Detecting Anomalies in Human Eyes using Structural Similarity Index Measurement

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Declaration

We hereby assure that all the work done for this thesis project is compiled with the results attained from our own work. All of the algorithms, tools and materials that helped us developing this project have been properly acknowledged and referenced. This thesis either in whole or in part, has not been previously submitted for any degree anywhere.

Signature of Supervisor **Signature of Co Supervisor**

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List of Abbreviations

SSIM	Structural Similarity Index Measurement
PPM	Pixel Per Metric

Abstract

From the idea of anomaly, we come to learn that basically it is an idea of abnormality of eyesight, and interruption on the screen of eyes that does not fit with the rest of the pattern. Whatever we see or the images we look at are made up of lights reflected from the object we look at. Cornea, lens acquas humor, sclera, retina, choroid, optic nerve each of these components are equally important for eyesight. A slight defect in any part of these components will highly effect to our eyesight. Our main aim is to identify all the eyesight related problems through object detection using image processing. Our target result will be within a range of -1 to1 which will be the structural difference between healthy and unhealthy human eyes. We have identified the problems following two algorithms, one is SSIM and another is Eucledian Distance. In SSIM, we are comparing one healthy eye to another infected eye to distinguish the difference, by which we suggest the detected anomaly to the user. In Eucledian Distance, we are measuring the size of the IRIS to detect eye anomalies like myopia and lazy eye. From our results, we got the values between our expected ranges with slight error margining.

CHAPTER 01

Introduction

1.1 Introduction

It is undeniable how important our eye sight is in our daily life, eyes are responsible for our four-fifths of all the information of our brain receives and circulate. It is inevitable that no camera, no television, no great technology could provide with such a high resolution of clearness, so all man made high technology is defeated or inferior to the great human eye undoubtedly.

It is needless to say if people are deprived of this blessing, they will not be able to see anything or circulate the information from brain storage. There is a proverb saying, “Before you die your life passes before your eyes, it is in fact true and that’s called living”. But it is unfortunate that not every single human being has great eyesight. Some suffer from myopia [7], some from hypermetropia, some from lazy eye and some from presbyopia. Where there is a disease there is a prevention. All of the eye sight problems are not corrective but some of them are identifiable and preventable [10]. Digital images are basically subject to a wide variety of s during acquisitions, processing, compression, transmission, in the end which will result into visual quality. Subjective evaluation is basically not time convenient, time consuming and not cheap.

To circulate this system and implement it we have to do all the tasks step by step. We are following here two major steps, first and prior one is to identify the differences between two pair of eyes following structural similarity index measurement and the second step is identifying the differences between two pair of eyeballs [2]. We will find some data of differences between eyes, following those data we can come into results who will provide which eyes are abnormal and which ones are not.

1.2 Motivation

It is really hard to ignore the fact that most of us in our daily lives come across each other and find problems regarding their eye that might be a result of several issues. Problems regarding the latter might include eye Miosis, eye glaucoma, corneal ulcer and most importantly Lazy eye. Our main objective is not to prevent such diseases but to cause an awareness of what the disease might be instead of wasting both time and energy in order to diagnose the problem where the subject might even turn out to be a result of wrong treatment.

Nowadays it is known about the difficulties faced during appointments taken from doctors, standing in a queue, waiting for long periods and then finally be able to reach their consultation. In this long period of difficulty, the patient often gets even more sick than before condition. But what if we have a system that will help us to identify the problems regarding our eyes. Then it will be beneficial to all the patients whoever are suffering from anomalies or any eye problems.

1.3 Problem Statement

It was not an easy task for us to make this image detecting system for eye. First of all, we could not find sufficient data for implementing our work. Then we had to consult with doctors and got some idea about eye problem detection process. As a result, we did not use any google data and went for real life data. Also we had to take some of data and information from medical books as they were not sufficiently enough in online. Secondly we could not find any ideas or information from some pictures due to bad resolutions and bad angles of the pictures. Good resolution pictures and convenient angles are here play vital role as pictures will be tested later.

