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A VERSATILE INSTRUMENT FOR PHOTOSCAN ANALYSIS

WHICH PRODUCES COLOR DISPLAY FROM

BLACK AND WHITE PHOTOSCANs

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Over the past several years many different techniques have been devised in an attempt to present radioisotope scanning data in a form that is most useful for evaluation by a clinician. One such technique, color presentation of a scan display, has been given considerable attention and effort. Past experience has indicated that color scan displays are useful in the examination of scan pictures, provided the original data are not distorted by the color processing.

The desirability of the color scan presentation of scan readouts has been demonstrated by the many determined attempts to achieve it. The direct production of color scan readouts, the "re-scan" color method, the multiple exposure color technique, the hand-colored digital readout display, the closed circuit color television system, and the flying-spot-scanning color readout system are examples of the approaches made to achieve visual aid for scanning with the use of color.

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Production of the original scan display in color has proved helpful in spite of the fact that the display is limited to a single color picture in which the colored contour intervals are fixed. The range of each color interval must be preset before the scan is made. In most clinical scanning procedures the operator is faced with the problem of preselecting the contour intervals with limited knowledge of what to expect in the way of maximum or minimum count rate. Considerable experience with patients and equipment has enabled some operators to produce useful color scans. Most systems that produce color scans directly depend on integration of count to determine rate levels for color contour selection and therefore are limited to the slower scan speeds to avoid scalloping and statistical "jitter" in color selection.

The re-scan technique proposed by Harris has been adapted to produce effective color pictures from scan data. This method involves scanning the original photostatic transparency with a device similar to an analog scanning densitometer. The amount of light transmitted through the negative is measured by means of a meter movement. As the meter moves, it inserts multi-colored transparent film between a light source and the color film to be exposed. Different colors are inserted for different meter deflections. A mechanical linkage assures a one-to-one relationship between the scanned negative and the color film (usually Polaroid color film).

This process is relatively slow and the color film costs can be quite high if several re-scans must be made to satisfy the observer.

Anger has produced some remarkable color scan pictures by multiple exposures of color film with light transmitted through both filters and

the black and white scan transparency. The pictures certainly demonstrate the value of color scans as an aid to evaluation of scan readouts but this is not a simple routine process and the pictures are made primarily for the purposes of demonstration and exhibition.

Several closed-circuit color television systems have been modified for the color analysis of black and white negatives and prints. A system of this type is simple to operate but must operate over a limited range of light intensity. If any part of the scan picture produces saturation of the vidicon tube the entire picture becomes distorted.

In an attempt to avoid the limitations of these systems, the Argonne Cancer Research Hospital group has had a flying-spot-scanning system under study for the past few years (Charleston, in press).

The system makes use of a cathode ray tube to generate a very short persistence spot which is focused by a lens onto a plane which holds a photoscan transparency. The light transmitted through the negative is collected by another lens and is projected onto the photocathode of a photomultiplier tube. The voltage output of this tube can be processed electronically in many ways before it is presented to the color television set (which is synchronized with the flying-spot-cathode ray tube) for display.

With the flying-spot-scanning color display technique, areas of activity can be mapped in color. Each area of equal (but different) exposure density is assigned a color to identify its relative level of activity. Many color combinations can be generated over a fairly narrow range of density levels. The system allows adjustment of the

three color channels (red, green, and blue) to cover the entire range of film densities, from the most dense region just below saturation, to the least dense region just above the fog level of the film.

The color contour lines can be adjusted through this range of film densities making it possible to observe the exposure density that corresponds to the "hottest" spot of the scan. For black on white negatives the most dense region is "hot," for white on black negatives the least dense region corresponds to the "hottest spot." When these densities are established and labeled with color, it is a simple matter to normalize against this level for generation of other colored contours in regions of interest.

Three channels of continuously variable comparators with upper and lower pick-off levels are used to label (with color) "density intervals" at will. Since the colors are interchangeable and can overlap, a great number of color combinations can be achieved simply by turning knobs.

