Abstract

A visual field test is a method of measuring an individual's entire scope of vision, that is their central and peripheral (side) vision. Visual field testing actually maps the visual fields of each eye individually. The visual field test is a subjective examination, requiring the patient to understand the testing instructions, fully cooperate, and complete the entire test in order to provide useful information. During the test lights are flashed on, and you have to press a button whenever you see the light. Your head is kept still. You have to rest your chin on a chin rest. The lights are bright or dim at different stages of the test. Some of the flashes are purely to check you are concentrating. Each eye is tested separately, and you should allow 15-45 minutes to have the whole test.

Visual field testing is most frequently used to detect any signs of **glaucoma** damage to the optic nerve. In addition, visual field tests are useful for detection of **central or peripheral retinal disease**, eyelid conditions such as **ptosis** or drooping, optic nerve disease, and **diseases affecting the visual pathways within the brain**. The visual pathways carry information from the eye to the visual or occipital cortex in the brain, where this information is processed into vision.

Normally the test is carried out by a computerised machine, a Humphrey. Occasionally the manual test has to be used, a Goldman. Again, for each test you have to look at a central point, and have to press a buzzer each time you see the light.

The majority of computerized perimeters are specialized pieces of hardware. They typically consist of a projection area, an embedded controller, an input device for an operating technician, an input device for the patient, and a method of printing results. These

machines are built for physician's offices or hospitals. As a result they are, bulky; not portable, and usually require their own room. They are also **expensive and may cost roughly Rs1.5lacs to Rs2lacs** along with good maintenance. Hence this is not surprising to know that the charges of the test for a patient may range from **Rs500 to Rs900 and hence it may not be affordable for different people for different reasons.**

All the above facts encourage developing some technique so that the test can be conducted at low cost without any specialised hardware but on computer screen. The first aim of this project will be developing algorithm for a visual test and implementing it **on ImageJ(a JAVA based image processing program)** so that a similar test can be conducted on a personal computer(but preferably with a large monitor conduct the test in good ergonomic conditions).

BACKGROUND WORK

VISUAL FIELD TEST AND PERIMETRY

The vision of a normal human can be affected and damaged by many possible reasons. Some of the most common causes of loss of vision are diseases like glaucoma and damage of optic pathway from eye to brain. In all cases of visual acuity, visual field test can be very helpful for an ophthalmologist to diagnose and treat the patient's condition. Also in cases like glaucoma, visual field test is important for regular monitoring of the eye condition.

The study related to visual field of eye is known as **perimetry** and the special equipment in which this test is done in called a **perimeter.** All type of visual field perimeters comprise a **fixation point** for fixating the eye during the test period with respect to the **screen**(which is in shape of eyeball); **discrete targets** placed momentarily on the screen area at locations calculated from predefined angles with the line of central vision and the location of the eye with respect to screen.

AUTOMATED PERIMETRY AND HOW IT IS CONDUCTED

Though the visual test can be done manually but now-a-days all visual field tests are done in automated perimeters like **Humphrey's Automated Field Analyser.**

VISUAL THRESHOLD:

The visual threshold is the physiologic ability to detect a stimulus under defined testing conditions. The normal threshold is defined as the mean threshold in normal people in a given age group at a given location in the visual field. It is against these values that the machine compares the patient's sensitivity. For several reasons thresholds are reported in decibels, in a range of 0-50. Fifty decibels (db) is the dimmest target the perimeter can project. It is unlikely that any normal person can detect this dim a stimulus. A young and perimetrically experienced person can probably see the 40db target and that too at the fovea. On the other end of the scale, 0 db is the brightest illumination the perimeter can project. Essentially, the ability to identify a 35db target indicates a better sensitivity of the retina than a point which can identify a 25db target; and this is more sensitive than another point that can identify only a 10db target. In other words, the lower the decibel value, the lower the sensitivity; the higher the decibel value, the higher the sensitivity.