The third drawback of this system will be this is not really regular in our country, so it will take a lot of time and initiative to cope up this system with hospital and medicals. The doctors, nurses, representatives must be acknowledged and in aware of this system.

1.4 Solutions

Lazy eye, short sight (myopia), long sight (hypermetropia), river blindness, astigmatism, these happen lack of focusing of cornea and lens. Each of the problem has different reason, some are corrected and some are not even corrected. Our System is to find out the differences between the pairs of normal and abnormal eyes and help sufferers to deal with their problem, reduce it to some extent. To get proper and valid information, we took some real life data from patients, medical books, doctors. Also, there will be a recommendation that the pictures must be taken in a good light so the resolution of the pictures come properly and we can continue the system accordingly.

1.5 Methodology

This system primarily worked based on comparing the patient's eye image with the standard one. However, accuracy of this system depends on the capture angle of the image and the light of the image. Our system can recognize the ocular difference in the patient's eye which cannot be detected by normal visualization. If the image is captured in the moderate light and the face is pointed toward the camera, then we will get a nearly accurate solution from this system.

1.6 Contribution Summary

Our work is going to help the medical sector to diagnosis eye related problems specifically lazy eye, short sight (myopia), long sight (hypermetropia), river blindness, astigmatism. This is going to make the process faster, help to reduce the expenses of the patients and save the valuable time of both doctor and patient. The accuracy of diagnosis might not be perfect all the time during eye treatment. This system is going to increase the accuracy of diagnosis for those specific eye problems which are mentioned over here.

1.7 Thesis Outline

Chapter 2 elaborates the background study behind the motivation of this project.

Chapter 3 covers workflow, explains the algorithms and implementations of this system

Chapter 4 shows the experimental results.

Chapter 5 ends this paper mentioning its challenges and limitations along with the future scope for this system.

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CHAPTER 02

Literature Review and Research

2.1 Literature Review

As we know, use of technology in the field of medical specially for diagnosis is not completely new. Hence, before starting our thesis paper we did research on our own and gone through several research papers published from reputed institutes and written by renowned authors across the globe. In this section, we mentioned the zest of the research papers that we gone through as well as their lacking that made their papers out dated. On the top of that, we tried to mention possible solutions and methods they could use to make their paper better.

In the paper, [2] Fares Jalled developed the need of computer vision that to how and why to detect objects and faces. The main objective of this article is to develop an Open CV-Python code using Haar Cascade algorithm for object and face. He tried to describe in detailed all concepts of object and face detection and importance of it in that field. An Unmanned Ariel vehicle (UAV) are used for detecting and attacking the infiltrated ground targets. There are few drawbacks in this kind of UAV's. The objects are not properly detected in some cases whereas it causes the object to hit the UAV. In this project, the author tried to avoid such unwanted collisions and damages of UAV. In the paper, the purpose was to detect the objects and the output objects were detected from the real scene. They implemented the face detection program to detect and follow people in case of surveillance and other domains. The author introduced a tool to explain object detection systems. He also presented several algorithms to visualize the success spaces of object detectors. In future this program can be used to control the cameras in a UAV and navigate through obstacles effectively. This program can be upgraded to reduce the process time of the controller so a different methodology can be tried and implemented.

Vladimir Vezhnevets [9] have provided the description, comparison and evaluation results of popular methods for skin modelling and detection. In this paper, they tried to summarize the most notable and significant differences between the methods, their advantages and disadvantages. They briefed conclusions.

For constructing classifiers in case of limited training and expected target data set, parametric skin modelling methods are better suited. The generalization and interpolation ability of these methods makes it possible so that it can construct a classifier with acceptable performance from incomplete training data."

The methods that are less dependent on the skin cluster shape and take into account skin and non-skin colors overlap look more promising for constructing skin classifier for large target datasets."

