

## Early Detection of Glaucoma Using Eye Tracker Metrics

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**Abstract:** Glaucoma is one of the main reasons for irreversible blindness in developing countries including India. Early detection of Glaucoma is important to save the vision loss due to Glaucoma. Here, we propose how eye tracker metrics analysis may help us to detect glaucomatous changes in high-risk groups. This paper presents the use of eye tracker data for early detection of glaucoma. Continuous eye movements are the part of our visual perception. Whenever we look at any scene, saccadic eye movements are generated. Saccade is a change in gaze position by a rapid sweep, followed by fixations where the eye is stable. Scan path is the sequence saccades and fixations. This eye movement data can be collected as a part of person's daily activities to analyze for early detection of Glaucoma.

**Keywords:** Eye Tracker, fixations, saccades, scan path

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### I. Introduction

The main cause of Glaucoma is increase in intra-ocular pressure. This elevated pressure destroys the optic nerve. This causes enlargement or deepening of optic cup and loss of vision. Glaucoma is a widespread eye disease that causes progressive loss of visual field function and irreversible blindness. Balance between inflow and outflow of fluid in the eye maintains normal eye pressure. Increase in eye pressure is an important risk factor for Glaucoma. Glaucoma is more common in adult people and rarely found in children. The elevated pressure in the eye can cause irrecoverable damage to the optic nerve which results in permanent loss of vision. In many chronic cases the side vision is initially affected and the disease slowly damages the normal vision and the patient is unaware of the problem.

The death of retinal ganglion cells is the cause of visual acuity and irreversible blindness. The increase in Intra-Ocular Pressure (IOP) is a major risk factor for Glaucoma [1]. The other risk factors in addition to IOP are age and family history; the main forms of the disease are [2]:

- Primary open angle glaucoma (POAG)
- Primary angle-closure glaucoma (PACG)

Whenever patients get clinically detected glaucoma irreversible damage has already occurred. The progress of Glaucoma can be prohibited with effective therapy, early diagnosis is one of the main goals in the treatment of the disease. It is believed that the thinning of retinal nerve fiber layer (RNFL) is highly correlated with visual field loss in Glaucoma. One key step in early diagnosis and treatment of Glaucoma is establishing

### II. Motivation

Early detection, through regular and complete eye exams, is the key to protecting the vision from damage caused by glaucoma. A complete eye exam includes five common tests mentioned in Table 1 to detect glaucoma. As effective therapy can inhibit the progress of glaucoma, early diagnosis is one of the main goals in the treatment of this disease. It is strongly believed that the thinning of the RNFL correlates highly with, or even precedes, visual field loss in glaucoma. Once glaucoma is diagnosed, patients need lifelong treatment and monitoring within eye hospitals to control the visual damage. Thus, there is a major workload of eye services for people detected with glaucoma.

It is important to have your eyes examined regularly. Your eyes should be tested:

- before age 40, every two to four years
- from age 40 to age 54, every one to three years
- from age 55 to 64, every one to two years
- after age 65, every six to 12 months

Anyone with high risk factors should be tested every year or two after age 35.

Early detection of glaucoma is very necessary to protect vision from damage caused by glaucoma for following reasons:

- There is no cure for glaucoma. Vision lost from the disease cannot be restored.
- Most types of glaucoma are asymptomatic.
- Immediate treatment for early-stage, open-angle glaucoma can delay progression of the disease. That’s why early diagnosis is very important.
- Glaucoma treatments include medicines, laser trabeculoplasty, conventional surgery, or a combination of any of these. While these treatments may save remaining vision, they do not improve sight already lost from glaucoma.

### III. Methodology

#### A. Existing Method

There are three methods for glaucoma detection: namely, OCT, TD-OCT and SD-OCT (also called Fourier Domain OCT). Huang was the first to present a non-contact, non-invasive method called optical Coherence Tomography. It determines the echo time delay and magnitude of light reflected from different layers of a structured tissue sample. This unique method through the eye made OCT applicable to the visualization of retina. Later in 1995, time domain OCT was introduced as an imaging technique for glaucoma detection. In SD-OCT (spectral Domain also called Fourier Domain OCT), a moving reference mirror, which is used in TD-OCT is not needed. SD-OCT provides faster scanning speed and higher resolution. The advance, recent invention is the use of specific algorithm and software to enhance scanning resolution and to decrease motion artifacts [4].

There are many features of Glaucoma correlates with other age related neurodegenerative disease. For example, there are evidences linking the etiology and disease process in glaucoma to Alzheimer (AD). The impact of glaucoma is well known but the pathogenesis of the disease is multifaceted and not well understood [5]. To be safe and accurate, five factors should be checked before making a glaucoma diagnosis [6]:

**Table 1.** A comprehensive glaucoma exam

Examination	Name of Test
The inner eye pressure	Tonometry
The shape and color of the optic nerve	Ophthalmoscopy (dilated eye exam)
The complete field of vision	Perimetry (visual field test)
The angle in the eye where the iris meets the cornea	Gonioscopy
Thickness of the cornea	Pachymetry

#### B. Proposed method

##### Eye Tracker:

Eye tracking is a sensor technology that enables a device to know exactly where a person is looking, his eyes are focused. It also determines user’s attention, focus, drowsiness, consciousness or other mental state.

##### Eye Tracking Method:

To track the eye movements, most of the modern eye trackers use near infrared technology along with a high resolution camera. This concept is commonly referred as Pupil Center Corneal Reflection (PCCR). In this method, near infrared light is directed towards the eyes (pupil). This causes visible reflections in the cornea. Cornea is the outermost element of the eye. These reflections are tracked by a camera.