Before starting the test the technician adjust the height of the arrangement and the position of the chin-rest so that the person can sit comfortably during the test and can see the stimulus without any difficulty. The eye other than the eye to be tested is covered by some means.

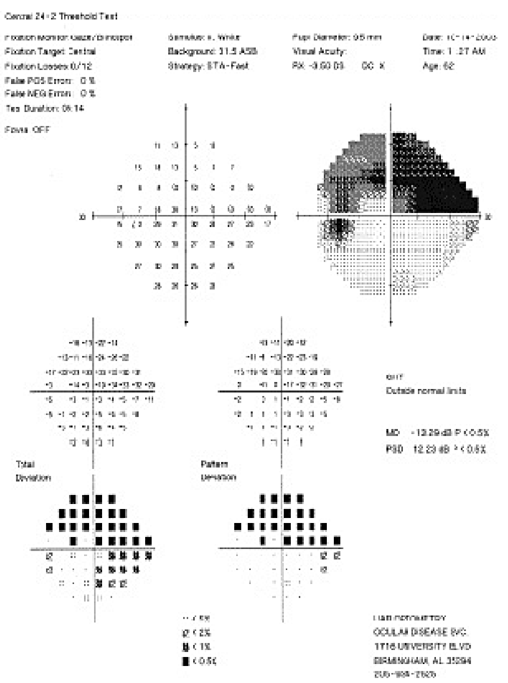
Figure 1,2

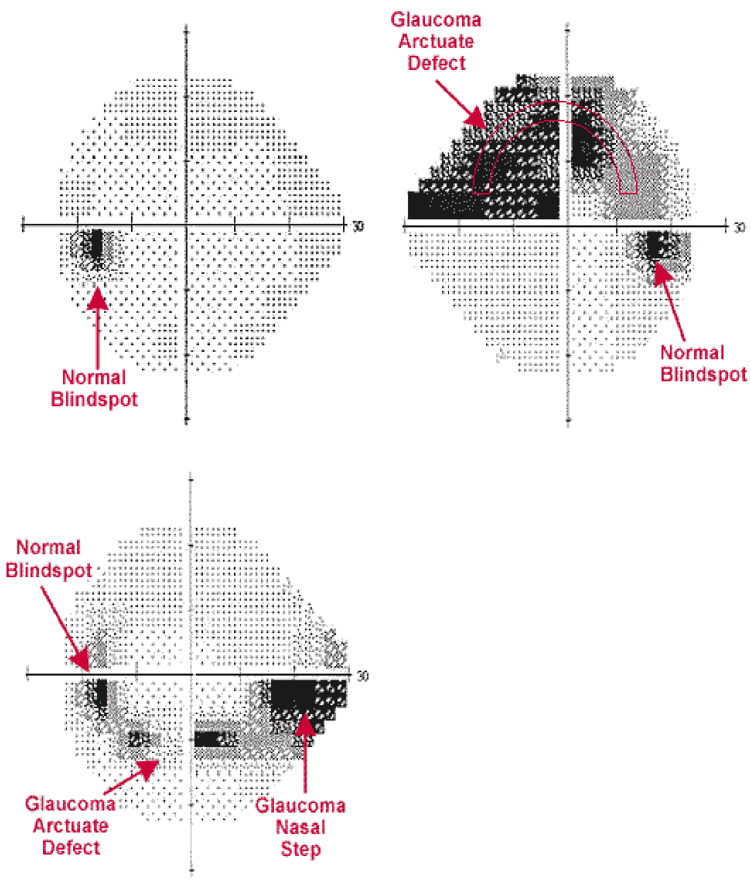
The test begins from the checking the threshold at the centre (fovea). This threshold is supposed to be the highest for a particular patient.

Then stimuli are put at different preset locations depending upon the angle made with the central vision to find the minimum intensity (max dB value) which the person can see. During the test the patient is asked to gaze at the fixation point and the order of the points are kept random so that the patient can not sense the pattern. These two points are very important for a reliable test.