Excluding color luminance from the classification process can help to generalize sparse training data but cannot help achieving better discrimination of skin and non-skin colors."

Different modelling methods react very differently on the colorspace change as evaluation of colorspace goodness in general by assessing skin cluster shape, skin/non-skin overlap etc regardless to any specific skin modelling method that cannot give the impression of how good is the colorspace suited for skin modelling."

In the paper, Image Quality Assessment: From Error Visibility to Structural Similarity [1] have summarized the traditional approach of image quality assessment based on error-sensitivity and have briefed its limitations. For the design of image quality measures, they have proposed the use of structural similarity as an alternative motivating principle. They developed an SSIM index to demonstrate their structural similarity concept and showed that it compares favorably with other methods in accounting for their experimental measurements of subjective quality of 344 JPEG and JPEG2000 compressed images. They find out in the research that in measuring signal distortions both the SSIM index and several recently developed divisive normalization based masking models exhibit input-dependent behavior. They are hopeful that the two approaches may eventually converge to similar solutions.

CHAPTER 03

Proposed Model

3.1 Finding Difference between eyes

The main goal of this paper is to develop a system that will detect the abnormality of eye sight. Our system can detect lazy eye by calculating the difference between a standard reference eye and a patient's eye [6]. It can also measure the dimensional difference of a cornea based on the standard reference cornea. The system can detect the basic abnormality of the eye sight both for doctor and normal user. In terms of lazy eye, if the difference is very low with the standard eye then it is really hard for the doctor to recognize the fault without testing [5]. If the difference is larger, the doctor can detect it without testing. Our system is very efficient in terms of calculating the slight difference. Figure 1 shows the flow chart of our system.

