Computerised evaluation of visual fields

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SUMMARY This report describes a method for conversion of visual fields from Goldmann perimeter charts to computer use, including area calculation, graphic display, and storage in the patient's data base. The computer program enables one to calculate and display several isoptres of each chart, as well as visual fields with scotomas or composed of islands. This method makes it possible to follow in an accurate fashion changes of visual fields of the same patient, either by its numerical value or by its shape changes, by displaying them one after or over the other on the computer screen.

Although automated perimeters of various kinds are now in use, the conventional manual Goldmann perimeter remains the most popular instrument for plotting visual fields. For this reason we sought a way to make a reliable assessment of the Goldmann visual field chart in addition to displaying its shape. A few methods have been suggested for converting the handwritten visual field record for computer evaluation,^{1–4} but all these methods required quite expensive instruments and/or special additions or changes to the conventional Goldmann perimeter.

This report describes a new approach to the conversion of handwritten visual field records for computer use—for calculating their areas, displaying them graphically, and storing them in the patient's data base. The method uses an instrument which is rapidly gaining popularity for clinic use—the computer.

Material and methods

A chart of the Goldmann perimeter is laid on a table for sonic digitisation, with the aid of a sonic digitiser for presenting the x and y co-ordinates of position in a digital form. The contours of the visual field isoptres that were taken are traced with a stylus generating sparks at its end (Fig. 1). The instrument measures the time required for the sound waves originating at a point on the traced curve to reach each of 2 linear microphone sensors located on adjacent sides of the

table. One sensor represents the x axis, the other the y axis. Since the speed of sound is given, the time for the sound wave to reach the x and y sensors, respectively, represents the distance of the sound source from the sensors (i.e., its x and y co-ordinates). This information is fed into a computer for further processing.⁵

The contours of the visual fields are drawn on a storage scope of the computer within seconds, and their areas are computed. These results together with the relevant data concerning the patient's disease are stored on the computer disc, and the results of each measurement are printed immediately in a slow output printer (Fig. 2). The results may be screened on the terminal scope for comparison whenever desired.

We have planned the computer program to measure up to 3 visual fields of different isoptres for each chart with the possibility of displaying the contours of these visual fields in 3 different forms: continuous lines, broken lines, and dotted lines (Fig. 3). (We can also plan a program to monitor more than 3 dioptres.) The size and the relative intensity of each target is written on the output printer (Fig. 2).

In addition it is possible to calculate the visual fields with scotoma by subtracting the area of the scotoma, or to calculate visual fields composed of islands by addition of the area of the visual parts of the same isoptres, of course with display on the screen (Figs. 4, 5). If the visual field is with scotoma or composed of islands, this is so indicated on the slow output printer. In order to follow changes of visual fields of the same patient they can be displayed one after or over the

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Fig. 1 Goldmann perimeter chart and stylus tracing contours of visual fields.

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PATIENT NO. 14
RIGHT EYE
2
1 23 09.80 00
14 V.F. NO. 1 FILE NO. 23 DATE= 9.80 0 MONTHS FROM FIRST V.F.

READY TO CALCULATE VISUAL FIELDS AREA...
SPECIFY TARGET !!
1
TARGET NO. 1 =SIZE 5, RELAT. INTENS. 4

THE VISUAL FIELD AREA = 2145.79 MM**2
SPECIFY TARGET !!
3
TARGET NO. 3 =SIZE 3, RELAT. INTENS. 4
1
V.F. WITH SCOTOMA
THE VISUAL FIELD AREA = 2152.56 MM**2
SPECIFY TARGET !!
5
TARGET NO. 5 =SIZE 1, RELAT. INTENS. 4
2
V.F. COMPOSED OF ISLANDS
THE VISUAL FIELD AREA = 2163.27 MM**2

14 2 0 1 2145.79 3 2152.56 5 2163.27

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SPECIFY EYE (0,1,2)
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Fig. 2 The slow output print of visual field details that include the size and relative intensity of each target, the special shape of the visual field, and its calculated areas.

Fig. 3 The display of 3 different isoptres in 3 different forms (continuous line, broken line, dotted line) on the graphic storage scope.

other on the storage scope. All this information can be stored in the patient's data base in the computer, and in this way we have in addition to the shape of the visual fields also a quantitative value of its area, and both of them together give us the full information about the visual field.

Discussion

Recording and measurement of the patient's visual field is an essential part of the diagnosis, follow-up, and management of glaucoma and optic nerve diseases. The visual fields are usually recorded on a paper chart and are kept in the patient's file. Today in the era of computers, when computers of various sizes are in use in clinics, we thought it essential to develop a method of keeping graphic information such as visual fields in the computer data base in addition to the patient's other medical records. We have previously described a simple method for computerised evaluation of the optic disc cupping,⁵ and here we describe a simple and inexpensive method for computerised evaluation of visual fields.

As the Goldmann perimeter is the most popular instrument for recording visual fields, we looked for a method of evaluating the visual fields based on the paper chart. Hartz *et al.* described a good method for converting the Goldmann perimeter data for computer storage and evaluation, but their system is

relatively expensive and demands special instrumentation.^{1,3,4} Dueker described a method for transferring the visual field record from a paper chart to computer storage by processing a video image of the chart, but this method is also expensive and requires special instruments.²

We used an instrument which already exists in many clinics, a small computer with a graphic terminal. We added only a digitiser, which can serve also for other purposes for converting analogue data to digital, such as areas, perimeters, length, etc., and for recording and displaying graphic data.⁵ Our digitiser is a vocal digitiser, but one can use other digitisers such as a sumagraphic (magnetic) digitiser. The resolution of this digitiser is high, 0.2 mm, thus facilitating accurate results. By measuring 10 visual fields 10 times we found an average difference of about 1%. The degree of error may of course be higher in very small visual fields.

Linstone *et al.* described a very simple method for planimetry of visual fields,⁶ and part of what we are doing is actually planimetry, but the numerical size of the visual field per se is not enough, and the ophthalmologist should see also the shape of the visual field. Our planimetry method makes possible the calculation of several visual fields of the same chart, also with scotomas and composed of islands, and the graphic program enables the display of these visual fields in different forms on the background of x and y axes and

Fig. 4 The display of visual field with scotoma (the internal figure) on the graphic storage scope.

Fig. 5 The display of visual field composed of islands on the graphic storage scope.

the 30°, 60°, and 90° circles. The written data of the visual field that include the size and relative intensity of each target, the special shape of the visual field (scotomas, islands), and the calculated areas can be displayed on the slow output printer (Fig. 2) or on the terminal screen, and stored in the patient's data base.

This system enables us accurately to follow changes of visual fields of the same patient, either by numerical value or shape changes, by displaying them one after or over the other on the screen. This accuracy depends upon the precision of recording the visual fields by the technician performing the Goldmann perimetry.

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