Inner ear research advanced by computer graphics

4010 Graphic Computer Terminal Application Note MED 4010-A
Many researchers in industry and medicine have turned to the use of both computers and the Tektronix graphic computer terminals for significant improvements in data handling and interpretation. At the UCLA School of Medicine, the people involved in study and analysis of inner ear disorders have configured a minicomputer system that includes automatic test data acquisition and the interactive display of a 4010-1 Graphic Computer Terminal. From this system, the researchers are able to test, stimulate, measure, process, and view the graphic data of their statistical analyses.

In addition, the 4010-1 terminal provides this graphic display immediately after the computer has completed the statistical processing. A permanent paper copy of the display can be run at any time on this system because it includes a 4610 Hard Copy Unit also produced by Tektronix.

The way it was

Before the use of the graphic terminal computer system, the procedure for acquiring numerical test data was very slow; because the analyst would have to spend too much time obtaining numerical data from rolls of polygraph paper from each test printout. This would limit the number of tests the investigator could perform. Apart from the task, the possibility of error in measuring the pictorial data and transposing it for numerical analysis was always likely. But these were not the only delays to obtaining results, for the polygraph provided each and every data point that the test and measurement system provided. And complex statistical analysis could not be done with this method of measurement.

Even when some limited statistics were obtained, the problem solving was not completed. For any further statistical analysis would normally require some pictorial guide for better, quicker clinical interpretation. This plotting then needed to be done, either manually or mechanically off the computation system — yet another delay in inner ear disorder research. Thus the need existed for an on-line stimulus, computation, and display system.

The equipment configuration

The need was satisfied by the UCLA Department of Surgery (head and neck division) with the following equipment: patient rotation table, television screen to display targets, electrodes, transducers, amplifiers, analog-to-digital converters, minicomputer with 28K memory, magnetic tape unit, flexible disc drive, and 4010-1 Graphic Computer Terminal coupled to a 4610 Hard Copy Unit.

With this system, the research team led by Dr. Vicente Honrubia, measures and records all test data automatically (on line) and immediately begins data processing through the computer. The computer is programmed for the analysis of various parameters of the nystagmus waveform. These parameters are found after identifying the minima and maxima (plots 1 & 2). The main parameters analyzed are slow amplitude, fast amplitude, slow velocity, fast velocity, slow duration, fast duration and frequency (plots 3-6). These parameters are used in various statistical analyses, including curve fitting and cross correlations (plots 7 & 8). All these are graphically interpreted by the 4010-1 terminal and permanent hard copies are made on the 4610 Hard Copy Unit.

But that's not all, for in this system the operator may, via that 4010, do interactive analysis and graphing. This means that with the current test data, modifications or changing parameters can be employed, and the new results calculated and displayed while the operator is at the graphics terminal. And a permanent hard copy is only a keystroke away. These hard copies are a standard 8 1/2 x 11 inches and can be used in clinical publications.

Collaborating systems

The use of interactive graphics and hard copy capability in the research of the inner ear disorders has shown the benefits of on-line test and analysis. The research group within the same Department of Surgery is also building a different minicomputer system complete with 4010-1 and 4610 for the analysis of nerve spike impulses and on-line monitoring of histograms. The refreshed screen allows the viewing of new information as often as needed. The nerve systems that are under test are part of intensive animal studies where stochastic signals under computer control are used to estimate the inner-ear sensory organs. Eventually this system and the previous system discussed will be compatible. Then they will be mutually
controlled and serviced by common commands and peripherals. Plus the access to each system by its own software operating system will enhance the capability, but retain the desirable modularity.

Plot 1. Sample of electro-oculographically produced records of eye nystagmus movements induced by sinusoidal head rotations at the frequency of 0.05 Hz with peak velocity of 30 deg/sec. For every cycle of rotation there are two nystagmus reactions with opposite direction of beating. Data are digitized at 200 scans per second with a 10-bit resolution. Each line holds 40 sec of data displayed every fourth scan.

Plot 2. Each nystagmus beat consists of a slow eye deviation (the slow component, SC) and a quicker return (the fast component, FC). A computer program identifies with a flag the inflection points in the traces of eye movement and reduces the information by storing in a table the time of occurrence and the eye position of each Minmax point. Statistics for the amplitude, duration velocity and frequency of the nystagmus components are obtained from the Minmax table. Samples of these statistics are shown for these data in Plots 3 to 6.

Plot 3. Display of the velocity of the SC of the same data as in Plot 1. Each dot indicates the average velocity of the eye during the SC of a single nystagmus beat whose amplitude changes periodically during the stimulus cycle. Every division in the ordinate is 10 deg x sec^{-1} and in the abscissa 5 sec.

Plot 4. Display of the velocity of the FC. The ordinate has the same scaling as in Plot 3, showing the greater velocity of the eye during the FC.

Plot 5. Display of the duration of the SC. The ordinate division indicates 1 sec.

Plot 6. Display of the duration of the fast component. The ordinate division also indicates 1 sec.
Advances in graphics

The role of the Tektronix graphic terminals is to show data, both numerically and graphically; to do this accurately, clearly, and rapidly — at computer processing speeds — and to allow the user the same interactivity on the terminal that is needed with the processor. The 4010-1 does this already, but that's not the limit. For the 4014 and 4015 Graphic Computer Terminals, which have upper and lower case character generation and big 19-inch diagonal storage screens also combine with hard copy units to provide the medical researcher new excellence in computer processing.

Inner Ear Research Equipment

Minicomputer controls fast signal acquisition and patient positioning. Software immediately processes input data. Both input and processed data are displayed on the 4010-1. Permanent hard copies are run as needed on the 4610.