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Processing and Analysis of Retinal Images in Optical Coherence Tomography (OCT)

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Abstract: ***There are currently detailed information on the retina because there in Optical Coherence Tomography (OCT), Nevertheless, use more in OCT depends on the qualitative analysis of the data. Although technological advances have provided a lot of time and effort in reaching speed data, the OCT did not reach for the full methods for image analysis, and thus there is an urgent need analytical tool for images that allow for the OCT to achieve its full potential as a diagnostic tool in the decadence in the early. The present were provides an introduction to processing and analysis of retinal images in OCT and taking samples from the Anterior Eye Segment. The following diseases have been invistegted using OCT images Astigmatism, Emmetrope, Myopia and Hypermetropia. The Angle Opening Distance (AOD) methods have been calculated for each case. Moreover, the Trabecular-Iris Angle (TIA) method and Trabecular-Iris-Space Area (TISA) method have been utilized to verify the decision process. Results have proved that the selected measures were efficient and the performance of the system was effective to facilitate the measurement process and saving time and effort.***

Keywords: about anatomy of the eye, anterior eye segment, OCT images preprocessing, histogram, edge sharpening, hypermetropic eye, astigmatism eye

1. Introduction

An optical Coherence tomography is defined as a modern, it imaging case of anterior and posterior eye segment. The Light is used to examine tissue. The OCT features much higher resolution in comparison with the hitherto solutions, and dispensing a moving mirror, which is necessary to scan the object and testing, also allows Reduce the scan time (object scanning) Almost. A hundred times, obtaining 3D images [1].

1.1Anatomy of the Eye

In this section, the anatomy of the eye will be explained:

- **Anterior chamber:** area between the cornea and the lens of the eye that include aqueous humor.
- **Ciliary body:** portion of the eye, above the lens, that manufacture the aqueous humor.
- **Aqueous humor:** The fluid created in the eye.
- **Cornea:** limpid body at the front of the eye covering the iris, pupil and anterior chamber; it is the eye's fundamental light-focusing structure.
- **Iris:** The tinted circle of tissue behind the cornea that controls the amount of light that enters the eye through modification the volume of the pupil.
- **Lens:** is the limpid body suspended behind the iris that helps to concentrate light on the retina.
- **Macula:** is the section of the eye at the heart of the retina that processes sharp, clarity Vision straight-ahead.
- **Fovea:** pit or depression at the center of the macula that provides the greatest visual acuity.
- **Pupil:** The adaptable opening at the position of the iris through which light enters the eye.
- **Optic nerve:** is the pack of nerve fibers exist at the behind of the eye that transfers optical messages from the retina to the brain.
- **Retina:** is the light sensitive layer of tissue lining the back of the eye.
- **Sclera:** The tough outer coat that protects the entire eyeball.
- **Vitreous** Clear jelly-like substance that fills the eye from the lens to the back of the eye as shown in Fig. (1)[2].

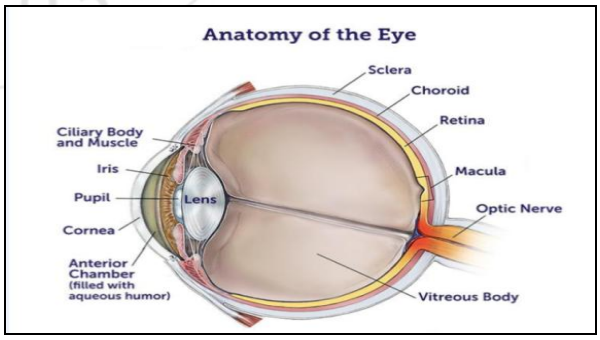


Figure 1: Anatomy of the Eye

1.2 Anterior Eye Segment

In terms of chosen of algorithms, the anterior eye segment is analysing the filtration angle and the anterior chamber volume. The anterior segment is the front third of. This part includes the structures in front of the vitreous humour: the cornea, iris, ciliary body, and lens it as shown in Fig. (2)[1].

In the anterior segment are two fluid-filled areas:

- The anterior chamber in the midst the posterior surface of the cornea.
- The posterior chamber in the midst the iris and the front face of the vitreous.

