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Early Detection of Glaucoma using Perimetry

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***Abstract*—**Glaucoma refers to a diseases characterized by optic neuropathy, specific pattern of visual field, raised intraocular pressure. Glaucoma is the second leading cause of blindness. Visual field testing is a subjective method, but yet a very important part for diagnosis & in follow-up of ocular or neurological diseases. Standard automated perimetry or white-on-white perimetry is state of the art for the visual field examination of glaucoma patients. Careful instructions & supervision of the patient help to achieve high quality results. The purpose of this work is to develop a new family of test algorithm such as Swedish interactive thresholding algorithm (SITA) for computerized static threshold perimetry which significantly reduces test time without any reduction of data quality. A comprehensive visual field model constructed from available knowledge of normal & glaucomatous visual field is continuously updated during testing. The main components of the system are push button, PIC microcontroller, bluetooth module, android phone to display output results. Android app mainly consist of number of screens which contain patient data, test selection according to age group, 76 led glow randomly & output screen.

***Keywords*—**Glaucoma, Standard automated perimetry, SITA, Visual Field(VF).

I. INTRODUCTION

A. What is perimetry

Perimetry is systematic measurement of people's field of vision. There are two types of perimetry [1].

1. Goldman kinetic perimetry: - A trained perimetrist can move the stimulus.
2. Threshold static automated perimetry:- Stimulus brightness is constant.

B. Normal Field of Vision

The visual field refers the overall area in which objects can be seen in the peripheral (side) vision as the eyes of the subject are focused on a central point. Furthermore visual field testing is a component of a routine comprehensive eye exam carried out by an optometrist or ophthalmologist, the test includes determining a patient's full horizontal & vertical range of sensitivity of their vision. The normal eye Can detect stimuli 130 degree vertically & a nearly 150 degree horizontally. From the point of fixation, stimuli can typically be detected 60 superiorly, 70 inferiorly, 60 nasally & 90 temporally. The visual field depends on the stimulus (size, brightness, motion) & the background conditions. The field of vision is called as a three dimensional hill, with the peak sensitivity to stimuli occurring at the point of fixation under photonic conditions & then decreasing simultaneous for locations in the periphery. Nerve fibres pass through the sclera at the optic nerve head, typically 10-15 nasals to fixation. At this location, no photoreceptors are present, creating a normal absolute Scotoma [2].

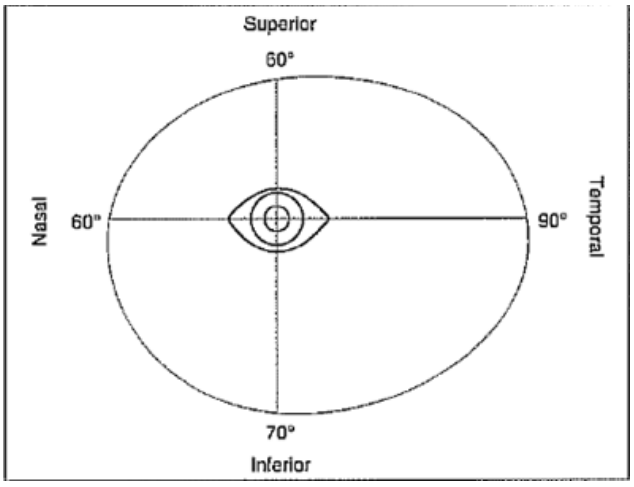

Figure 1.The Boundaries of normal visual field.

C. How is the test performed

Visual field test are used to detect various eye diseases such as Scotoma, optic nerve damage & optic neuropathy among others. This paper aims to provide further information on the current literature as well as future developments & its impact on modern day medicine. Three main field & automated exams are used to perform this test, which are as follows:

1. Confrontation visual field exam:- This exam is an elemental check of the visual field.
2. Goldman field exam:- In the Goldman field exam the patient is located centrally three feet from the screen & asked to stare at an object & report to the examiner when the object migrates into the peripheral vision.[1]
3. Automated perimetry:- Standard automated perimetry or white-on-white perimetry is the most common form of visual field testing. Here a white stimulus is projected on a white background to determine the threshold values. [1][3].

D. Literature Survey

Ron chibel et.al [4] Presents a visual field (VF) defects in healthy participants & patients with glaucoma using a chromatic multifocal pupillometer. Assess visual field defects & retinal function objectively in healthy participants & patients with retinitis pigmentosa (RP) using a chromatic multifocal pupillometer. This study tells us about multifocal pupillometer for diagnosis of retinal function, optic nerve & visual field defects.

Christoph et.al [5] presents a prototype design for measuring the intraocular pressure (IOP) is the result of a dynamic balance between aqueous humor formation & outflow, which are nearly equal under normal conditions. Aqueous formation (2 ml/min) has two components: a hydrostatic component, produced by passive leakage of fluid from the blood, & a secretory components resulting from the active transport of sodium & other ions by the ciliary epithelium. The aqueous is produced by the ciliary processes in the posterior chamber. It circulates in the eye & finally drains out through the trabecular meshwork into schlemms veins. The uveoscleral or unconventional pathway contributes to a smaller proportion of aqueous humor outflow.

