Lens localization Algorithms For Early Detection of Cataract Using Slit-Lamp Images

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Abstract : The whole world is suffering from dominant eye disease named cataract. Both developed and undeveloped countries are suffering from cataract due to aging. This may cause partial blindness in initial stages and complete loss of vision in mature stages. The eye lens becomes opaque due to joining of protein molecules together. The disease is also caused due to high smoking, eye injuries and use of various medicines having steroids. The national and regional health organizations are serious as this disease is observed frequently in children of minor edge. The only remedy is the eye surgery. The numbers of patients in developing countries are very huge.

The detection of cataract at early stage is challenging. The lens is circular and well protected in lens capsule. The major types are Nuclear, Cortical and post sub capsular. The slit-lamp microscope is used for observation and detection manually. The grading based on Lens Opacity classification System (LOCS_III) is followed by ophthalmologists. The automated detection categorization uses slit-lamp camera mount system and images obtained from the same. The detection at earlier stage using these systems is based on correctness of lens localization.

The proposed system uses lens localization algorithm based of mean intensity variation in color planes in RGB images, hough circle detection trans form and active shape model (ASM).

***IndexTerms* - Eye lens; slit-lamp; Cataract; LOCS-III; ASM etc;**

I. INTRODUCTION

National and regional health organizations are trying hard to make nation and regions free from cataract and make people aware of this serious eye disease. Almost half of the blindness cataract is the leading cause of blindness in the world. The observation of this blindness causing disease in children of minor edge makes people very serious. The detection at earlier stage is challenging with manual observation. It needs lot of expertise and keen observation though slit lamp of eye lens. The automated detection and grading is based on digital camera images obtained from slit-lamp mounted camera. The correctness in detection and categorization is depending on exact locating the lens structure. In proposed system various non transform based, transform based and model based approached are suggested for lens localization. Based on the place of opacity within the lens structure cataract is classified into three types: nuclear cataract, cortical cataract and posterior sub capsular cataract (PSC). In Nuclear type of cataract (NC) opacity begins at the center of the lens and it grows towards the edge of lens. In Cortical type of cataract, opacity begins at the periphery of the lens and grows towards the center. The Posterior sub capsular cataract builds at back side of lens.

Objective of proposed system is to find out accurate, computationally efficient technique for early stage detection using intensity gradient. The proposed lens localization technique will be invariant to eye position, illumination and scale. This will automate inter intra and inter observer detection grading variation. Different combinations of Hough circle transform, ASM.

II. LENS LOCALIZATION

From research survey it is observed that the correct detection and categorization of cataract is based on correctness of lens localization algorithm which is the key of success in computer aided diagnosis of cataract. Based on the intensity spread inside the lens structure the features are extracted [1-6]. To improve the image quality retro illumination is required. The images have been acquired using slit lamp camera mount setup. LED lamp source is developed for illumination. For better resolution canon SX-100 digital camera with 8 mega pixels resolution and multimedia mobile with 8 mega pixels resolution is used for image acquisition. The images obtained are of cataract patients from Lions eye Hospital, Miraj and Cottage Hospital, Pandharpur.

Different edge detection algorithms like canny, sobel, prewitt are used to detect edges in the cataract eye images. Canny edge detection algorithm shows better results compared to other operators. Hough circle detection algorithm is used for pupil detection and regional properties like intensity variation are used to categorize the type of cataract.

2.1 Development of Lens Localization algorithm using mean intensity values

It is observed that the mean intensities in iris and pupil region are different. The pupil without cataract is black and having low mean intensity value compared to mean intensity value of iris. The pupil with cataract is having higher mean intensity values compared to mean intensity values of iris. These intensity gradients can be used as threshold for pupil segmentation.

The input image in RGB format is read from database and grayscale image is obtained from same. The grayscale image is cropped and image is obtained such that it contains complete pupil and part of iris. The cataract pupil and iris mean intensities are different. The pupil is segmented using mean intensity gradient. The Set of MATLAB command is used for segmentation of pupil from iris region as indicated in flow diagram below. The binary image is obtained and unwanted pupil region is cleared to prepare circular mask for pupil segmentation from iris region.

The flowchart for pupil detection algorithm using region properties is as below.