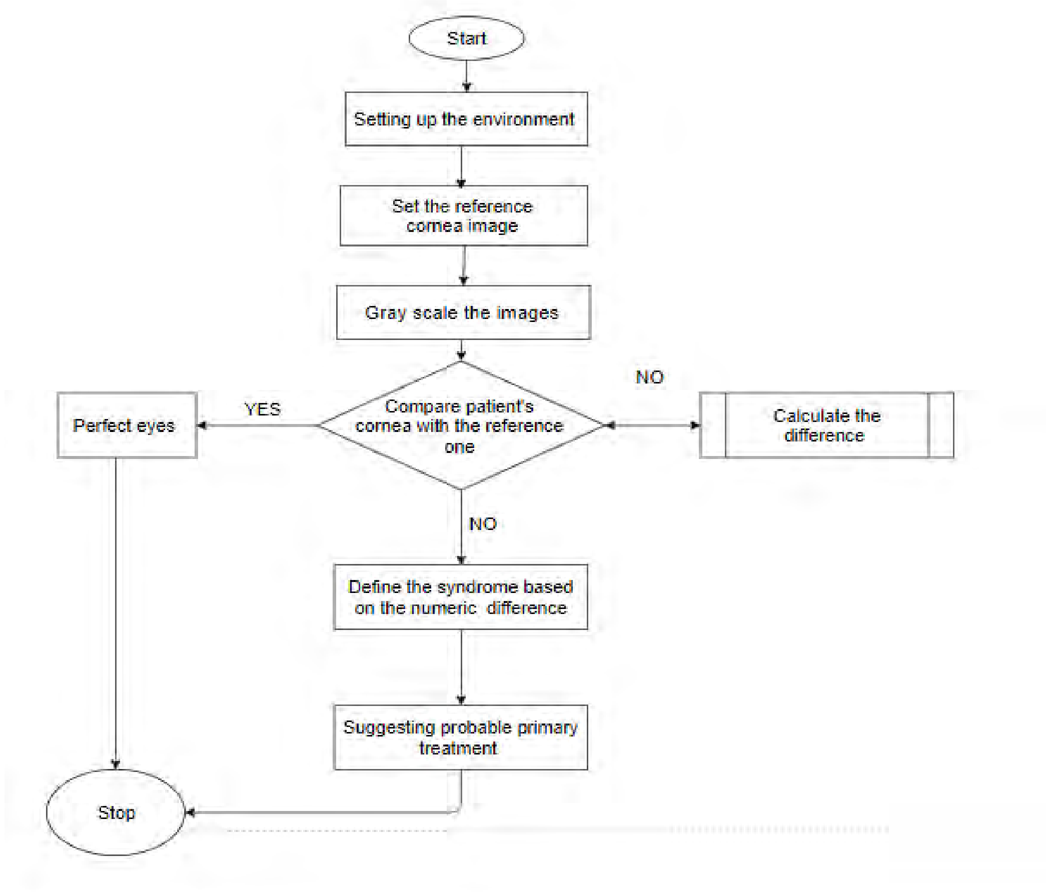

Figure 1: Finding Difference Between Images

3.1.1 Algorithm

Structural Similarity Index Measurement (SSIM)

```
do:
images=[user input]
findXY()
if x, y valid:
      compute_SSIM()
else:
      exit()
```

3.1.2 SSIM Implementation

In terms of lazy eye, we are calculating the difference separately for left and right eye. For the right eye, we are taking a standard right eye and the patient's right eye [7]. Figure 2 shows standard eye and Figure 3 shows a patient eye.

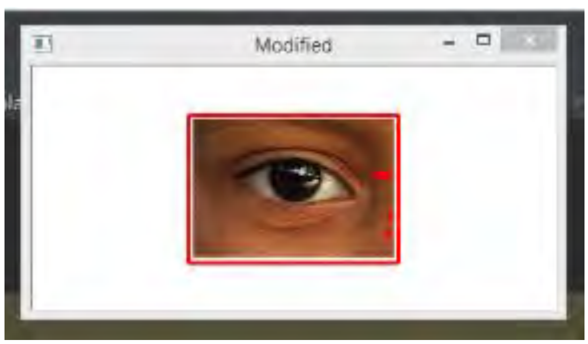

Figure 2: Standard Healthy Eye

As to calculate wheather the patient eye is a lazy eye or not we first convert the iamge into greyscale.Form the grayscale image, using Structural Simlarity Index (SSIM) we will calculate difference between patinet's eye and the standard eye. Figure 3 showing the difference with the standard one.

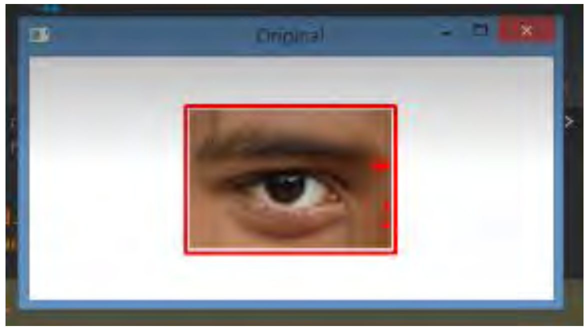

Figure 3: Slightly Deviated Eye

After calculating the difference this system will find out the thresholded image. Thresholded iamge define where the changed occurs. If we caompare a healthy eye with the standard one the SSIM value will be 1.0. Figure 4 shows the thresholded image.

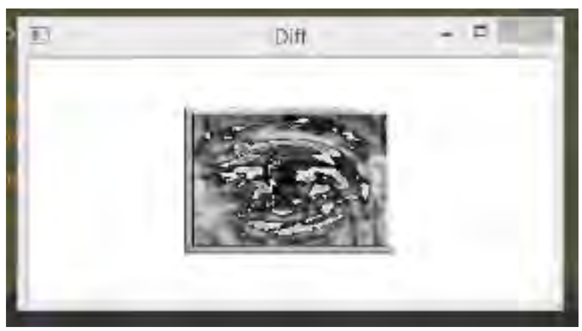

Figure 4: Greyscale Differences

If the thresholded image value is less than 1.0 then this patient's eye contain some sort of problem. In this particular example the threshold image SSIM value is 0.04193877013058 79 [2].In this case the difference is sifnificantly high. Because we can even detect the problem in this patient image by just having a look on it. This perticular syndrome is one kind of lazy eye which is known "Intermittent Exotropia". Figure 5 shows the marked contours of the unhealthy eye which was calculated with SSIM.