By narrowing down the "window" or range between upper and lower comparator levels for each channel it is possible to generate very sharp, fine-line contours which are identified by color.

The real impact of the technique can be realized while the operator is dynamically manipulating the enhancement and color labeling parameters. It has been our experience that an observer watching the dynamic changes as they take place will quickly notice even minor perturbations or discontinuities, although he would be hard pressed to pick out the same structure from a static display.

For direct quantitative analysis of count rates or film density, a film step-wedge of varying density can be used to quantify the various

levels by matching colors on the calibration wedge with those generated from the scan film. A calibrated film step-wedge made with random pulses would probably be the most useful for these purposes.

One of the most promising features of this type of system for scan film analysis makes use of the differentiated output signal from the flying-spot-scanner. When a differentiated signal is fed to the television tube readout, the steeper density gradients within the film will be enhanced to a greater degree than the slowly changing gradients. This means that some fine structure information can be displayed (provided its gradients are significant) even though it may be partially obscured by gross structure in the film.

Variable differentiation circuitry has been built into the ACRH system to allow one to vary the degree of this type of enhancement. The differentiation of the output signal from the flying-spot-scanner produces a "shadow" effect which simulates a three-dimensional display of the photoscan. Hot spots can be made to look like hills, cold spots can be made to look like valleys, producing a topographic display.

The flying spot, as it sweeps across the scan negative, is transmitted through the film and detected by the photomultiplier, is essentially converting the spatial structure (lines per cm) within the exposed transparency to correspond to temporal signals (cycles per second) at the electrical output of the photomultiplier tube. It is therefore possible to operate on these electronic signals (cycles per second) in routine fashion with low pass electronic filtering, high pass filtering, and band pass filtering. The final display will have been subjected to spatial filtering by electronic means, similar in

effect to the optical spatial filtering process suggested by Beck, Harper, Charleston, and Yasillo (1967). Band pass filtering studies are underway presently at the ACRH Hospital, and the preliminary results are most promising.

The system has additional flexibility in that magnification can be achieved electronically (by changing the flying-spot cathode-ray tube raster size) for "close-in" analysis of regions of interest to determine if there is some sub-structure information present in the magnified area. Minification, which has proved helpful for orientation, and in some cases valuable as a direct visual aid, can be achieved in the same manner as magnification.

Both the brightness control of the scanning cathode-ray tube and the variable high-voltage adjustment of the photomultiplier tube establish the central operating range of the system. It has been demonstrated that even bad photoscan negatives (either very dense or very thin), can be handled by the system as long as the film is not saturated or solarized.

Since the system generates only a single small spot at any one time, high level signals that may reach saturation in some areas do not disturb the rest of the display.

In practice this saturation effect is a most useful feature, especially in the differentiated mode of operation. The simulated peaks and valleys mentioned previously can be made to "plateau off" as the gain of the system is changed, leaving only the highest or lowest points in evidence on the display.

The system will process any film transparency, black on white, or white on black, to produce an image on a color television receiver in

green, blue, red, yellow, purple, black, white, and shades of grey.

The black on white can be inverted to produce an image of white on black, thus making the readout independent of the original scan polarization. Simultaneously varying amounts of differentiation, contrast, and brightness can be selected at will with or without colored contour lines, color area mapping, or spatial filtering.

At the present time this device is being used as a laboratory study tool. Past experience with the ACRH flying-spot-scanning system however, indicates that it offers considerable potential as a useful tool for clinicians.

REFERENCES

- Charleston, D. B.; An analog approach to scan readout data manipulation and enhancement, in Gottschalk, A., and Beck, R. N. (Editors) Fundamental Problems in Radioisotope Scanning, Charles C Thomas Publishers, Springfield, Illinois (in press).
- Beck, R. N., Harper, P. V., Charleston, D. B., and Yasillo, N. J.; Improvement of image quality of photoscans by spatial filtering. J. Nucl. Med. 8:286, 1967 (Abstract).