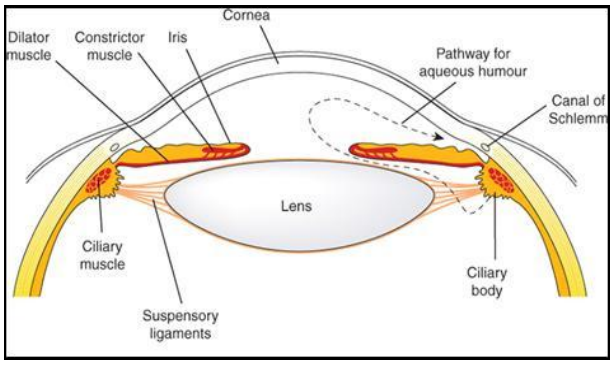


Figure 2: Anterior Eye Segment

1.2.1 Anterior Eye Segment Analysis

The filtration angle is the section which is dependable for the aqueous humor drainage from the eye's anterior chamber. Conditions for a correct intraocular pressure are not only a true production of the aqueous humour by the ciliated epithelium but also a true rate of aqueous humour drainage through the filtration angle. More difficult drainage as well as a pressure increase result from all anatomical anomalies, the angle narrowing and the angle closing. The examination that allows determining the angle width is called the gonioscopy. the glaucoma classify to the open angle glaucoma and to the closed angle glaucoma is based on the angle width (filtration angle) as shown in Fig. (3)[3].

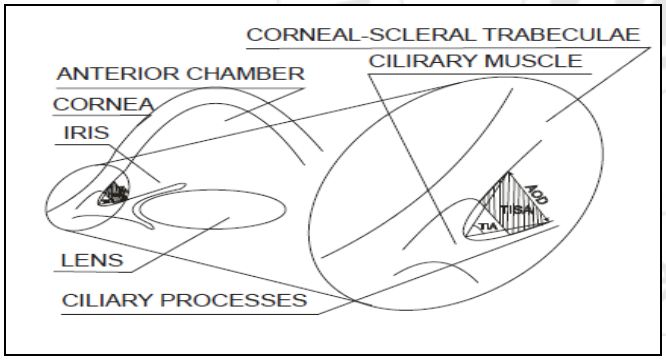


Figure 3: Part of the anterior segment of an eye with remarkable positions of characteristic areas

1.2.2 Three Methods to Measure the Filtration Angle

a) AOD (Angle Opening Distance) method
b) TIA (Trabecular-Iris Angle) method
c) TISA (Trabecular-Iris-Space Area) method

AOD (Angle Opening Distance) method consists in the measurement of distance, TIA (Trabecular-Iris Angle) in the measurement of angle and TISA (Trabecular-Iris Space Area) method consists in the measurement of area as shown in Fig. (4)[3].

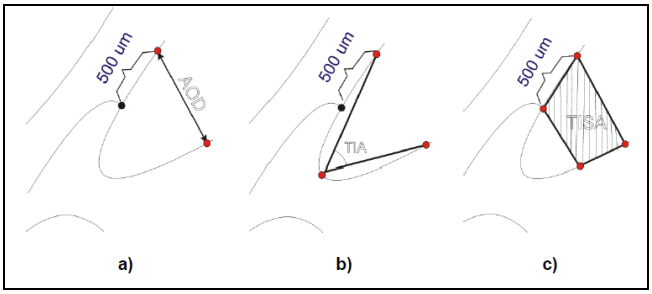


Figure 4: Three methods to measure the filtration angle: a) AOD method, b) TIA method, c) TISA method

2. OCT Images preprocessing

Image processing includes changing the nature of an image so as to either

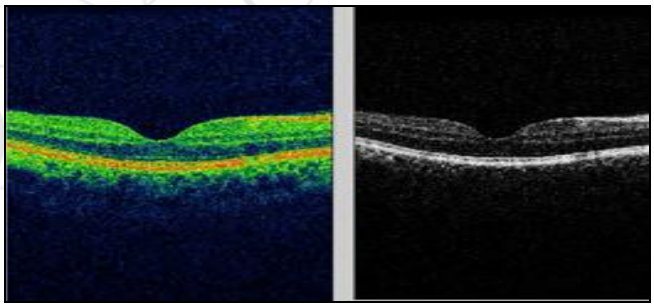
1) Develop its photographic information for human interpretation, or
2) Render it more appropriate for autonomous machine perception.

We shall care about digital image processing, which includes using a computer to change the nature of a digital image .It is important to recognize that these two aspects are two separate but equally important aspects of image processing. [4].