The major advantage of automated perimetry is that it compares the patient's sensitivity to stored values that have been obtained from normal people; in other words, **the Normative data**. Alternatively, it can be determined using a smarter program called **SITA - the Swedish Interactive Threshold Algorithm**. Whichever way they are determined, the normal thresholds are stored in the computer of the perimeter and it is against these normal thresholds that the perimeter compares the patient's data**.** After the test is complete the perimeter generates a report. All the important parameters are discussed below.

Figure 3,4





NORMAL BLIND SPOT:

For this test fixation of the eye is a must and its is generally done by **Blind Spot fixation method** i.e. displaying stimulus on the normal blind spot periodically and checking if the patient is responding to it or not. If the patient can see and respond to it that means he has lost his fixation. **Less fixation loss signifies a more reliable test result**.

The human eye has a blind spot in its field of vision. This lies on the point of the retina where the optic nerve leads back into the brain. This position is at about **15 degrees from the central vision**. The retina has no light-sensitive rods or cones at this point, and so a small object in the field of vision's blind spot becomes invisible. This is the basis of Blind Spot Fixation Method. The position of the blind spots are shown in **Figure 5**

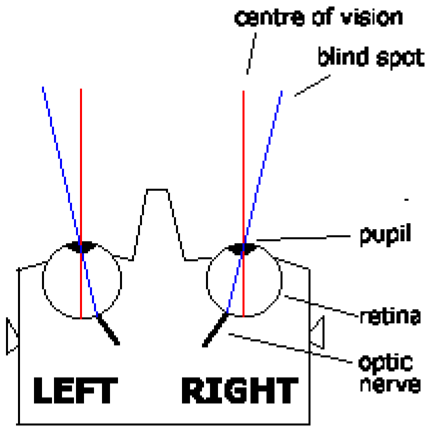


Figure 5

RELIABILITY FACTORS:

1.) *FIXATIONLOSSES:*

The Humphrey field analyzer periodically checks the patient's fixation by presenting stimuli within their blind spot (Heijl-Krakau Technique). When the number of fixation losses is greater than 20%, a symbol (XX) will appear next to the fixation losses to alert the doctor there is reason for concern.

2.) *FALSE NEGATIVE ERRORS:*

A brighter stimulus is presented at a test point in the field that was earlier reported, as being seen, having "Normal Sensitivity" but now the patient does not respond to the bright stimulus.

High, false negative scores might indicate fatigue or inattentive patient.

3.) *FALSE POSITIVE ERRORS:*

The projector makes a noise when it moves and the patient responds to the sound though no stimulus has been presented. The patient is responding to outside factors or trying to out guess when the stimulus will be presented. A high false positive score indicates that the patient is "Trigger Happy.

Types of Visual tests:

On the basis of region of visual field to be tested these tests can be of two types

1> 30-2 threshold test:

In this central 30 degrees of the visual field is tested. There are total 76 points in this test.

This test can take a longer time and so it may not be suitable for elderly people or kids. Also it may bring fatigue and so reducing the reliability of the test significantly.

2> 24-2 threshold test:

It checks for the central 24 degrees of the visual field with 54 points at different angular positions. This test is comparatively faster, brings less fatigue and so is widely used.

PROGRAMING PLATFORM USED:

The platform chosen for developing computerised visual test is **ImageJ**. It is a well know JAVA based image processing program developed by **National institute of Health or NIH** (primary agency of health and related research in USA). ImageJ was designed with an **open architecture** that provides extensibility via Java **plugins** and **recordable macros**. Custom acquisition, analysis and processing plugins can be developed using ImageJ's built-in editor and a Java compiler. The complete details ImageJ and online documentation can be found at **http://rsbweb.nih.gov/ij/**

The API documentation can be found at **http://rsbweb.nih.gov/ij/developer/api/index.html**

Being an open source ImageJ source code is freely available can be modified by anyone according to requirement.