Figure 5: Marked Contours

On the other hand, if we compare healthy eye with the standard one, we would not get any significant amount of difference in some case no difference. As we mention earlier, if the patient's eye is completely okay based on the standard eye then the SSIM will be 1.0 or close to this. In this case the SSIM value is 1.0. So we can conclude that, this eye does not contain any syndrome of lazy eye.

3.2 Measuring Eyeball Sizes

Eye Miosis is one of the diseases that we are planning to detect with our system. In this disease patient's eyeball size reduces significantly. The standard size of a fully grown adult is .944 inch [11]. We are comparing a standard image of an eyeball to other infected images so that we can determine their sizes and confirm the presence of the disease. Figure 6 explains the workflow of the cornea size measurement.

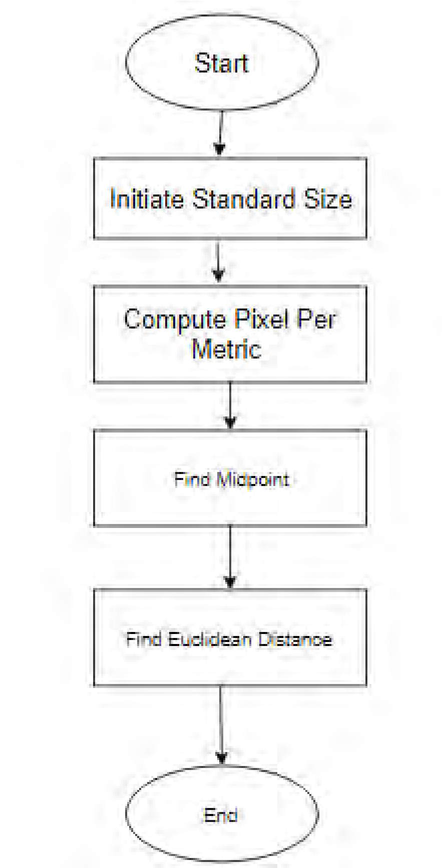

Figure 6: Measuring IRIS Sizes

3.2.1 Algorithm

Euclidian Distance

```
do:
convert to grayscale
      gaussianBlur()
      if blurred:
            detectEdge()
            findContours()
            computeMidpoint()
            calculateEuclidianDistance()
      else:
            promptForNewImage()
```

3.2.2 Calculating PPM

For measuring IRIS sizes firstly, we will be calculating the PPM of an image. PPM will help us to find the midpoint of the image [8]. The coordinate of the midpoint will allow us to use the edges and contours of the given image and measure its edge to edge size. Figure 7 pointing the standard IRIS.