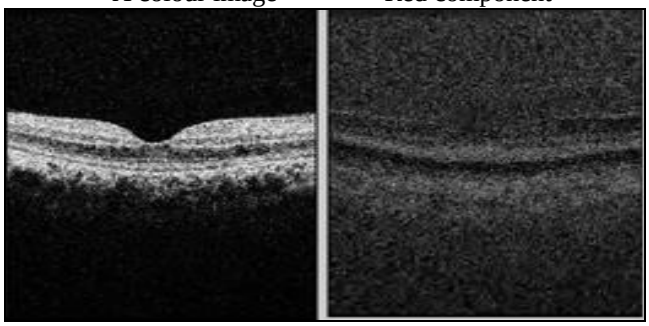
2.1 Colour models

2.1.1RGB

It is an additional color model in which red, green, and blue light are mixed together in different ways to produce a broad arrangement of colors. The name of the model describes from the initials of the three additive main colors, red, green, and blue. The major purpose of the RGB color model is the feeling, performance, and show of images in electronic systems, like televisions and computers, though it has also been used in traditional photography as shown in Fig. (5)[5].



A colour image Red component

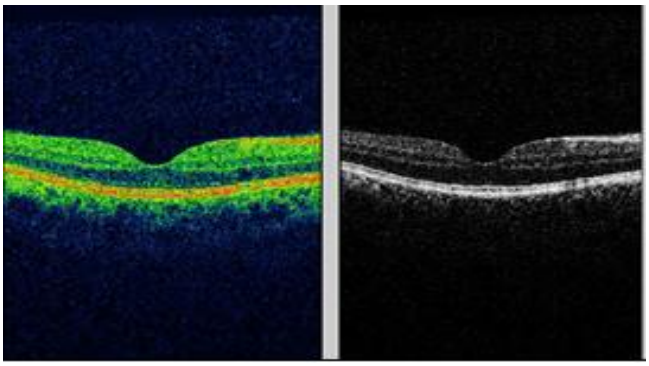


Green component Blue component

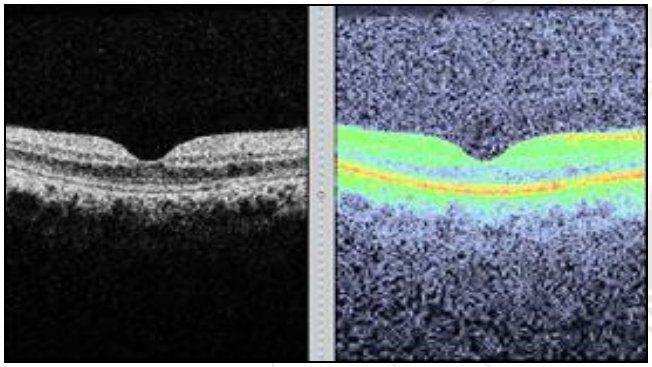
Figure 5: RGB image and its components

2.1.2YIQ

This may be defined as the color model used for (TV/Video) system in Japan, and North and Central America. Video standard is called (NTSC). The Y component is the luminance (this corresponds roughly with intensity) I and Q carry the colour information as shown in Fig. (6)[5].



A colour image Y



I Q

Figure 6: The YIQ components

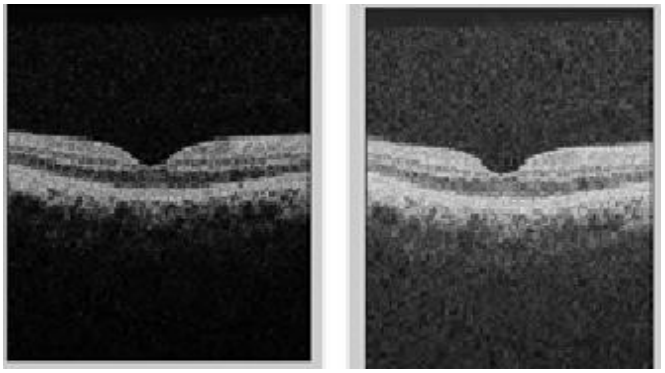
2.2 Histograms

Given a greyscale image, its histogram comprises the histogram of its grey levels; that is, a graph referring to the number of times each grey level happens in the image, as the following examples show:

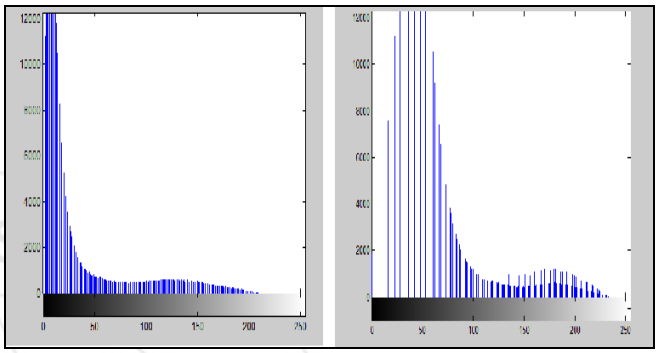
1) In a dark image, the grey levels (and hence the histogram) would be clustered at the lower end:
2) In a uniformly bright image, the grey levels would be clustered at the upper end:
3) In a well contrasted image, the grey levels would be well spread out over much of the range:

2.2.1 Histogram Stretching

It is an operation that changes the range of pixel intensity values in image processing; implementations involve photographs with needy contrast because of glow. For instance, it is at times described as contrast stretching or histogram stretching. In broad ranges of data processing, like digital signal processing, it is indicated as dynamic range extension. The clear difference of an image is an assessor of its dynamic range, or the "spread" of its histogram. The dynamic range of an image is referred to as the entire range of intensity values existed within an image as shown in Fig. (7)[4].



a) The original image b) The image after histogram stretching



a) The original image b) The image after histogram stretching

Figure 7: Histogram stretching

2.3 Edge sharpening

2.3.1 Unsharp masking

The deduction of a scaled (unsharp) version of the image from the original is the idea of unsharp masking. In practice, this affect can be attained by subtracting a scaled blurred image from the original. The schema for unsharp masking is as shown in Fig. (8), Fig. (9) [6].

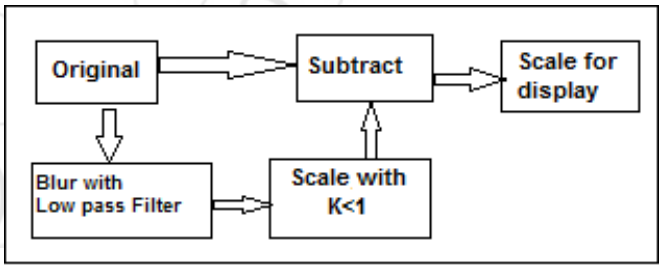
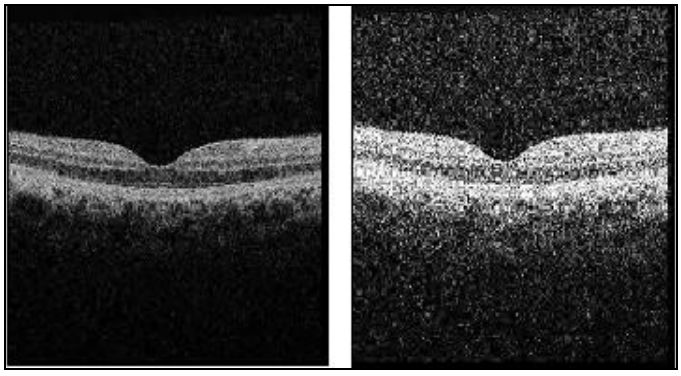


Figure 8: Schema for unsharp masking



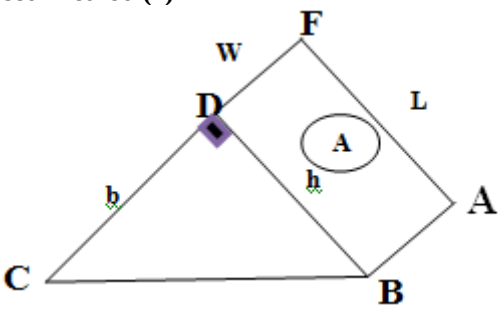
a) The original image b) The image after unsharp masking

Figure 9: unsharp masking

3. Proposed Diagnostic Methods

It has been proposed two methods for the diagnosis of the following diseases using OCT images Astigmatism, Emmetrope, Myopia and Hypermetropia. Order to calculate each of the AOD, TIA, TISA methods. The pictures were taken and divided as the form.