ALGORITHM:

For a visual test in the computer screen we need to look at the following things,

1> For fixation, **Blind Spot Fixation Method** is going to be used.
2> As the test is done on a flat screen, there is limitation in the screen area (monitor). So, 24-2 threshold test looks to be more preferable than 30-2 test (as bigger screen is needed).
3> After the test is complete we need to have Normal threshold values with which patients result is to be compared to produce a useful report. But in absence of any Data base of **Normal Threshold values**, it is assumed that these Data are known and if the Data can be made available, the code can be easily modified so that it can produce same type of report that an Automated perimeter generates.

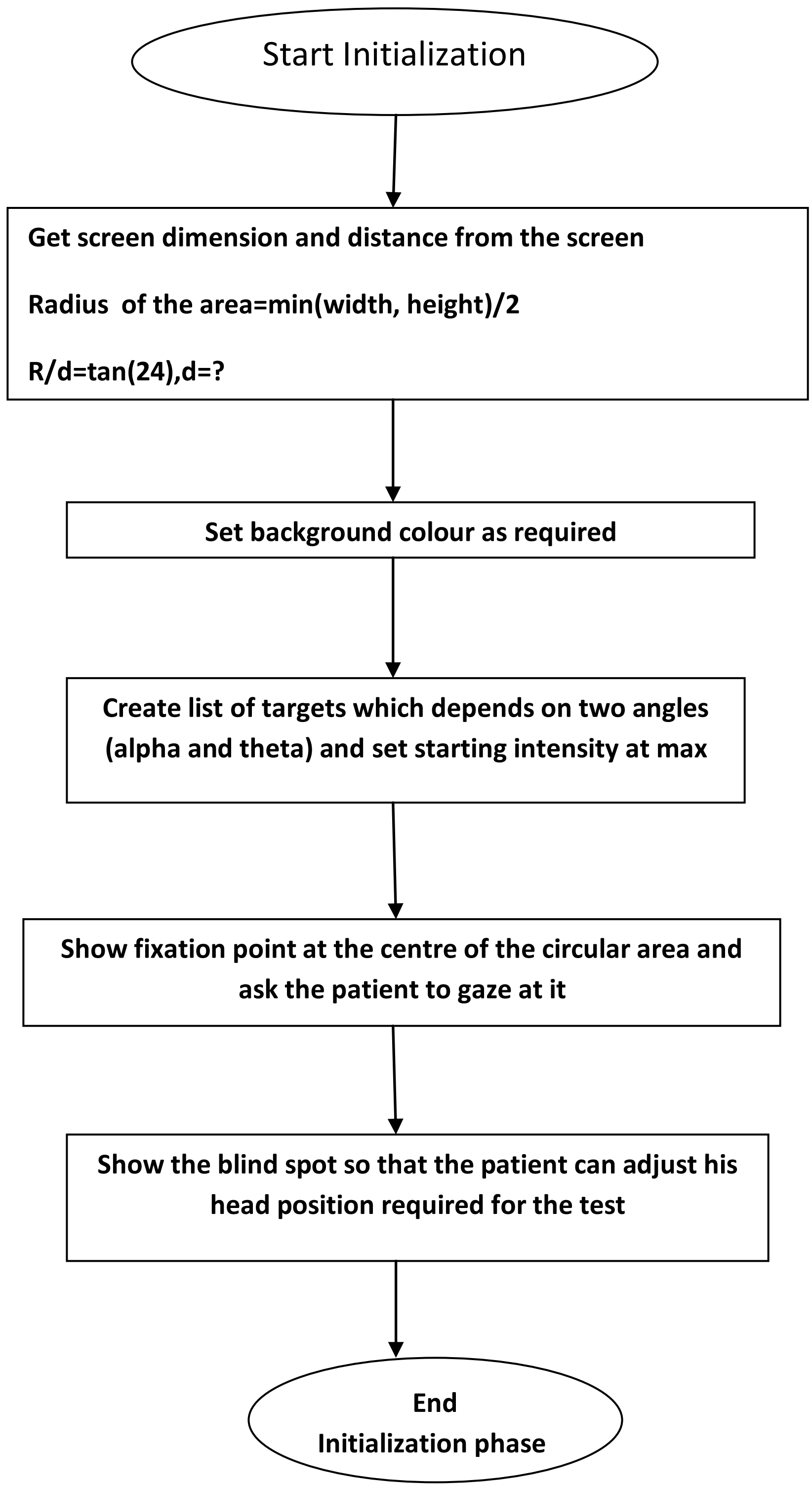
The test algorithm can be divided into the following,