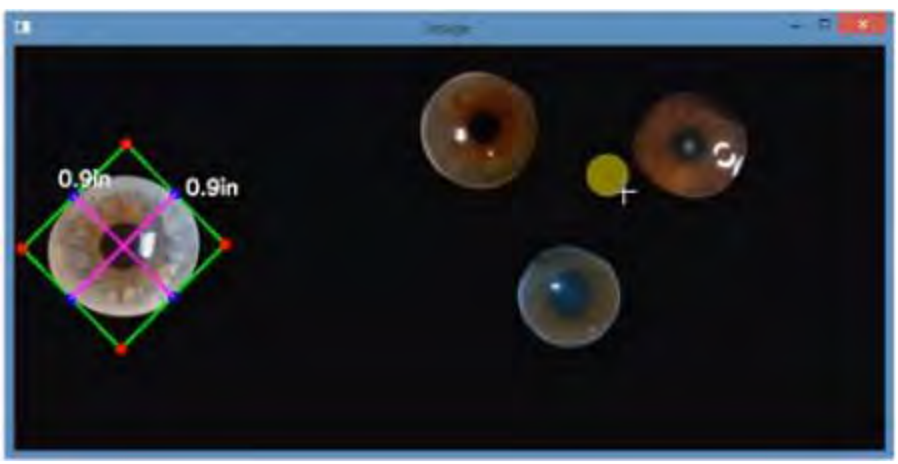

Figure 7: Marking the standard IRIS

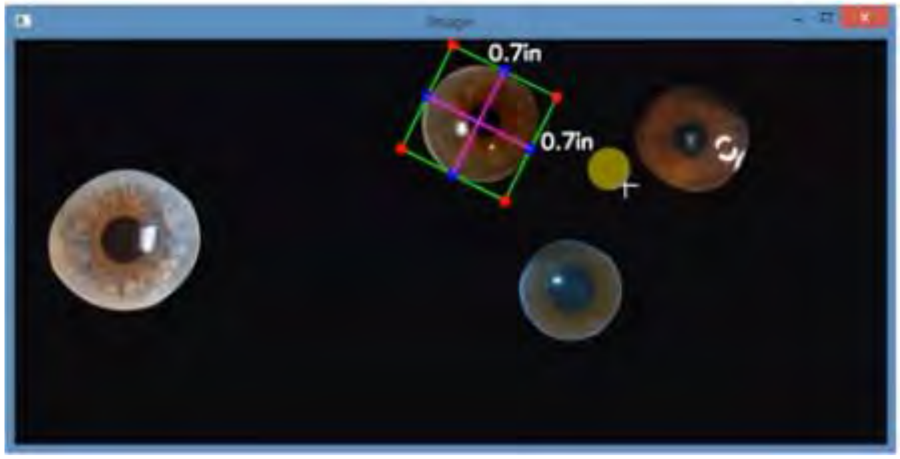

Figure 8: Measuring Infected Eyes

Figure 8 shows an IRIS with the measured size from edge to edge. With our reference value and reference image using `numpy` and `imutils` we can measure the size of our dataset. Our script will loop through the process to find more available IRIS from an existing image. This continuous process will make sure that our data is accurate and reliable. This achieved data will ensure that the patient is suffering from Eye Myopia [10].

CHAPTER 04

Experimental Data and Results

4.1 Difference between healthy and unhealthy eye

Standard Threshold Value of SSIM = 1.0

The Standard Threshold value of SSIM was acquired by comparing two healthy eye images. Table I. was populated with results from our experiments with experimental data from local and online sources.

Table I. SSIM of Multiple Eye Diseases

Variant of Eye Diseases	SSIM Value
Eye Myosis	.84459876
Lazy Eye	.72545866
Eye Glaucoma	.54786354
Corneal Ulcer	.43574864

The SSIM Values are the outputs from `scikit-image` [1]. This result varies from the range of -1 to 1. Based on the results from our multiple tests we can categorize them into visible diseases of different types.

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The input x and y are pixel densities of the given images in respective directions [1]. Other properties of the image are obtained from other tools that we used.

4.2 IRIS Size Measurement

Table II. was populated with data from various medical journals of ophthalmology. Size of the human iris usually varies from the range of .6 cm to 1 cm. Children of the age group in between usually have larger eyeballs proportionate to their other body parts [12]. This is why their eye looks much bigger. With the growth of age, the size of their iris also increases, but this increment is minimum than the growth of other limbs. So, it seems eye size remains same throughout the life of a human being Table II contains a list of measured standard size of iris of different age groups. This data was based on the people of Indian Subcontinent.