Proposed Method (1)



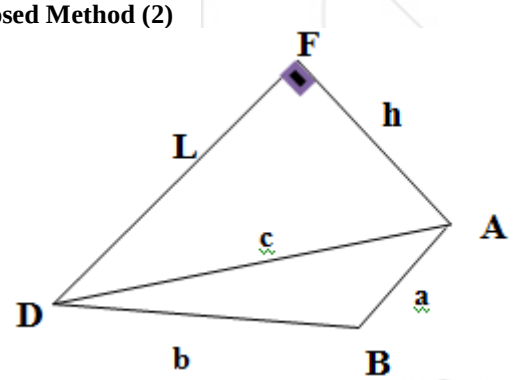
A normal from B is projected onto CF. it meets it at D. thus the polygon ABCF is Subdivided into two parts a rectangle ▯ ABDF and a triangle Δ BCD.

Area of rectangle ▯ ABDF = Length (L) x Width (W) (1)

Area of triangle Δ BCD = $\frac{h \cdot b}{2}$ (2)

Area of (ABCDF) = Area of rectangle ▯ ABDF + Area of triangle Δ BCD (3)

Proposed Method (2)



Thus the polygon ABDF is subdivided into two parts a triangle Δ ABD and a triangle Δ ADF.

Length of $(AD)^2 = (AF)^2 + (DF)^2$ (4)

$S = (a + b + c) / 2$ (5)

Area of triangle Δ ABD = $\text{sqrt}\ (s^* (s-a)^* (s-b)^* (s-c))$ (6)

Area of triangle Δ ADF = $\frac{h \cdot L}{2}$ (7)

Area of ABDF = Area of triangle Δ ABD + Area of triangle Δ ADF (8)

4. Data Acquisition

It was obtained four samples from Anterior Eye Segment in the Center ALNOKHBA Medicine and Eye Surgery and LASIK In the following diseases Astigmatism, Emmtrope, Myopia and Hypermetropia to calculate AOD (Angle Opening Distance) method, TIA (Trabecular-Iris Angle) method, TISA (Trabecular-Iris-Space Area) method Easy and simple way to facilitate the process of identifying the disease and save time and effort, type of the image (JPG), size of the image 274 KB.

5. Experimental Results

5.1 Hypermetropic Eye

Commonly known as far sightedness or longsightedness.

Symptoms of the disease

It causes is a defect of vision brought about by an imperfection in the eye, and it causes the eye to lose sufficient power to see close or nearby objects

Reasons hyperopia famous:

- Abnormal shape of the cornea
- Low converging power of eye lens due to weak action of ciliary muscles.

Disease treatment

Use of convex corrective lenses for near objects as shown in Fig. (10)[7].

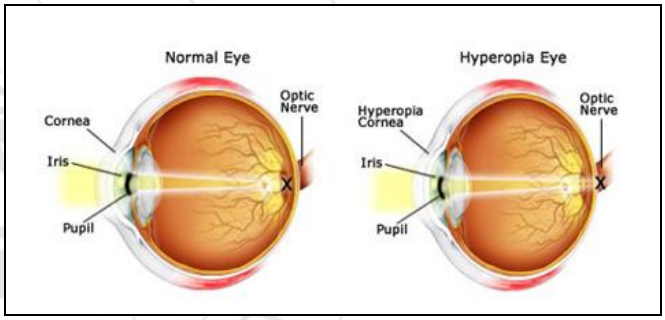


Figure 10: Hypermetropic eye

5.1.1 Result of Hypermetropic Eye

Measures were obtained from group patients. The AOD 500 measured was (498 to 514) µm, AOD 750 measured was (684 to 792) µm, TISA 500 measured was (159064.9 to 192050.9) µ m², TISA750 measured was (315111.9 to 402829.9) µm², and TIA degree measured was (30.3^0 to 39.8^0) degree as shown in table (1), table (2).

Table 1: Comparison of methods filtration angle in case (1)

Case (1)	*AOD 500 µm*	*AOD 750 µm*	*TISA 500 µm²*	*TISA 750 µm²*	*TIA degree*
OS(L)Right	479	688	175250	341705	32.9^0
OS(L)Left	506	763	189756	381394.5	39.8^0
OD(R)Right	498	792	191750	397875	30.3^0
OD(R)Left	514	684	189750	348375	38.1^0

Table 2: Comparison of methods filtration angle in case (2)

Case (1)	*AOD 500 µm*	*AOD 750 µm*	*TISA 500 µm²*	*TISA 750 µm²*	*TIA degree*
OS(L)Right	479	688	159064.9	315111.9	32.9^0
OS(L)Left	506	763	182188.19	374013.6	39.8^0
OD(R)Right	498	792	186248.2	402829.9	30.3^0
OD(R)Left	514	684	192050.9	350687.5	38.1^0

5.2 Emmetropia eye

It Characterized by normal eye or perfect vision and it requires no corrective lenses .but Corrective eye surgery such as LASIK and PRK achieves at correcting anemmetropic vision. The light rays are parallel that coming from that object, and the rays are focused on the retina without effort and achieved perfect vision as shown in Fig. (11).

