Improved Computer Definition of Regions of Interest by Using a Double-Cursor Method

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In the computer analysis of radionuclide studies it is often necessary to define a region of interest (ROI) over an organ or part of an organ. The entire organ boundary is not always apparent on a single image. A method for combining the information from two images in entering the ROI has been developed. It is based on the use of a double cursor that moves simultaneously over both images. Programming was done using special FORTRAN-callable subroutines existing in our system for access to the display. The method is now in routine use for the definition of the left-ventricular ROI during processing of radionuclide cardiac studies.

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In nuclear medicine, computers are used primarily in an interactive mode. Intermediate steps in the processing (usually images or curves) are displayed to the operator, who makes decisions affecting subsequent processing. Perhaps the most common form of interaction is the definition of a region of interest (ROI), from which numerical information is to be extracted. Ordinarily, the ROI will coincide with an organ or a part of an organ, and will be defined by the observer's drawing the outline in some computer-readable fashion.

The hardware used to enter the outline into the computer varies (*1,2*). Mechanically most sophisticated is the light pen, which allows the operator to draw the outline freehand on the displayed image. Other techniques are based on the superposition of a bright dot (cursor) on the display. In both methods the clear outline of the organ or organ part must be apparent to the operator on a single image. This condition, unfortunately, is not always satisfied. For example, part of the boundary may be visible in one image, the rest in another—e.g., two different images in a dynamic series, or an ordinary image and a functional image. Similarly part of a boundary may be ambiguous on any one image, but definable by combining information from two images.

An efficient procedure to use the information from both images in delineating a ROI would be very desirable in such situations. We have developed such a procedure, based on the drawing of the same outline on two different images simultaneously.

MATERIALS AND METHODS

The procedure uses a special purpose computer*. The television monitor display (TV) can present up to four images of a size suitable for ROI definition (128 × 128).

The TV memory is eight bits deep, with a ninth bit for graphic overlay. The cursor is written in the ninth bit, so that it may be moved without erasing elements of the image. Programming was done in FORTRAN, using two special FORTRAN-callable subroutines provided with the system. The first writes in the TV memory, the second accepts an uninterrupted string of numbers from the keyboard to control cursor movement. Specifically, the cursor was defined as two dots, separated horizontally by a distance of 128 display elements. Since the computer is able to display two 128 × 128 images side by side, the dots appear at the same coordinates in the two different images, and move along the same paths on both (Fig. 1). Next, a number is read and interpreted as cursor movement, the cursor is erased and rewritten in its new position. The string of numbers accepted from the keyboard includes a validation instruction, which causes lines to be drawn from both current dot positions to their positions at the last validation. From the operator's point of view, the double cursor responds as fast as he can type in numbers from the "numerical pad" section of the keyboard. The operator thus moves the two dots together, tracing corresponding paths on two different images. The validity of the outline is continually assessed in relation to both images.

RESULTS AND DISCUSSION

The definition of a cursor and its control from the keyboard are standard features of nuclear medicine computer systems. Nevertheless, for most users of such systems unable or unwilling to program in assembler language, use of a cursor is confined to the limited number of applications provided with the system, even though the potential applications of this kind of interactive input cover a much wider range. The ability to use a higher-level language to control cursor shape and movement, and the interpretation of the

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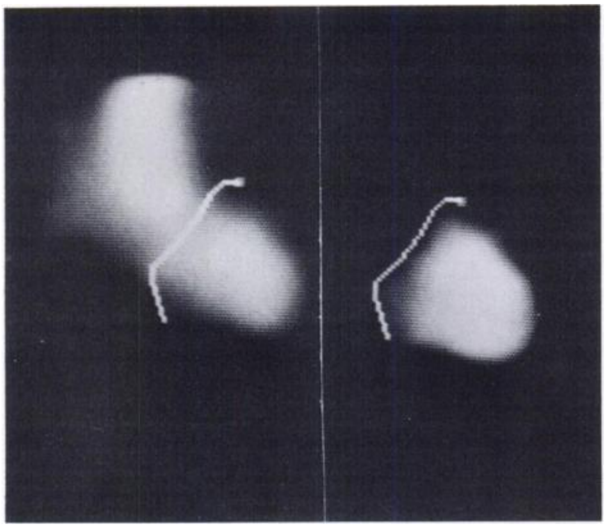

FIG. 1. Double cursor, used to define valve plane in RAO first-transit cardiac study. The same line is drawn simultaneously on end-diastolic image (left) and on difference image (end-diastole minus end-systole) (right).

validated cursor coordinates, therefore provide an extremely valuable advantage.

The FORTRAN-callable subroutines available on our system provide this control. Any shape can be defined in FORTRAN, displayed, and moved over the image display as a cursor, all under the control of a single program. For example, line segments may be used to construct a ROI, in preference to tracing the outline point by point, or a whole predefined ROI shape may be moved into the proper position. The cursor coordinates read by the program can be interpreted as complete outlines, partial outlines, starting points for search procedures, or as directional information, etc.

In this work, the cursor is defined as two dots and written in the TV memory so as to occupy corresponding positions on two of the four 128 × 128 images displayed on the TV.

The technique has been applied to the processing of cardiac studies for ejection fraction and wall motion. In these studies it is necessary to define a ROI encompassing the left ventricle. The free boundary may be obtained from an end-diastolic image, but the valve planes are not always clearly delineated on this image. A functional image (end-diastole minus end-systole) is added to the display, and usually outlines the valve plane very well. The ROI is defined simultaneously on these two images. Neither image is perfect, but used in combination they provide a much more rapid, reproducible, and precise way of outlining boundaries than is obtainable from either alone. The final product is consistent with both images, or the best compromise if ambiguity exists. The reproducibility is especially critical when several operators are processing nuclear medicine studies, as is often the case. In such a situation this method has been greatly appreciated by physicians, technologists, and physicists alike.

Further applications can be conceived in any study where a segmental boundary ambiguity on an ordinary image may be resolved on a functional image. In dual-isotope studies, the double cursor offers the most efficient means of defining a region that is normal in both views, for normalization prior to further processing.

FOOTNOTE

* Informatek Simis-3, Informatek States, Inc., Atlanta, Ga.

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2. NEWMAN W, SPROUL R: *Principles of Interactive Computer Graphics*, New York, McGraw-Hill, Chapters 9, 11, 1973

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