1> Initialization phase
2> Interactive phase
3> Result phase

INITIALIZATION PHASE:

The first step of this phase is to get a screen area on which the stimuli are to the shown. To cover 24 degree from a comfortable distance it is required to have a full screen image for the test.

Using the available screen data and the fact that it must cover 24 degrees of visual angle, the distance of the patient's eye from the screen can be calculated. As the screen area is just a projection of


Start Initialization
Get screen dimension and distance from the screen
Radius of the area=min(width, height)/2
R/d=tan(24),d=?
Set background colour as required
Create list of targets which depends on two angles (alpha and theta) and set starting intensity at max
Show fixation point at the centre of the circular area and ask the patient to gaze at it
Show the blind spot so that the patient can adjust his head position required for the test
End
Initialization phase

24 degree visual field, all the stimuli must be confined within a circular area corresponding to 24 degrees.

Next step will be setting the background colour and intensity which should be set to any desired value (due to the fact that the intensity of the perimeter and of the computer screen are not being co-related).

In the next step, the number of targets, their locations and their intensity for each target are decided. An automated Perimeter like Humphrey's field analyse uses a huge data base for deciding these things or generates these data using **SITA - the Swedish Interactive Threshold Algorithm**. For a particular patient this may depends on age, sex and which eye to be tested. In absence of any data base this can be done by taking points depending on their angular position with respect to the central vision. The points which are taken in this particular code are on the circles of different visual angle.

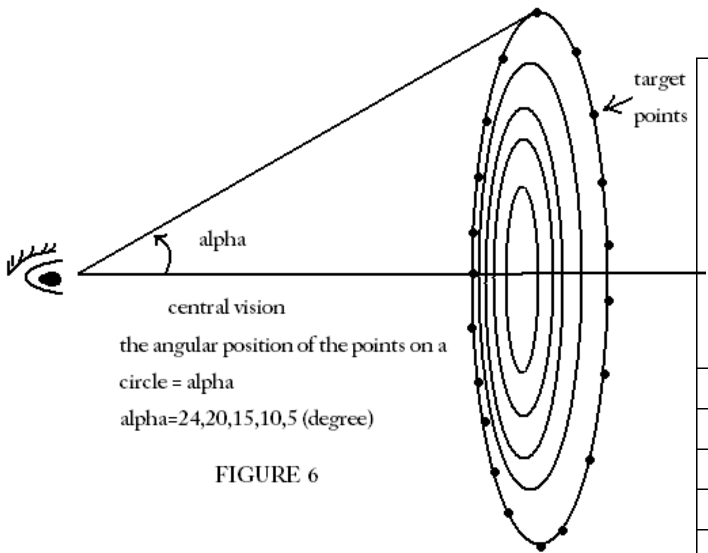


FIGURE 6

Visual angle(**alpha**) In degrees	Number of points on the circle	Angle made by the successive points at the centre of the screen(**theta**) In degrees
5	4	90
10	8	45
15	10	36
20	16	22.5
24	20	18

Total number of points=58

The initial intensity for all points is arbitrarily taken as maximum available i.e. on gray scale 255.