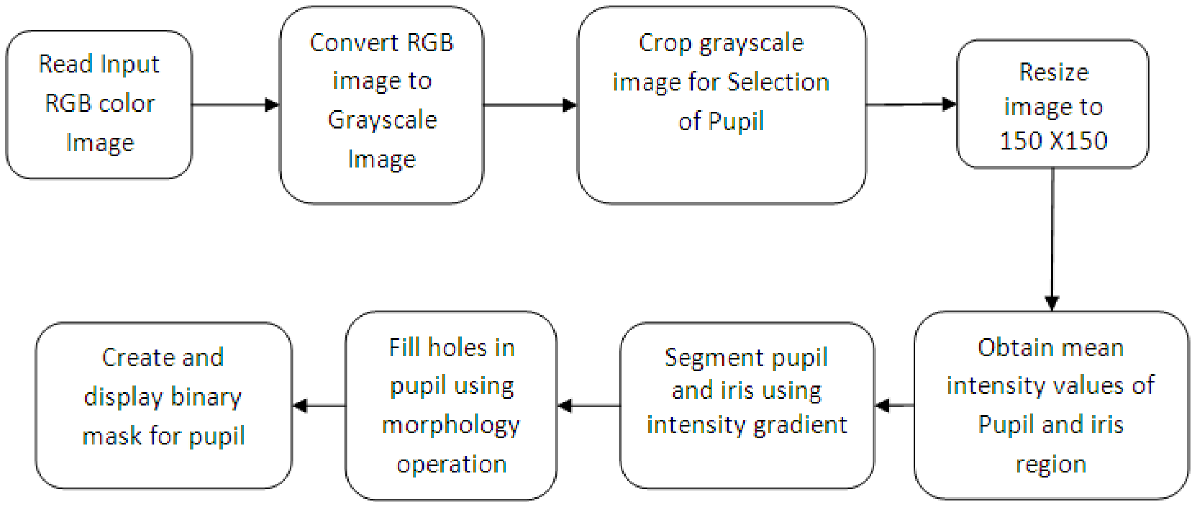


Figure.1: Flow diagram for pupil detection algorithm using region properties

Lens localization is performed using active shape model and categorization is done using correlation technique and support vector machine. From pre processed images the masks to separate the iris and lens structure are developed. The lens structure is separated from rest of color image. The grey scale and binary image is obtained. In categorization using correlation, the masks for nuclear and cortical cataract are prepared and correlated with input binary image. In feature based detection method using support vector machine, the texture and color features are extracted and compared.

2.2 Development of Pupil Detection algorithm using Hough circle detection transform

Hough circle detection algorithm is popular in detection of circular object in input image. As the pupil is circular in shape, Hough circle detection transform is most suitable for lens localization or pupil detection. The flow chart for pupil detection is as below,

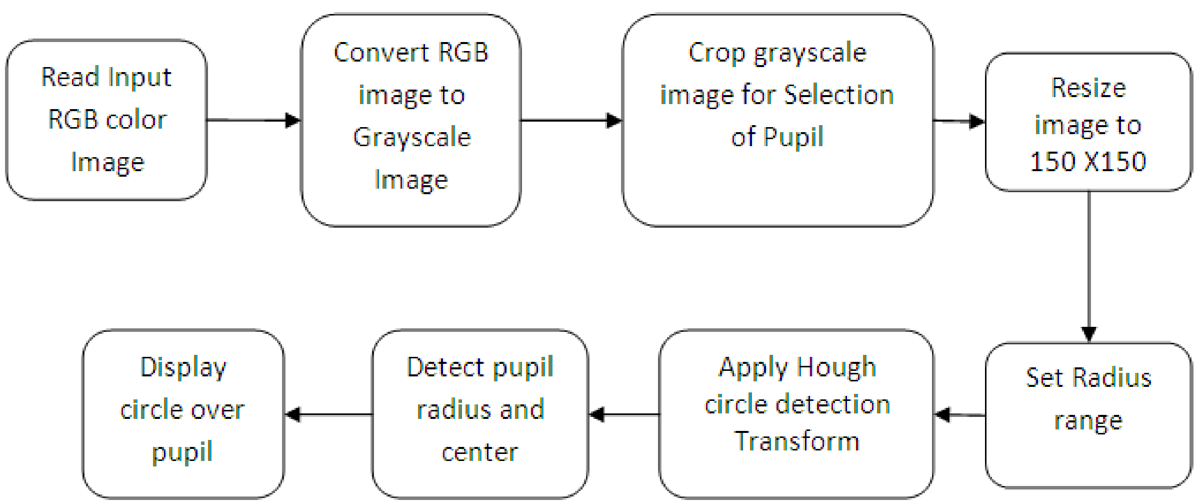


Figure 2: Flow diagram for pupil detection using Hough circle detection transforms

