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INSTANT DETECTION OF CATARACTS

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Abstract - Throughout the world more than 20 million people are blind because of cataract. Several surveys say that cataract is responsible for 50-60% of blindness in India. The main reason for this is lack of trained ophthalmologists. According to economic times report, the ratio of ophthalmologists to patients in India is 1:90000. Hence there is a huge gap between the demand and the availability of eye surgeons in this country. This creates a requirement of developing a solution to detect and analyze cataracts in remote areas with least training and educational requirements. There have been several attempts to automate the cataract detection process. This paper contains some details about the present trends in automating cataract detection, theoretical background of some important concepts and details of my work with its results.
Keywords - Cataract, Image processing, Automation, Blindness.

1. INTRODUCTION

Cataract is basically a clouding of the lens in the eye which leads to blurred or decreased vision. There are many causes for the formation of it. Throughout the world approximately 20 million people are blind because of cataract. It is said to be the 60% cause of blindness in parts of Africa and parts of South America. Three out of every four people, aged 60 years or above in India are said to have or had cataract.

2. LITERATURE SURVEY

According to a survey, cataract is responsible for 50-80% of bilateral blindness in India [6]. The report also suggests that the no of cataract blind would increase from 7.41million in 2001 to 8.25 million in 2020 due to a substantial increase in the population of people above the age of 50 years. It is also seen that it contributes to 51% of avoidable blindness in the country. The world health organization made a resolution called ' vision 2020' to eliminate the avoidable blindness, to which India is also an important stake holder. The key to this initiative is to provide sufficient, sustainable and successful cataract services to all the communities [7]. According to its report, it is estimated that by 2020 even with all the attempts by the WHO and other organizations, there would be a huge gap between the surgical requirements and surgical output of India.

The office of registrar general and census commissioner says that 70% of the Indian population lies in the rural areas. But according to the WHO, 70% of the public hospitals are situated in cities. Because of this condition the rural population of India should travel to cities to get good health services. This is said to be one of the main reasons that contributes to the gap in surgical requirement and surgical output of the country. But, providing facilities near to them would mean large investment and low utilization of the infrastructure in smaller communities. Hence there is a requirement of a cheaper alternative for detecting and operating cataracts in remote areas.

3. MOTIVATION

According to an article in the economic times[8], the general ratio of an ophthalmologist to patients in India is 1:90000, which is pretty huge. In United states the ratio is 1:15000.This shows that we have a huge lack of trained personnel in India. This could be one of the major factors in addressing the rural cataract treatment. Hence a solution should be found, which can be implemented in remote and rural areas with minimal educational and training requirements.

4. PROBLEM DEFINITION

To design a compact electronic device that can detect the presence of cataracts instantly.

5. CONVENTIONAL METHODS TO DETECT CATARACTS

To detect a cataract an ophthalmologist performs a test called as visual acuity or a refraction test. This is usually done using a bi microscope or a slit lamp. This instrument is used to view the parts of the eye that bend the light (cornea, iris, lens and vitreous). For getting a clear view, a pupil dilation solution is used. A drop or two of this solution is put in the patient's eye before examination. The instrument sends out an intense beam of light as it sees the eye. This beam provides a magnified view of the eye through which the technician can visually detect the cataract. The following is an image of a slit lamp:

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Fig. 1 Slit lamp

6. PRESENT TRENDS IN AUTOMATING THE CATARACT DETECTION

Many research works have been conducted to automate the cataract detection. Rafat R. Ansari and Harbans S. Dhadwal [1] proposed a method of using fiber optic probes for detecting the change in molecular weight of the protein molecules present in the lens. The change was detected using the principles of dynamic light scattering. Higher molecular weight of a particular molecule will result in increased opacity of the lens. Jagdish Nayak [2] proposed a method of using image processing and SVM algorithm for feature extraction and classification of extracted features respectively. His setup could classify an image as a normal, cataract and a post cataract lens. The method is said to have achieved 100% of accuracy in detecting cataracts. Sucheta Khole and Shanthi K. Guru [3] proposed a method of detecting the presence and the stage of the cataract by using SVM and MDA algorithms. The presence was detected by the use of SVM algorithm and the MDA algorithm was used to detect the stage of the cataract. The proposed system is expected to give 93% and 77% of accuracy and precision respectively. Retno Suprayanti ,Hitoshi Habe and Masatsugu Kidode [4] proposed a method of detecting cataracts using image processing and the principle of specular reflection analysis. All the methods involving image processing and machine learning are proven to be more accurate and less expensive.