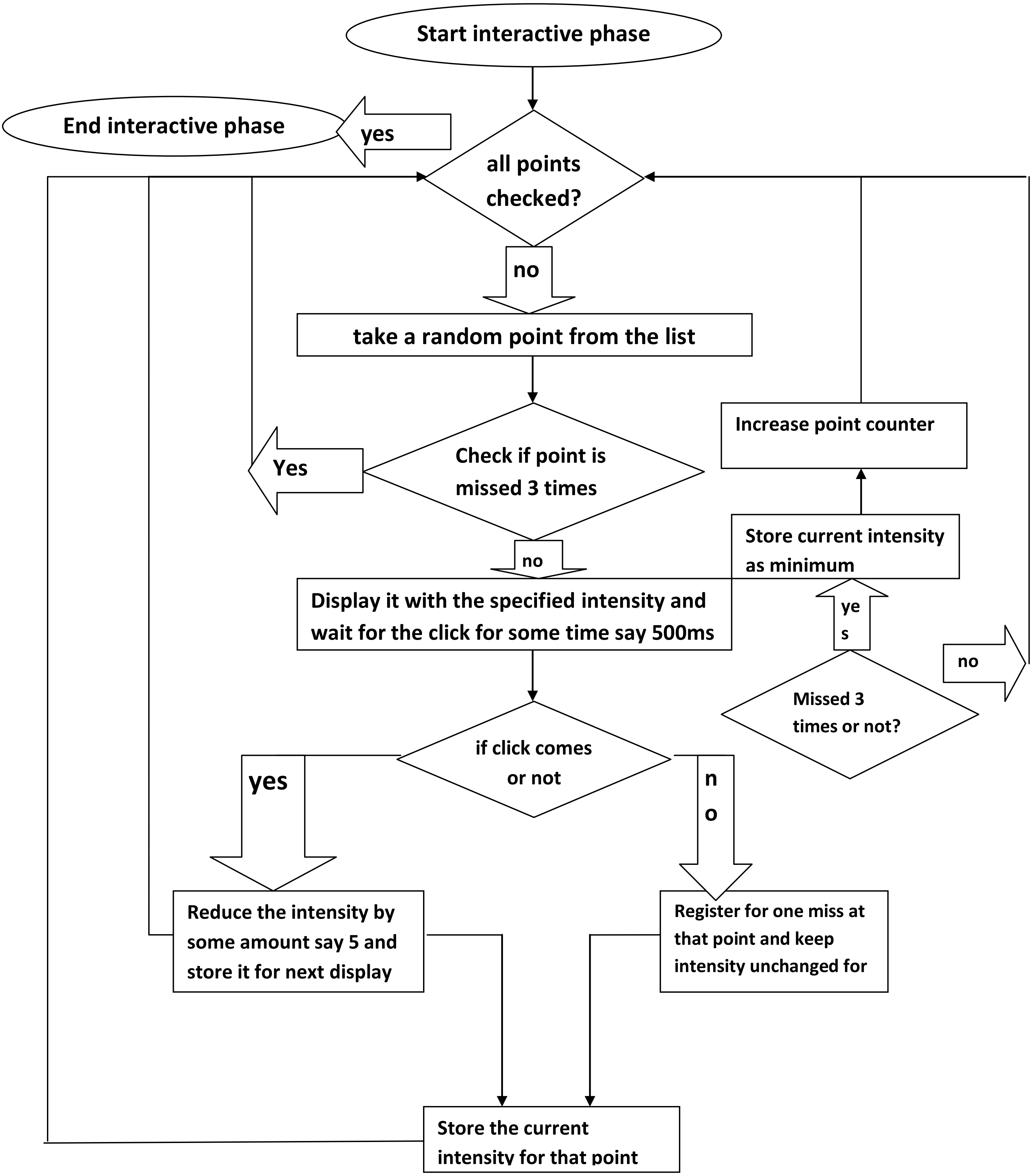
After setting the screen area the fixation point (generally a cross mark) is displayed on the centre of the screen. The patient is required to gaze at this point throughout the test. It’s mandatory for the patient for a reliable test.