Eye movement tracking has been only used for developing applications for physically handicapped people. With the new technologies and modernization, eye movement tracking is being explored in a broader perspective for integrating with daily applications. The detection of visual scan with or without user’s knowledge opens new possibilities in the field of automation and intuitive application development.

Using the Tobii X2/X3/TX300/Spectrum



**Fig.1** Use of Eye Tracker (Source: Tobii X)

**Eye tracker types:**

There are two types of eye tracking devices:

- 1. Remote/ Screen Based
- 2. Mobile/ Head Mounted

1. Remote/ Screen based eye tracker:

Remote eye trackers need the respondents to sit in front of a screen or monitor. They need to interact with the stimuli on the screen. There is a freedom of head movement and the respondent feels unrestricted.



**Fig. 2.** Remote/Screen Based Eye Tracker(Source:Tobii X)

2. Mobile/Head Mounted eye tracker:

As the name suggests, mobile eye trackers are fitted near the eye. Usually, they are mounted on eye glass frames. It allows the respondents to move freely.



**Fig. 3.** Mobile/Head Mounted Eye Tracker(Source:Tobii X)

Since the last decade, there are many enhanced eye trackers generally used for many applications. The application of eye tracking is very popular for example, usability, sports scientist, cognitive psychology, reading researchers, neurophysiologists, multimedia commercial devices, medical equipments, electrical engineers, and many more. An eye tracking system uses a device with sensor technology. It tracks and records the eye movements to know exactly where we do look and for how long. An eye tracker also involves software for pupil detection, image processing, data filtering, and also to determine eye movement metrics such as fixations, saccades, scanpaths, etc. [7]. Thus, we can get huge data from an eye tracker and there is a wide scope for analysis of this data. There has been significant advancement in eye tracking technology recently. Current eye trackers have become affordable, accurate and easy to use. These eye trackers do not require the head to be constrained in a specific position and can collect the data in standard viewing postures. This has enabled large scale low-cost availability of such data from multiple subjects [8].

Now days the laptops, tablets, smart phones with 3G, 4G technology are very commonly used. We have gone through the popularity and use of touch control in various devices. Similarly, eye tracking technology is also going to take off a big way.

The reason behind this is that all smart phones have high resolution cameras. This can be combined with eye tracking technology to get data about the user's vision when the user is performing his routine task. As eye tracking is growing quickly in popularity knowledge about it has become more accessible than ever, creating a vast ocean of information.

#### IV. Eye Tracker Metrics

We can get following recordings from an eye tracker:

**Saccades:**

Saccades are rapid eye movements by which we shift our line of sight and point the fovea at objects of interest. The saccade is a ballistic movement, meaning it is pre-programmed and does not change once it has started.

**Fixations:**

Between saccades the gaze position is kept fairly fixed in what is called a fixation. The fixation plays a vital role in the analysis of eye tracking data as it allows the analyst to determine where the subject was looking at any given point. Because of the continuous low-velocity eye movements during fixations, fixations are described in terms of the mean x-y coordinate of the gaze position when measured over a minimum period of time during which the gaze does not move further than a predefined maximum distance. In other words, the so called point of regard (POR), which is the point in space observed by eye gaze at a specific moment, must remain within a specified area for a specified minimum time in order for it to be regarded as part of a fixation.

**Scanpath:**

Eye movements are mainly categorized into Fixations and Saccades, i.e. when the eye gaze is stable in certain position and when it moves to another position, respectively. The resulting sequence of fixations and saccades is called the scan path [9].

**Smooth pursuit:**

Smooth pursuit describes when eye follows a moving object.

**Microsaccades:**

Microsaccades occur while attempting a fixation.

**Tremor:**

The smallest known eye movement is an oscillation called tremor.

Most of the information about eye is available during fixations or smooth pursuit but not during a saccade. The locations of fixations or smooth pursuit along a scanpath show what information locates on the stimulus were processed during an eye tracking session. On an average fixation duration is 200 ms during reading of text, and 350 ms during the viewing of a scene. It takes around 200 ms for preparing a saccade towards a new goal. For the analysis of cognitive intent, interest, and saliency, scanpaths are very useful. The use of eye tracking in human computer interaction (HCI) typically investigates the scanpath for usability purposes, or as a method of input in gaze-contingent displays, also known as gaze-based interfaces [10].

## V. Conclusion

Glaucoma is one of the four causes of irreversible blindness in developing countries like India. Whenever patients get clinically detected glaucoma, irreversible damage has already occurred. Early detection of Glaucoma is important to save the vision loss due to Glaucoma. Here, we propose how eye tracker metrics analysis may help us to detect glaucomatous changes in high-risk groups. This paper presents the use of eye tracker data for early detection of glaucoma. The eye movement data fixations, saccades, scan path can be collected as a part of person's daily activities to analyze for early detection of Glaucoma. Once glaucoma is diagnosed, patients need lifelong treatment and monitoring within eye hospitals to control the visual damage. Thus, there is a major workload of eye services for people detected with glaucoma. Therefore, people with glaucoma represent a major workload of eye services. Now days the laptops, tablets, smart phones with 3G, 4G technology are very commonly used. We have gone through the popularity and use of touch control in various devices. Similarly, eye tracking technology is also going to take off a big way. The reason behind this is, all smart phones have high resolution cameras. This can be combined with eye tracking technology to get data about the user's vision when the user is performing his routine task and can be used to improve our ability to assess the risk of glaucoma in different populations.

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