7. THEORETICAL BACKGROUND

Cataract is a medical condition where the lens of the eyes becomes progressively opaque, which leads to blurring of vision. The normal eye is made up of the sclera, cornea, pupil, aqueous humor, iris, conjunctiva, lens, vitreous humour, ciliary body, macula, retina, fovea and the optic verve. Lens is the clear part of the eye behind the iris that helps to focus light on the retina. The lens helps to focus on both far and near objects so that they are perceived clearly and sharply. The ciliary muscle helps to change the shape of the lens. This changing of the lens shape is called accommodation. It is said that the diameter of the lens is 10 mm, and basically there are three types of cataracts. They are discussed in the following section.

7.1 . Nuclear Sclerotic Cataracts

This is the most common age related cataract. Sclerosis is a medical term for hardening. The lens of the eye gets hardened and gets a yellowish shade. It starts gradually clouding from the centre. The clouding and hardening occurs only in the nucleus of the lens. Because of this property the term nuclear is added. The hardening of the lens causes the loss in focus and the cloudy yellow shade makes the lens opaque. In this condition the complete lens has to be replaced with an artificial one.

Fig. 2 Nuclear sclerotic cataracts

7.2 Cortical cataracts

White opacities or cloudy areas develop at the edge of lens. This region is called as cortex. The variation in the water content of the lens fibres create a spooky kind of a structure that begins from the edge and ends at the centre. These structures cause scattering of light which in turn causes blurred vision, glaring, higher contrast and depth perception. People having type 2 diabetes are prone to have this cataract.

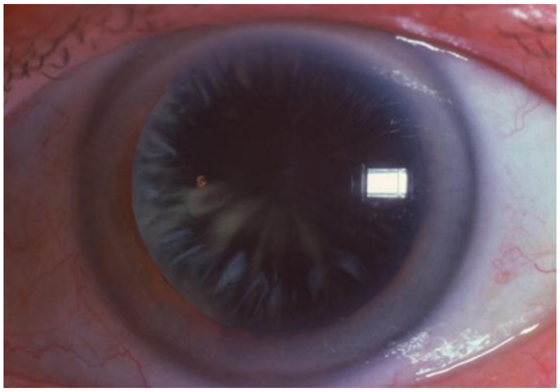

Fig. 3 Cortical cataracts

7.3 Posterior subcapsular cataracts

These are the cataracts where the opaqueness or cloudiness occurs at the back of the lens or posterior to the lens. People with diabetes or those taking high doses of steroid medications have a greater risk of developing a subcapsular cataract.

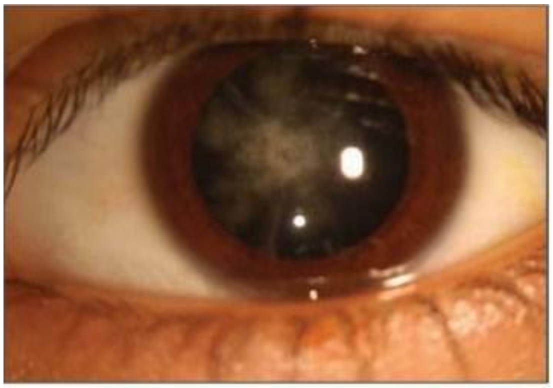

Fig. 4 Posterior subcapsular cataracts

7.4 Image processing

The science of extracting data form an image can be defined as image processing. Image processing is basically used to extract particular features from an image. Based on these extracted features we classify the image into different types using different algorithms.

