Technical note

A microcomputer assisted method for obtaining composite pictures of focal brain damage

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SUMMARY A method used to produce composite drawings of superimposed areas of brain infarction is described. The method uses a microcomputer interfaced to a digitising pad and linear plotter. Areas of brain damage are drawn on standardised maps, digitised, manipulated in computer memory, and summated using computer graphics facilities. The composites show the position of brain damage in groups of patients as a contour map of the extent of lesion overlap. The method can be used to study neurological and neuropsychological deficits using CT scan, or other imaging techniques. Deep and superficial lesions may be displayed equally well.

The technique of superimposition of line drawings encircling lesions found in groups of patients is standard in brain research. Where more than a few patients are involved the simple overlap of lesion outlines may result in a jumble of crossing lines which gives deceptive importance to the borders of the constituent lesions. When small lesions are involved it is especially difficult to discern the area which have lesions in common for such composite images.

We describe here a method using a microcomputer to perform the task of superimposition of areas of brain damage, such as infarcts, to give a composite picture. These composites show the position of brain damage in groups of patients as a contour map of the degree of lesion overlap.

Method

A standard map of the nine sections of the brain corresponding to the CT scan images was prepared (fig 1). The lesions seen on CT scan of each patient were outlined on such a map by a neuroradiologist (RDH) who was unaware of the patient's clinical deficit.

A Research Machines Laboratory microcomputer (RML 380 z) with 54 K RAM and high resolution graph-

ics, was interfaced to a digitising pad (Summagraphics Bytepad) and liner plotter (Hewlett-Packard 72250 B).

Four programs were written in RML Basic

Program 1

Stores coordinates of lesion perimeter on disc.

1 One of the standard maps with a lesion drawn in, is positioned on the digitising pad. Exact positioning is critical as coordinates are read in absolute values from the pad. To obtain the precise position, four preselected points, one in each quadrant of the map, must overlie specified coordinates on the pad. Each point is checked in turn and the actual and intended positions of the map are displayed in plotter absolute units.

2 Once correctly positioned, the brain slice number is entered. The coordinates for drawing that brain slice number on the screen and by the plotter are read off a disc file. Also in the file are coordinates of the bottom left hand corner (given in absolute plotter units) for the rectangle which contains that slice on the map. This value is subtracted from all absolute plotter values in subsequent operations to reduce the total number of pixels under manipulation.

3 The slice outline is displayed in high resolution (HR) graphics and the pen used to draw around the perimeter of an infarcted area on a map (fig 2).

4 The coordinates of the infarcted perimeter are stored on disc with an identifying file name.

Program 2 "Filling-in" program

1 The perimeter coordinates of an infarcted area are read off disc and displayed within a delimited rectangle on the screen in medium resolution (MR) graphics. The size of

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Fig 1 Standard map of the brain in the plane of the CT scanner

this screen rectangle is limited by the computer's memory size (RAM), since an array in memory is dimensioned by the sides of the rectangle. The rectangle is sufficient to accommodate the area of one half hemisphere of the largest brain slice (that is 1680 pixels). Once displayed, the perimeter outline is filled in by an illuminating pixel which

spirals progressively internally. The rectangle which represents one hemisphere on the screen and contains the blocked-in area, is "read" into a dimensioned array on disc. For a "lit-up" pixel, 1 is stored at that point in the array representing the screen point, whereas 0 is stored if the pixel is unlit.

Fig 2 Computer drawn outlines of simulated brain lesions (slice 4 of the standard brain map).

Program 3 Superimposition of infarcted areas

1 To superimpose areas of infarction, each area stored as an array containing digits 1 or 0, generated by program 2, is read in turn from the disc into a dimensioned array, (DIM D). This array is then added to an accumulating array (DIM A).

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DIM D(1680, 1):REM PIXELS OFF DISC
DIM A(1680, 1):REM ACCUMULATION
FOR S = 1 TO 1680
  A(S, 1) = D(S, 1) + A(S, 1)
NEXT S
```

The area of screen represented by the accumulating array is displayed. RML MR graphics allows 14 intensities of brightness. The value of each digit in the array is increased by one, each time that point is superimposed. To accommodate an infinite number of superimpositions the values indicating the illumination intensity can be converted to an integral percentage. The accumulation is stored on disc for plotting.

Program 4 Print out

An accumulation of infarcts is read off disc and displayed on the screen. The plotter is scaled to encompass a whole brain slice with the hemisphere under study occupying the correct relative position. The plotter draws the slice outline. The screen is then scanned and a square of stippling relating to an intensity of illumination of the pixel at the corresponding plotter position, drawn in (fig 3). Thus the linear plotter is effectively converted to a raster plotter for a "screen dump".

0-25% 26-50% 51-75% 76-100%

Fig 3 Contour map of overlap of the lesions seen in fig 2.

Discussion

A composite picture clearly summarises the localisation of the lesion for a particular syndrome of symptoms, signs or investigative results. Blunk *et al*¹ have described a method of displaying quantitatively the overlap of lesions seen on CT scans of patients with different types of aphasia. It is, however, difficult to understand the anatomical site of the overlap from their composite images. The method of displaying the degree to which different patients' lesions overlap described by Heir *et al*² is similar to ours though achieved by a more laborious technique.

We describe here our method, currently in use. With the introduction of computers which allow a perimeter with an irregular outline to be "blocked-in" with a single command, the technique will be simplified. Further technical improvements in the form of low-cost, high quality raster printers will permit rapid printing of screen contents.

In companion paper we describe the use of this system to demonstrate the position of lesions found in patients with uncomplicated hemiparesis.

References

- 1 Blunk R, De Bleser R, Willmes K, Zeumer H. A refined method to relate morphological and functional aspects of aphasia. *Eur Neurol* 1981;20:69-79.
- 2 Heir DB, Mondlock J, Caplan LR. Behavioral abnormalities after right hemisphere stroke. *Neurology (NY)* 1983;33:337-344.