large batch oriented

operations. Selection of a micro-CPU with the power to accomplish these operations becomes a key factor in designing a workstation for interactive interpretation. The CPU needs to be fast, available, use a proven operating system, be able to follow rapidly changing technology, have a large peripheral or bus following and, operate on 32-bit floating point data.

The three basic choices that are available are the National NS-16032, the Motorola 68000, or the Intel iAPX286 (80286) integrated circuits. Tables 1 and 2 give execution times and performance comparisons to the VAX-11/780 for the Intel and Motorola chips (6). There are more complete discussions available elsewhere describing selection of the best CPU for the type of stand alone workstation required for geophysical applications (7).

APPLICATIONS SOFTWARE

The real key to how well a workstation can be used by geophysicists is the application software that is tied to it. Eight generalized steps have been outlined describing how to do interactive 3D interpretation (slides 18 A, L&R) (8). The first 2 steps require the development of a digital data base, including location maps and depth information like well log or seismic information. The digital data is then processed (filtered, attribute analysis, etc.) and the effect of the different algorithms evaluated on the screen in softcopy. These two steps would be followed by the interpretation, including interactive picking, countouring and surface definition. Progress during the interpretation session would be documented on paper and stored on magnetic media. This allows rapid retrieval for presentations or updating an interpretation. There are many separate and different application capabilities that have been developed, some of which can presently be implemented to meet the needs of seismic interpreters. These utilities include mapping systems (slides 19 L&R), interactive picking of seismic data (slides 20-21 L&R), rotating seismic horizon picks (slides 22 L&R), fitting surfaces to these picks, and panning or scrolling a seismic display (slide 23 L&R).

The need for using interactive graphics workstations is particularly important in working with the volumes of data that come from a 3D survey. Because spatial sampling is so much larger than temporal sampling much more subsurface area can be displayed on a graphics terminal with horizontal sections than with vertical sections (slide 24L). There is a need to be able to display a horizontal section on the workstation monitor with the same resolution that is available on 16-mm movie presentations (slide 24R), cartoon this data interactively (slides 25 L&R), and interactively pick events on the screen (slides 26 L&R). Related displays that have potential use by interpreters include fence diagrams and contour maps (slide 27 L&R). A key is to convince users that seismic can be displayed and picked on a graphics unit with similar or better resolution and ease than on paper sections

Table 1. Execution times

Machine	Language	word	Time (milliseconds)			
		size	search	sieve	puzzle	acker
VAX-11/780	C	32	1.4	250	9,400	4,600
	Pascal (UNIX)	32	1.6	220	11,900	7,800
	Pascal (VMS)	32	1.4	259	11,530	9,950
68000 (8 MHz)	C	32	4.7	740	37,100	7,800
	Pascal	16	5.3	810	32,470	11,480
	Pascal	32	5.8	960	32,520	12,320
68000 (16 MHz)	Pascal	16	1.3	196	9,180	2,750
	Pascal	32	1.5	246	9,200	3,080
8086 (5 MHz)	Pascal	16	7.3	764	44,000	11,100
432/rel. 2 (4 MHz)	Ada	16	35	3200	350,000	260,000
432/rel. 3 (8 MHz)	Ada	16	4.4	978	45,700	47,800
80286 (8 MHz)	Pascal	16	1.4	168	9,138	2,218
80286 (10 MHz)	Pascal	16	1.1	125	7,311	1,774

Table 2. Performance Relative to VAX-11/780

Machine	Language	word	Ratio to VMS Pascal (>1 => faster)				
		size	search	sieve	puzzle	acker	avg±sd
VAX-11/780	C	32	1.0	1.0	1.2	2.1	1.3±.4
	Pascal (UNIX)	32	.9	1.2	1.0	1.3	1.1±.2
	Pascal (VMS)	32	1.0	1.0	1.0	1.0	1.0±.0
68000 (8 MHz)	C	32	.3	.4	.3	1.3	.6±.4
	Pascal	16	.27	.32	.36	.85	.5±.2
	Pascal	32	.24	.27	.35	.80	.4±.2
68000 (16 MHz)	Pascal	16	1.1	1.3	1.3	3.6	1.8±1.0
	Pascal	32	.95	1.0	1.3	3.2	1.6±.9
8086 (5 MHz)	Pascal	16	.2	.3	.3	.9	.4±.3
432 (4 MHz)	Ada	16	.04	.08	.03	.04	.05±.02
432/rel. 3 (8 MHz)	Ada	16	.32	.26	.25	.21	.26±.04
80286 (8 MHz)	Pascal	16	1.0	1.5	1.3	4.4	2.1±1.4
80286 (10 MHz)	Pascal	16	1.3	1.9	1.6	5.6	2.6±1.7

(slide 28 L&R).