8. METHODOLOGY

Around 90% of cataract cases are characterised by the formation of a whitish translucent layer in the pupil region of the eye. By using different image processing techniques my aim is to design a very affordable and user friendly system to detect cataract without the assistance of an ophthalmologist or a doctor. My aim was to design a system that can detect cataract from a normal image acquired using a camera. In this process my aim was to eliminate the dilation requirement of the eye before the examination. I used a Nikon D3200 camera with 24.2 megapixels for acquiring the images of the patients. The images were taken in M.M Joshi eye institute Hubballi, Karnataka, India.

I have used two important features to classify the images. Average intensity or mean intensity of an image gives us the average intensity of all the pixels in its frame. The eyes with cataract will have a higher intensity average than any normal eye because of the formation of whitish layer in their lens. The second feature I used is histogram uniformity. This feature measures weather the distribution of grey levels in the histogram is uniform. A normal eye has higher uniformity in histogram distribution than a cataract eye. After examining several samples, a threshold for both the values were set.

Histograms of healthy and cataract eyes:

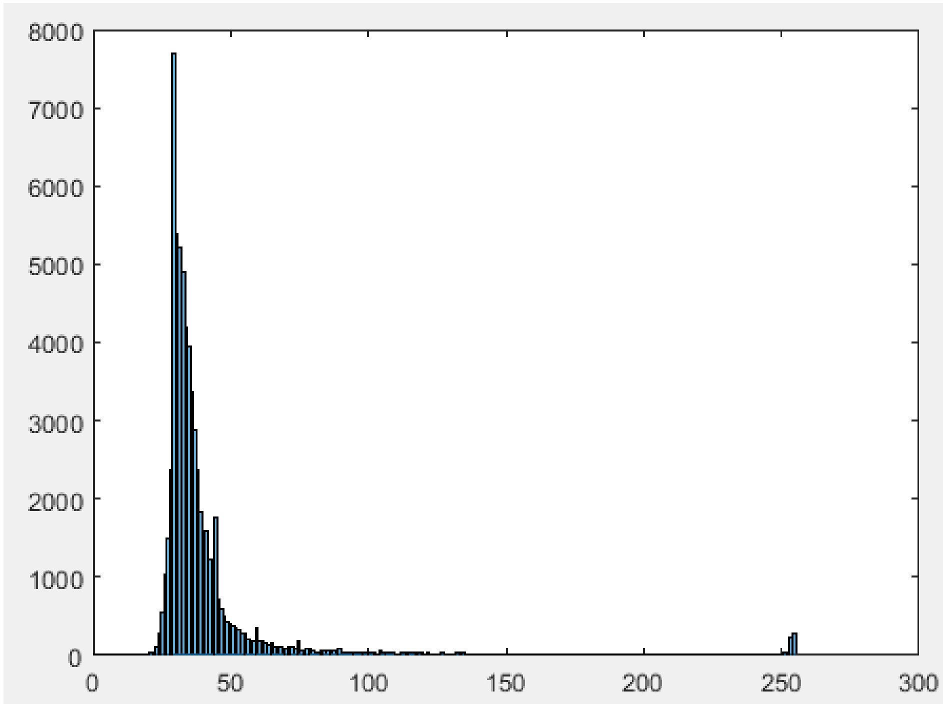

Fig. 6 Histogram of a normal eye

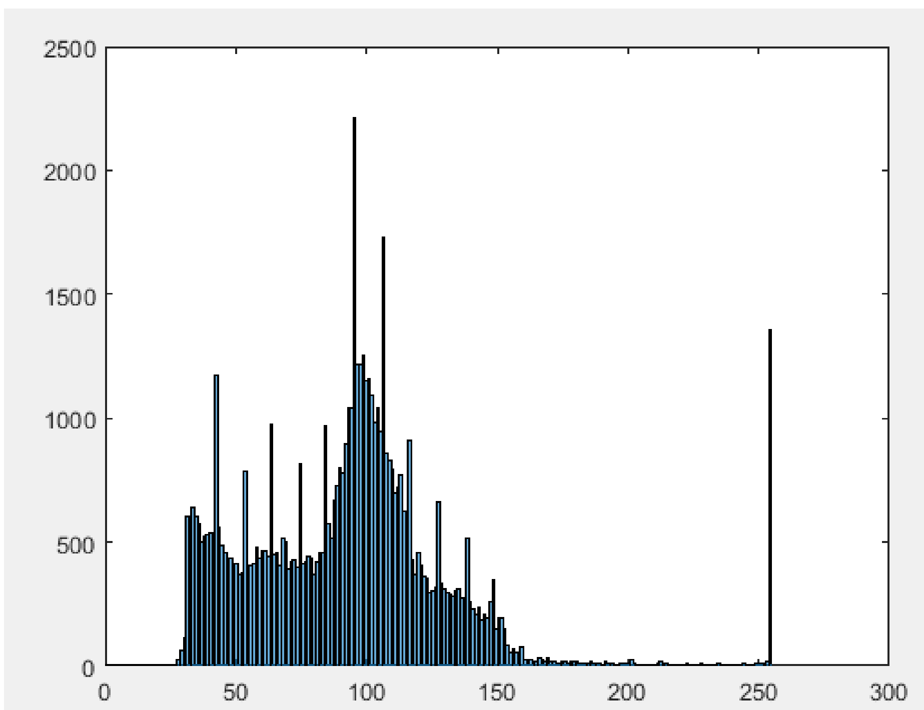

Fig. 7 Histogram of an eye with cataract

The Images acquired are converted to black and white images initially. Then the image is filtered for noise removal. The pupil from the image is cropped using mouse and the cropped image is converted to a standard image of size 256X256. Then the features from the images are extracted to test for the presence of the cataract.

Following is the block diagram of the operation:

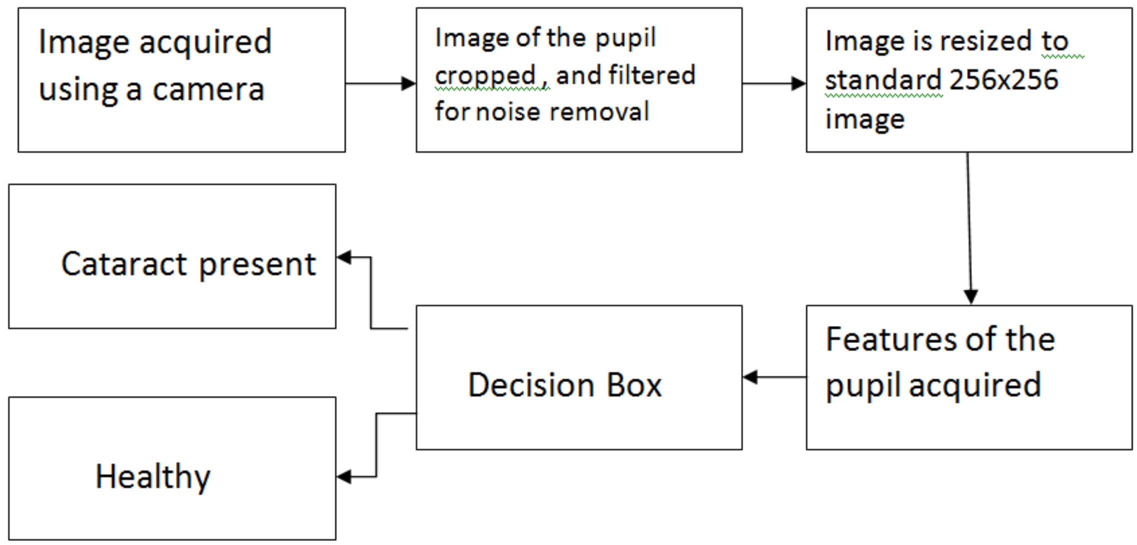

Fig. 8 Block diagram

9. RESULTS AND DISCUSSION

A total of 40 different image samples (both cataract and non cataract) were analysed. The images of the patients were acquired using a Nikon D3200 camera. The images were acquired prior to the dilation of the eyes. Following are the readings of 10 different samples:

Sample no	Mean intensity	Histogram Uniformity	Doctor's opinion	System output
1	76.7142	0.1727	Cataract present	Positive
2	66.0227	0.2556	Cataract present	Positive
3	90.2800	0.1443	Cataract present	Positive
4	40.4252	0.7205	Cataract absent	Negative
5	55.3186	0.4255	Cataract absent	Negative
6	100.9475	0.2436	Cataract present	Positive
7	69.5111	0.2348	Cataract present	Positive
8	47.3716	0.5272	Cataract absent	Negative
9	57.8344	0.4228	Cataract absent	Negative
10	80.8500	0.2819	Cataract present	Positive

Fig. 9 Table of observations

The threshold for both the features were decided based on the least values of both cataract and non cataract images. In case of mean intensity the highest value of the non cataract images was 57.8334, and the lowest value of the cataract images was 66.027. The threshold of the mean intensity was calculated by finding the middle value of the least and the highest value. Hence the threshold of the mean intensity is given by:

A = [(66.027-57.8334)/2] +1

T = 57.8334 + A

The threshold of the histogram uniformity was found in a similar way. Using this system the presence of cataract can be detected at an accuracy of almost 99%.

But one of the drawbacks of this system is, it fails to detect cataracts that are not characterised by a whitish layer. These types of cataracts account from 1% to 15% of the total cataract cases . The occurrence of such cataracts mainly depend on the geographic location and surrounding conditions of the patient. Some examples of such cataracts are blue dot cataracts, traumatic cataracts, Christmas tree cataracts and cataracts secondary to mucopolysaccharoidiss. In case of Hubballi - Dharwad , the place from where the images were taken, these types of cataracts approximately account up to 1% of total cataract cases.