Kazunori Hirasawa et.al [6] presents the traditional method used to measure the extent of the visual field via an examiner controlling a moving stimulus. This technique is useful when examining patients without visual field defects within the central 30 degree or patients with intracranial diseases. Manual kinetic perimetry has the advantage of obtaining measurements while keeping pace with the patient's response time for stimulus exposure. The stimulus velocity among examiners is difficult because the perimetric results depend on the skill of the examiner.

George et.al [7], this paper introduces that imaging of the optic disc is an essential part of the evaluation of a patient with or suspected of having glaucoma imaging of the optic disc is an essential part of the evaluation of a patient with or suspected of having glaucoma. Obtaining a valid, quantitative history however is probably the most important part of patient encounters, as it is through the history that the physician obtains information about how to understand, relate to & advise patients. Every concerns & need as well as symptoms is essential.

Addepalli et.al [8] This Paper compares the diagnostic performance of glaucoma specialist and experienced optometrists in gonioscopy and optic disc assessment. This study is done to validate the diagnostic performance of two experienced optometrists for using their skills of detecting glaucoma using gonioscopy and optic disc assessment in a major epidemiological study. Optic disc results were categorized for 200 eyes as 0, 1 and 2 for normal, suspects and glaucomatous respectively.

This literature survey revels

A concept of perimetry to detect VF defects [4].Visual field defects are detected in greater detail and earlier by the automatic static perimeter than by manual perimeter [4]. Presents a strategy which measures intraocular pressure [5]. The traditional method used to measure the extent of the visual field via an examiner controlling a moving stimulus [6]. The optic disc is an essential part of the evaluation of a patient with or suspected of having glaucoma [7].

There are also another risks that are not detected & patient suffer from irreversible loss of vision such as patient history, i.e. age, frailty, race, type & degree of refractive error, systemic hyper & hypotension, vasospasm, migraine, pigmentary dispersion syndrome, pseudo exfoliation syndrome, obstructive sleep apnea syndrome, diabetes, medication interactions & side effects, the degree of exposure to intraocular & intracranial pressure elevations & fluctuations, smoking & symptoms in addition to genetics & family history of the disease [9]. Perimetry has become one of the concepts of medicine, which physicians use to further develop their understanding of some diseases, especially glaucoma. This disease is linked to increase in the internal pressure in the eye which subsequently degrades the field of vision. Perimetry is a test that measures individual's condition like field of vision. Through this means we can further our understanding of the glaucoma & evaluate an individual's condition. The visual field refers the overall area in which objects can be seen in the peripheral (side) vision as the eyes of the subject are focused on a central point. Furthermore visual field testing is a component of a routine comprehensive eye exam carried out by an optometrist or ophthalmologist, the test includes determining a patients full horizontal & vertical range of sensitivity of their vision [10]. The normal eye can detect stimuli 130 degree vertically & a nearly 150 degree horizontally. From the point of fixation, stimuli can typically be detected 60 superiorly, 70 inferiorly, 60 nasally & 90 degree temporally. The visual field depends on the stimulus (size, brightness, motion) & the background conditions. The field of vision is called as a 3 dimensional

hill, with the peak sensitivity to stimuli occurring at the point of fixation under photonic conditions & then decreasing simultaneous for locations in the periphery. Nerve fibres pass through the sclera at the optic nerve head, typically 10-15 nasals to fixation. At this location, no photoreceptors are present creating a normal absolute Scotoma [12].The another method to detect glaucoma is fundus imaging. Vessel segmentation in fundus images plays a role in treating patients [13]. The another method to detect glaucoma at first stage is by face recognition of patient. Neural network method mainly improves the face recognition process [14].

II. RELATED WORK

A. Static Perimetry

Static perimetry tests different locations in the field one at a time. First, a light with less intensity is presented at a particular location. If the patient does not see the light, then the intensity is increased until it is seen. The minimum brightness intensity is increased until it is seen. The minimum brightness intensity level required for the detection of a light stimulus is called the threshold sensitively level of the location. This procedure i then repeated many time in other location, until the entire visual field is tested. Automatic static perimetry is primary method of visual field in patients. The most frequently used test in glaucoma are central 30 degree or 24 degree central field. In 24-2 test 56 test points present in 24 degree central field [10]. Threshold static perimetry is generally done using automated equipment. Basically in static perimetry number of light stimuls is seen one after another. Patient has to look constantly to these stimuls and press the switch. Perimetry testing is important in the screening, diagnosing, and monitoring of various eye, retinal, optic nerve and brain disorders [1].

B. Kinetic perimetry

A stimulus of known luminance is placed in an unseen area (outside the border of hill of vision) and moved towards seen area to find the local threshold. Generally performed centripetally. The hill of vision is found by approaching it horizontally. The location where the first stimulus is seen has same sensitivity. This number of points form a ring called isopter. Stimulus size can be varied. It is 2D measurement of hill of vision. Results depend on the experience of the operator [1][6]. IV. WORKING Push button is a simple switch mechanism for controlling some aspect of a machine or a process. PIC microcontroller to program push button. 5v power supply is given to PIC microcontroller. Bluetooth device is used to transfer data from PIC microcontroller to android phone.