The input color image is read from database in RGB format. Grayscale image is obtained from it. The gray scale image of eye contains eye regions like eye lashes, scalara, iris and pupil. The image is cropped in such way that it will contain complete pupil. The cropped image must contain complete pupil and part of iris. Results are better for square cropped image from input image. Pupil radius in cropped image is depends on the resolution of input image. The cropped input image is resized to normalize the pupil radius for Hough transform pre parameters. The 150 x 150 pixels resolution with radius 50 to 60 pixels value gives better results. MATLAB function imfindcircles ( ) uses Hough circle detection algorithm for finding circle in input image. It returns possible centers coordinates for detected circles and corresponding radius. By adjusting input parameters in Houagh transform single circle can be obtained if many concentric circles with different radii are obtained.

The selected circle covers maximum pupil area and its center is approximately at pupil center. By using MATLAB viscircles ( ) function, the over lapping circle can be plotted on pupil region. Using this information mask for pupil segmentation is created.. The input images and result are as shown in Fig.1.in result

2.3 Active shape model based approach for development of lens localization algorithm

In model based approach, system learns a model from input training data and test data is used to find a modeled object. Active shape model (ASM) is used in this approach which is a parametric deformable model. This model contains point distribution model (PDM) and iterative refinement procedure for more correctness [1]. Considering the non circular shape of lens contour ASM is preferred for extraction of lens structure from eye image. PDM is trained well before application of ASM to input image. It allows deformation in certain extent consistent with training data set. By using the position of set of 'n' landmark points placed on pupil boundaries, the shape of lens structure is described. The landmark points are labeled manually. By minimizing the sum of squared distances between the landmark points on different shapes, the group of training data is aligned into a common coordinates following transformation. Principle component analysis method is used for alignment of training shapes. The unknown shape is approximated by following equation.

$$x = \bar{x} + \phi b \quad \text{.......(1)}$$

where $\bar{x}$: mean shape

b: vector of shape parameters

ϕ: set of Eigen vectors

The sequence of steps in ASM analysis are as initialization, matching point detection and pose parameter update, model update shape, convergence evaluation. The transformation between the shape space and the image space is as per equation below.

$$X = T(x) = \begin{pmatrix} s\cos\theta & -s\sin\theta \\ s\sin\theta & s\cos\theta \end{pmatrix} \begin{pmatrix} x_i \\ y_i \end{pmatrix} + \begin{pmatrix} t_x \\ t_y \end{pmatrix} \quad \text{.......(2)}$$

In the shape model as described above, the shape space and in image space is represented as x and X. Here xi and yi denotes position of ith landmark point in shape space. The tx and ty represents model center in image space. The initialization process searches match points around a current position. It selects proper pose parameter vector and shape vector. For each landmark point on the model in image space, the nearby best matching point is searched. The landmark point will be moved to same point. The matching points are searched along the profiles normal to the model boundary through each model point. To find edge of lens, the derivative of intensity derivative on normal profile is used. The distance between estimated match point and model landmark points is minimized performing iterative operations. This minimizes the error between previous and next iteration model.

III. CATEGORIZATION

In present experimental work categorization can performed with various methods like taking correlation between input image and prior designed masks and trained support vector machines.

3.1 Categorization using correlation

In nuclear cataract the intensity variation is more at centre of pupil while less at periphery. In cortical cataract the intensity variation is more at the periphery and less at centre. The Hough circular detection transform gives information regarding centre coordinate and radius of pupil. This information is used to create binary masks for detection of nuclear and cortical cataract. These masks are correlated with input binary image obtained from pre processing. The value of correlation coefficient is between 0 and 1. If the result is towards 0, the cataract is at earlier stage and if towards 1, the cataract is at mature stage. The results are used to categorize the cataract.