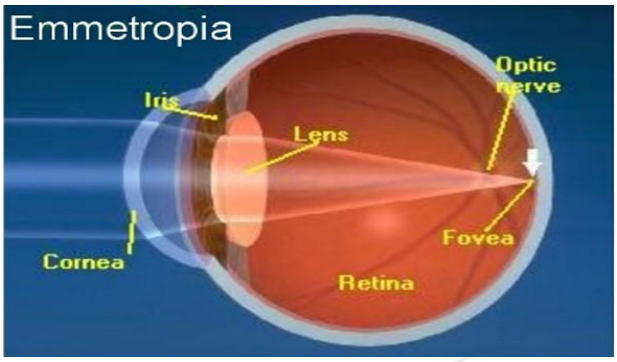


Figure 11: Emmetropia (eye)

5.2.1Result of Emmetropia Eye

Measures were obtained from group patients. The AOD 500 measured was (453 to 629) µm, AOD 750 measured was (685 to 984) µm, TISA 500 measured was (169087.5 to 239769.5) µ m², TISA750 measured was (340578.5 to 482250) µm², and TIA degree measured was (29.6^0 to 35.3^0) degree as shown in table (3), table (4).

Table 3: Comparison of methods filtration angle in case (1)

Case (1)	*AOD 500µm*	*AOD 750 µm*	*TISA 500 µm²*	*TISA 750 µm²*	*TIA degree*
OS(L)Right	629	984	239769.5	482250	32.0^0
OS(L)Left	523	769	191262	379512	29.6^0
OD(R)Right	453	685	169087.5	340578.5	30.8^0
OD(R)Left	529	717	199648.5	369867.5	35.3^0

Table 4: Comparison of methods filtration angle in case (2)

Case (2)	*AOD 500µm*	*AOD 750 µm*	*TISA 500 µm²*	*TISA 750 µm²*	*TIA degree*
OS(L)Right	629	984	219293.63	462172.1	32.0^0
OS(L)Left	523	769	182964.02	363130.36	29.6^0
OD(R)Right	453	685	169906.9	354495.3	30.8^0
OD(R)Left	529	717	190736.6	355311.84	35.3^0

5.3Myopia eye

It also can be defined as short-sightedness and near-sightedness

Symptoms of the disease

The light that coming from that object concentrated in front of the retina not on it, causing the image that one sees when looking at a distant object to be out of focus. On the contrary, in case of looking at a close object, it does not affect focus as shown in Fig. (12)[9].

Disease treatment

Use of

1. Corrective lenses, such as glasses or contact lenses.
2. Refractive surgery.

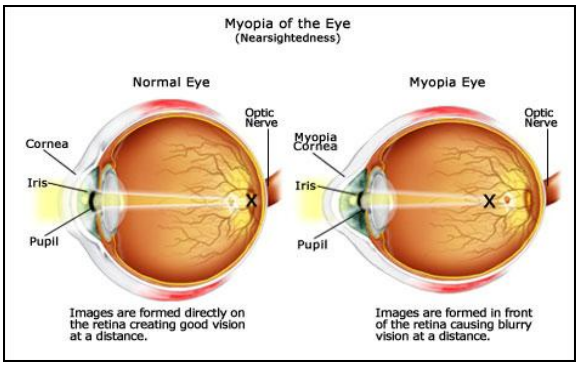


Figure 12: Myopia eye

5.3.1Result of Myopia

Measures were obtained from group patients. The AOD 500 measured was (937 to 1242) µm, AOD 750 measured was (1318 to 1550) µm, TISA 500 measured was (268404.3 to 435619.5) µ m², TISA750 measured was (550310 to 774180) µm², and TIA degree measured was (60.2^0 to 67.9^0) degree as shown in table (5), table (6).