The next most important step is to set the patient’s head at the required distance from where his vision can cover 24 degrees. To achieve this, the blind spot can be used. The location of the blind spot can the easily found out using the fact that is located at about 15 degree from the central visual line. At the beginning of the test the blind spot is displayed at its calculated position and the patient is asked to adjust his head so that the blind spot will not be visible anymore while at the same time he has to gaze at the fixation point at the centre. As the blind spot is located considering the fact that the total circular screen area correspond to 24 degrees of visual field, fixing the eye location using the blind spot confirms that the eye of the patient is located at the required position. Once the patient adjusts himself he is not supposed to shake or dislocate his head until the test ends. In actual test in automated perimeters this is achieved by supporting the head by a chin-rest. So the same can be done in this test if possible.

After setting all these the next phase i.e. Interactive phase can be started.

INTERACTIVE PHASE:

The interactive phase is the part of the test where the patient interact with the software. It starts with displaying the target points and waits for the patient to respond to it by clicking the mouse at any point on the screen. All targets are displayed with the starting intensity (the maximum) at the beginning and then search the minimum intensity which can be seen by the patient at that point.


Start interactive phase
End interactive phase
yes
all points checked?
no
take a random point from the list
Increase point counter
Yes
Check if point is missed 3 times
Store current intensity as minimum
no
Display it with the specified intensity and wait for the click for some time say 500ms
ye
s
no
Missed 3 times or not?
if click comes or not
yes
n
o
Reduce the intensity by some amount say 5 and store it for next display
Register for one miss at that point and keep intensity unchanged for
Store the current intensity for that point

The following points must be considered about the timing and ordering of the targets.

1>The order in which the points are displayed must be random so that the next location of the stimulus target can not be guessed by the patient.

2>The time interval between successive display of stimuli must also be random otherwise the patient can easily know when the next stimulus is displayed and hence leading to high False positive Error. The test result can not be reliable in these conditions.

After each display software must wait for some time to detect any mouse click from the patient. If the patient clicks for the given intensity at a particular point, it must reduce the intensity when the same point is displayed next time and check if it can be seen or not. Again if a point is not responded for the first time, it can not be said for surety that the current intensity at that point is the minimum intensity that can be seen. There may be cases when the patient sees the point but can not respond to if due to bad timing or it may also possible that he was not attentive enough at that time and simply missed that point. So to discard these possibilities, a particular intensity should be taken as the minimum intensity only when it is missed for a particular number of times say 3 times(this can be changed so according to requirements).

Lets take a case. Suppose at some time at a particular point intensity 247 is missed once. For the next time also the point will be displayed with intensity 247. If he misses 3 successive times the it can be safely taken to be the minimum intensity at that point.

To monitor the fixation of the patient some random stimuli are put at the blind spot and checks the patient's response. If the patient responds to it, his fixation is lost. In this way the fixation is tracked throughout the test and it the fixation error crosses a certain limit say 20% the test has to be terminated and started again.

After all the points are checked for the minimum intensities, the Interactive phase is completed.

RESULT PHASE:

This is the last phase in which the test report is generated. The minimum intensities which were recorded during the test can be used to generate a gray scale image showing these intensities.

The report should show the fixation error so that the reliability of the report can be known during the diagnosis.

The result can be finally printed if required.

ADVANTAGES OF THE VISUAL TEST ON COMPUTER SCREEN:

1>This program enables visual field perimetry to be performed on the small screen of a personal computer or for a better result on a big screen.
2>The program will lower the cost and increase the availability of this important test.
3>This visual field test can be less fatiguing than most computerized perimeters.
4>A portable visual field test that can easily be transported to schools, nursing homes, or even remote areas where modern medical services are not available.
5>This perimeter that is easy to setup and use.

SCOPE FOR FURTHER IMPROVEMENT:

1> The intensity level during the test is controlled by changing the gray scale values only. Its effect and the effect of the change in intensity in an automated perimeter should me co-related so that test can be widely used.

2> There is a scope of improvement in the search algorithm used to find the minimum intensity level at a point. A better algorithm will not only shorten the time of test but also improve the reliability of the test by reducing fatigue.

3> The method of fixation can be improved.

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