Equation 1 computes two dimensional correlations where A is input image and B is mask and R is correlation coefficient

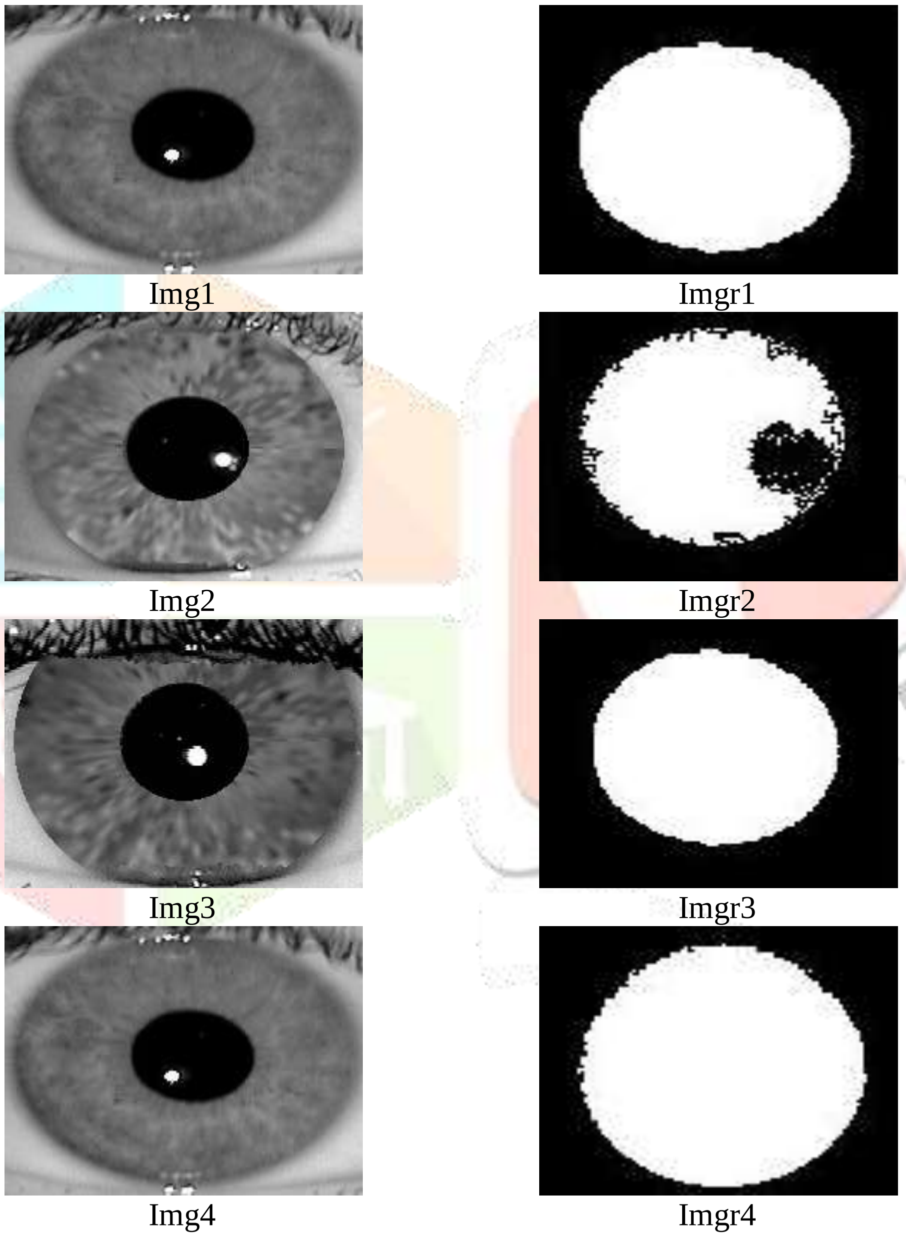
$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\left[\sum_m \sum_n (A_{mn} - \bar{A})\right]^2 \left[\sum_m \sum_n (B_{mn} - \bar{B})\right]^2}} \quad \text{......(3)}$$

where $\bar{A}$ = mean2(A), and $\bar{B}$ = mean2(B).