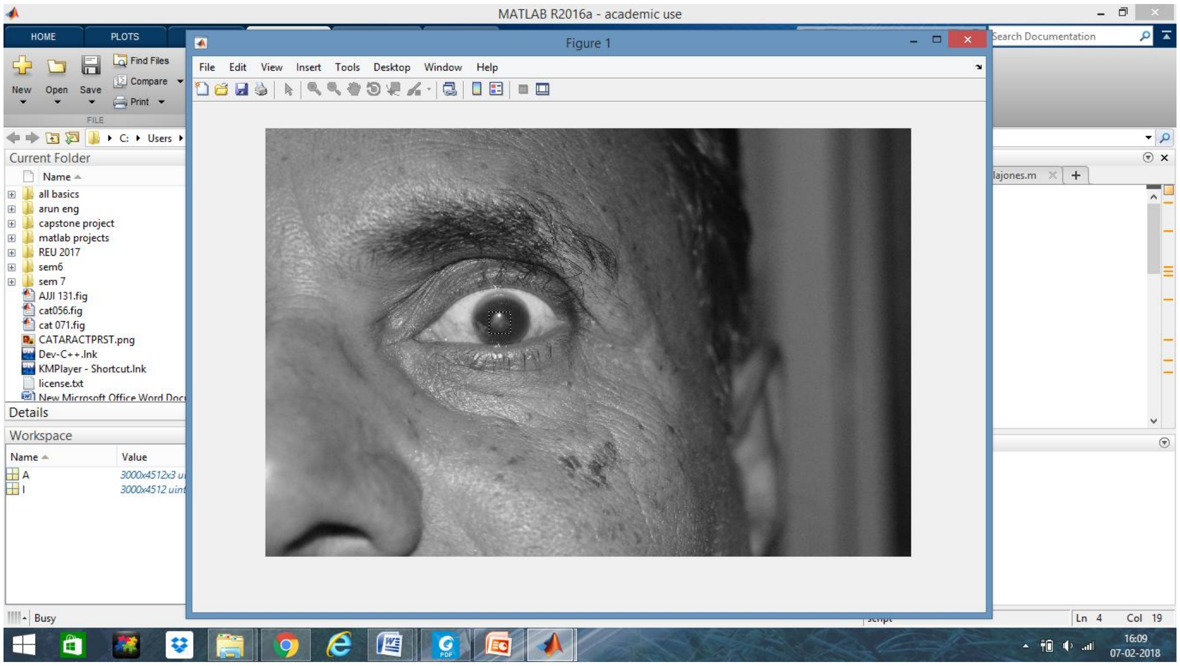

Fig.10 Cropping the pupil area

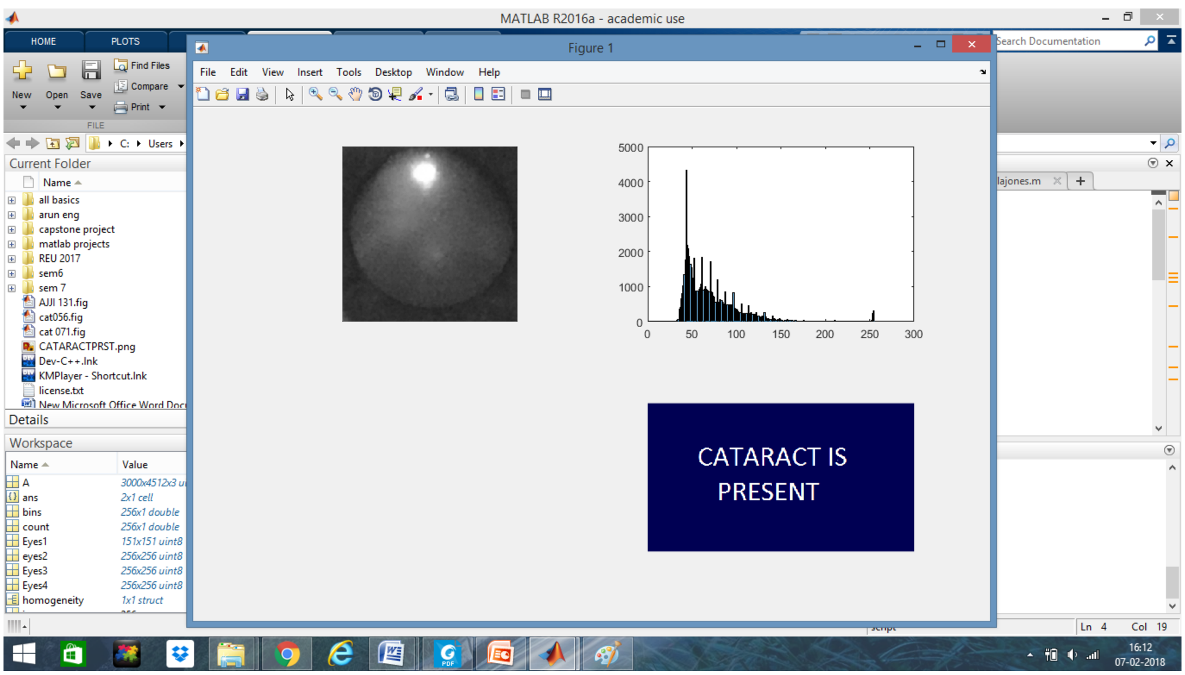

Fig. 11 Results

10. CONCLUSION AND FUTUREWORK

In this paper we have discussed about the present trends in automating the detection cataracts and the requirement of developing a system to make the detection more user friendly and affordable. I tried to develop a system that can detect the presence of cataracts without the requirement of a doctor or an ophthalmologist. Using this system, I was able to detect the presence of cataract with great accuracy. There is a huge scope and requirement for the development of such automation techniques in the medicine industry today.

Many research works have been conducted to automate the cataract detection system. There are many systems that can detect both presence and stage of the cataract. But very less research has been conducted to find out the type of cataract using simple image processing algorithms. Hence my aim is to improve my present system to detect the presence, stage and the type of the cataract in future.

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