Table II. Sizes of healthy iris

Age Group	IRIS Size(in Cms) (avg)
0-9	.65
10-19	.72
20-29	.87
30-50	.94

Table III. was populated with data from various medical journals of ophthalmology.Patients of Eye Myopia usually suffer from nearsightness, which is usually a result of the reduction of eyeball [11]. This reduction of size is proportionate to their age. As the grow up patient's eyeball will not be responsive to light because of nearsightness. Constant pressure from the optic nerves will cause this decrement of size.

Table III. Sizes of unhealthy iris

Age Group	IRIS Size(in Cms) (avg)
0-9	.45
10-19	.52
20-29	.67
30-50	.78

4.3 Result Comparison

From our acquired results above we can plot those values into a line graph and can get a visual reference of our data. Figure 10 shows a plotted graph from our data. Different age group relates to their iris size on the lines of the graph.

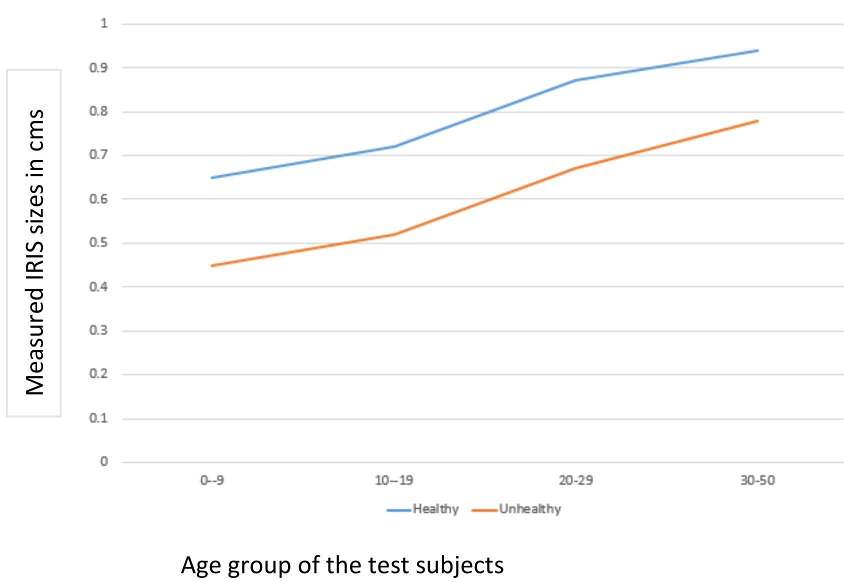

Figure 10: Difference between healthy and unhealthy eyeball

4.4 Tools Used

We used opencv throughout our whole system and the programming language we used is python. Image manipulating libraries like `imutis` were also used to compress and resize the images to our required sizes. Mathematical libraries like `numpy`, `scipy` were used for calculating values to use as input of SSIM and PPM.

CHAPTER 05

Conclusion and Future Work

Future is unpredictable and no one can define the limit of growth and prosperity. Every successful system should learn how to adopt with the upcoming trend as to hold or grow their market. However, in terms of health care we have to ensure that a particular testing system is helpful and affordable for the patient.

5.1 Conclusion

Technology can make our life easier and comfortable as well. However, we cannot fully dependent on it because a machine or a system might not give us 100% of its advantages. All the type of tech based solutions may not give perfect solutions every time because there is nothing called perfection. It is necessary to live a healthy life, which can make a person happy and long live. Our acquired results from the test varied within our expected range with a slight error margin of 12%-15%.

5.2 Future Work

There is no end of development while working with human organ testing. However, in our thesis, the system that we design is a prototype. So far our system can detect anomaly and measure the cornea size of the patients based on the reference set of image. This one we worked is a prototype. We need a huge amount of work as to launch the system in the market. Now our system can detect the anomaly form the still image. However, in future the system will detect the eyes from the video and then calculate the visual problem of human eye.

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