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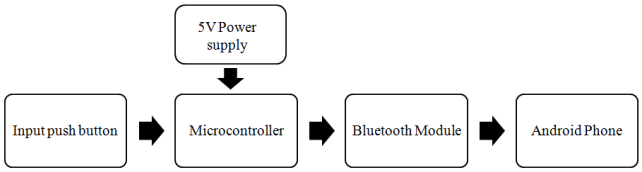

Figure. 2. Early Detection of Glaucoma using Perimetry.

A. Interfacing between smart phone & smart perimetry

The conventional perimetry consist of bulky perimetry machine. Patient aren't comfortable with these test conducted because they have to sit straight without moving & have to focus continuous without blinking of eyelid. So to avoid this conventional perimetry problems new system is developed. Instead of whole bulky machine a simple user friendly app is prepared which will conduct test. Recent home monitoring contains the electronic technology which measures the sensitivity of the central visual field using simulation. In simulation the higher frequency test are tested to improve the early detection of visual field loss in glaucoma. [11]

B. Smart phone app working

The smart phone needs a specially designed app to respond to the smart perimetry & monitor the reading of patient. The patient first need to get himself registered to app before undergoing the testing procedure. After this stage the patient can proceed with the testing procedure & the test results would be displayed on the smart phone in PDF format. If patient want to perform test second time then they have to enter their data one more time. By this way the doctor will be able to view the previous test results & compare it with the current results.

IV. METHODOLOGY

1. Turn both required equipments on i.e app and hardware device.
2. Open the app.
3. Create a new file for the new patient.
4. After completing the patient's personal data in the file, start a new examination.
5. Determine the perimeters of the measurement.
6. Choose one eye (right/left) to start the procedure.
7. The non-tested eye should be covered and the patient should sit comfortably and remain concentrated in front of the perimeter screen. Silence should be kept.
8. The patient must keep his eyesight fixated on the target in the middle of the screen.

9. The recognition of any other lights in the screen should be done by the patient by pressing the response button.
10. Examiner sets demonstration mode first, before the actual examination starts, in order for the patient to get used to the response button.
11. Result of test will generate report in pdf format.

V. RESULTS AND DISCUSSION

The results of the patient are stored in a pdf format file. The result contains report of tested eye. In this the left eye is tested. The result contains red and green colour format red indicates patient doesn't see the test location and green indicates number of test locations seen. In first section there are three graphs of different intensity.

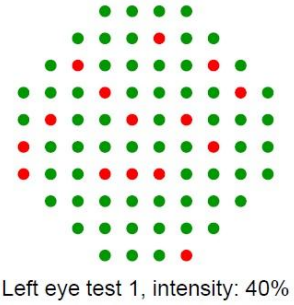

Figure. 3. First graph of red and green colour test points.

The second graph contains the locations of these test points from pupil i.e one to one mapping takes place between mobile screen where test is performed and the pupil. Atlast there is a table which contains distance and angle made by test points which aren't seen by the patient.

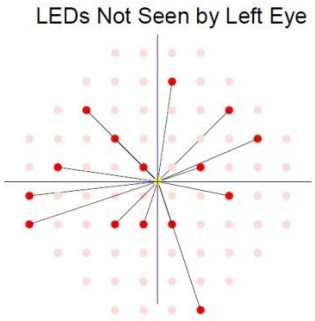

Figure. 4. Second graph of LED not seen.

A. Analysis

The distance between pupil mobile screen is fixed. When we get distance of test points then by similar triangle formula the distance is calculated of test point not seen. The main disadvantage of this test is patient corporation fixed distance, pupil size is assumed. So to increase the accuracy the distance between cornea and retina is taken whose results are as shown in table.

Table I:-Distance and Angle of Test Point Not Seen By the Patient

LED	DISTANCE	ANGLE
8	1.519 mm	-81.87 degrees
12	1.519 mm	-135.00 degrees
17	1.519 mm	-45.00 degrees
22	0.911 mm	-135.00 degrees
27	1.636 mm	-23.20 degrees
30	1.519 mm	-171.87 degrees
33	0.304 mm	-135.00 degrees
35	0.679 mm	-18.43 degrees
39	1.945 mm	173.66 degrees
46	1.095 mm	11.31 degrees
49	2.038 mm	161.57 degrees
52	0.911 mm	135.00 degrees
53	0.679 mm	108.43 degrees
54	0.679 mm	71.57 degrees
76	2.038 mm	71.57 degrees

VI. CONCLUSIONS

This smart perimetry will bring light to millions of people suffering from glaucoma. As once wisely said prevention is better than cure, the same way the early the diseases is detected the fast is the recovery. As this era is moving towards smart technologies, this smart perimetry will have a huge impact in the coming future.

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