Table 5: Comparison of methods filtration angle in case (1)

Case (1)	*AOD 500µm*	*AOD 750 µm*	*TISA 500 µm²*	*TISA 750 µm²*	*TIA degree*
OD(R)Left	937	1401	334668	676800	60.2^0
OD(R)Right	1194	1420	435619.5	738840	61.9^0
OS(L)Left	1242	1550	434732	774180	67.9^0
OS(L)Right	1011	1318	346000	634125	63.6^0

Table 6: Comparison of methods filtration angle in case (2)

Case (2)	AOD 500µm	AOD 750 µm	TISA 500 µm²	TISA 750 µm²	TIA degree
OD(R) Left	937	1401	295812.2	624455	60.2^0
OD(R) Right	1194	1420	423519	747646.6	61.9^0
OS(L) Left	1242	1550	411087	755096.9	67.9^0
OS(L) Right	1011	1318	268404.3	550310	63.6^0

5.4 Astigmatism Eye

Symptoms of the disease

It an optical defect, It causes blurred vision because the optics of the eye are unable to the object is focus a point into a sharp focused image on the retina.

The two types of astigmatism:

1) Regular astigmatism: the more popular astigmatism coming up from either the cornea or crystalline lens and corrected by eyeglasses or toric lenses
2) Irregular astigmatism: causes corneal scar and corrected by lenses as shown in Fig. (13)[10].

Disease treatment:

Use of

1. Glasses, or
2. Contact lenses, or
3. Refractive surgery.

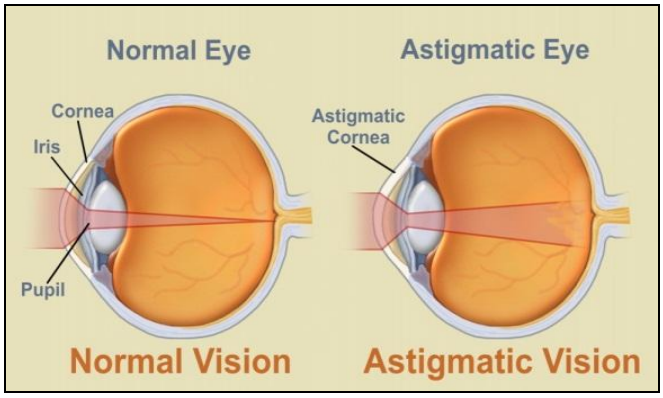


Figure 13: Astigmatism (eye)

5.4.1 Result of Astigmatism

Measures have been obtained from a group of patients. The AOD 500 measured was (473 to 546) µm, AOD 750 measured was (622 to 781) µm, TISA 500 measured was (176116.36 to 202654.5) µ m², TISA750 measured was (321068.2 to 400376.3) µm², and TIA degree measured was (25.3^0 to 34.5^0) degree as shown in table (7), table (8).

Table 7: Comparison of methods filtration angle in case (1)

Case (1)	*AOD 500 µm*	*AOD 750µm*	*TISA 500 µm²*	*TISA 750 µm²*	*TIA degree*
OS(L)Right	546	679	196356.5	344540	34.5^0
OS(L)Left	473	667	202654.5	376626.527	27.6^0
OD(R) Left	479	622	179107.5	322608	28.7^0
OD(R) Right	512	781	182113.5	374496	25.3^0

Table 8: Comparison of methods filtration angle in case (2)

Case (2)	*AOD 500 µm*	*AOD 750µm*	*TISA 500 µm²*	*TISA 750 µm²*	*TIA degree*
OS(L)Right	546	679	180573.4	339276.8	34.5^0
OS(L)Left	473	667	189033.5	367851.2	27.6^0
OD(R) Left	479	622	176116.36	321068.2	28.7^0
OD(R) Right	512	781	179829.2	400376.3	25.3^0

6. Conclusion

As mentioned earlier information about the retina and the extent of evolution in the discovery of diseases. Using OCT, we were able to diagnose of the following diseases as Astigmatism, Emmetrope, Myopia and Hypermetropia In different ways such as The Angle Opening Distance (AOD) methods, the Trabecular-Iris Angle (TIA) method and Trabecular-Iris-Space Area (TISA) method. And work the image processing for retina different ways such as colour models, histograms and edge sharpening. Results have proved that the selected measures were efficient and the performance of the system was effective to facilitate the measurement process and saving time and effort.

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