Computer graphics allows a detailed analysis of seismic data that has not been possible before. An example is interactively calling a CMP gather, interactively picking stacking and interval velocities, and then seeing how well the NMO correction flattens events (slides 29 L&R). Complex trace analysis is greatly enhanced with local compute-power in (slide 30), an interactive workstation. The effect of a 90 degree phase shift for traces across a pinchout illustrate this (slides 30-35). The graphics processor allows very rapid color reassignment which can completely change the look of a vertical (slides 37-38 L&R) or horizontal section display (slides 39-40 L&R, 41L). With digital data close up vertical sections can be immediately displayed (slide 41R), and then a surface fit to the interpretation picks displayed (slides 42 L&R). Color reassignment can completely change the characteristics of field seismic data (slides 43-44 L&R). When a sequence of these sections are rapidly displayed, an interpreter is able to recognize patterns that explain the subsurface geology (slides 45-46 L&R). Another animation procedure that has been illustrated at the SAL is the display of a sequence of numerically derived seismic wavefronts (slide 47).

The types of application software described above have not been implimented in a production enviroment. Because this is still somewhat of a research area it would be useful for different professions that are attacking similar problems to work together. For example, the medical world has several data evaluation problems that are very similar to working with 3D surveys. These include data from CAT scans (computer assisted tomography), NMR (Nuclear Magnetic Resonance), sonograms, and positron emission scanning. The data represents three-dimensional space and has been nicely displayed by different medical research groups (slides 48 L&R). One example procedure that has been used on physical model seismic data is the Mayo Clinic's projection imaging techniques (9) (slides 49 L&R, 50).

CONCLUSIONS

Micro-computer and graphics-processor developments make it technically possible for individual geophysicists to interactively work directly with seismic data. Combining the proper hardware with a workable application software package allows a better understanding of the data information content to be developed. Using an interactive workstation is an information processing rather than a manufacturing mode of working with data. However, it is important to remember that these new interactive workstation technologies will not be accepted unless they take into account the human needs of users. This specifically requires that the workstation be easy to use. As truly user friendly systems are developed they will find widespread use. This will provide an opportunity for rapid transfer of information between decentralized workstations. Networking a set

of powerful micro-based workstations creates a multi-dimensional communication structure that allows rapid information exchange, and promotes independent developments by users. The bottom line of industry and academia developing interactive workstations for seismic interpretation will be an increase in productivity, accuracy, and information flow.

REFERENCES

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- (9) Harris, L. D. and Nelson, H. R., Jr., "Three-Dimensional Display and Analysis of Seismic Volume Images," SAL Annual Progress Review, V. 6, Section F, November, 1980.

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- 4 2. From forced technology to high tech/high touch.
- 5 5. From centralization to decentralization.
- 6 8. From hierarchies to networking.
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- 15 L&R Trends in networking computers/Tektronix workstation.
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- 21 L&R Vertical section, SALGLF model/interpretation.
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- 27 L&R Seiscom-Delta fence diagram/E&S contour map.

- 28L&R ID-100 8 color display, SALNOR raw and migrated sections.
- 29 L&R Geosource E&S display of CMP gathers and NMO correction.
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- 48 L&R University of Kansas, raster, vector and surface displays.
- 49 L&R SALITB model.
- 50 Mayo clinic numerical projection of volume images.

Video Sequences

Elastic wavefront snapshots on CDC Ramtek.

Adage interpretation and surface display over SALNEL model.

SALNOR vertical section animation on CDC Ramtek.

Phillips data horizontal section animation, color assignment, and picking on Ikonas.

Reprojection imaging comparing raw and 3D migrated data over the SALITB model.