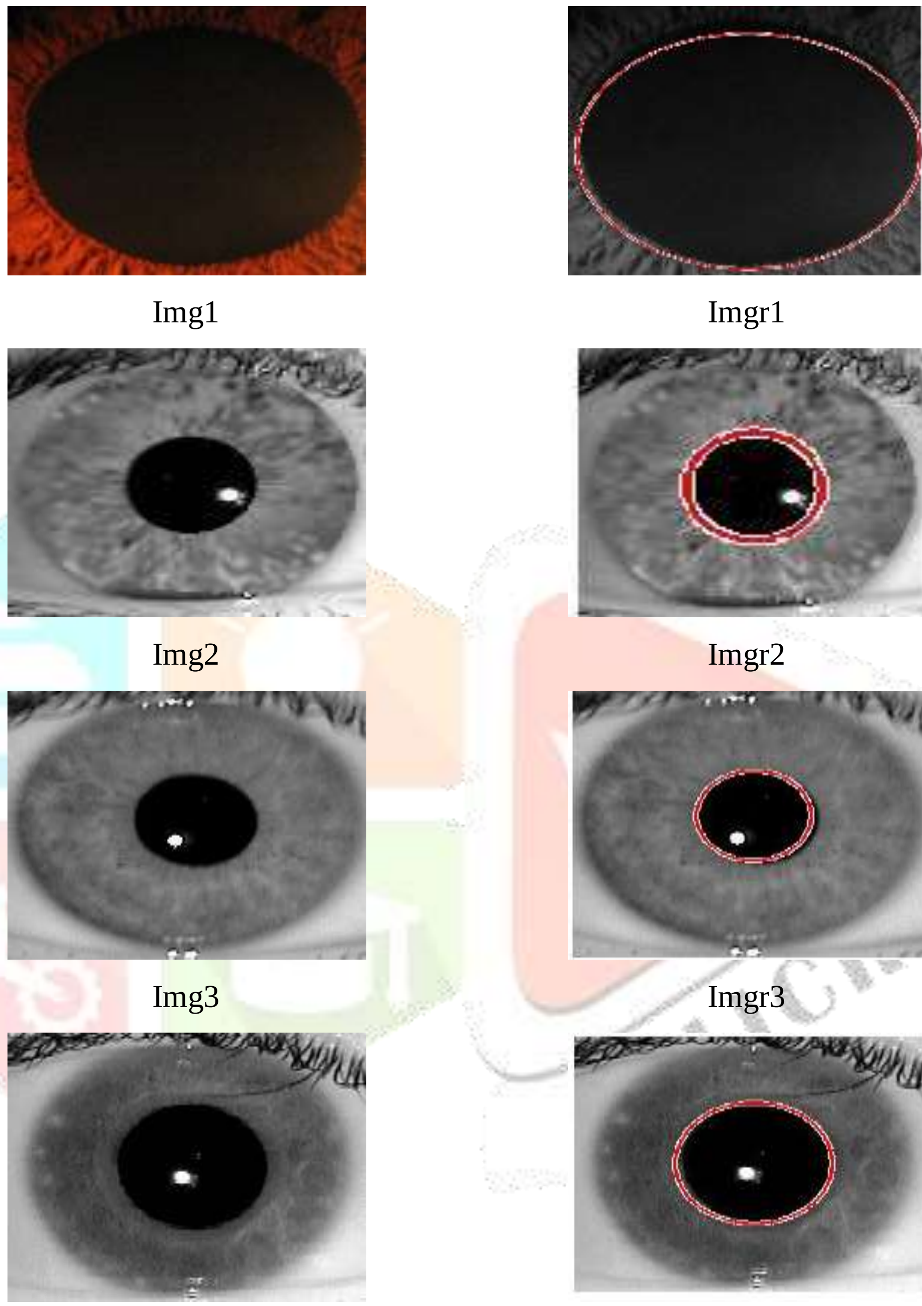
IV. RESULTS AND DISCUSSION

The experimentation is performed on slit lamp images obtained from eye hospitals. The database of 80 slit lamp images have been created from various type of cataract images and processed with proposed algorithms. The results for three methods are as displayed below. In region based properties the result are shown four input sample images are as shown in figure 3. It is observed that algorithm based on region based properties as best suitable for the nuclear cataract. In cortical cataract the information is at the edge of lens structure. During the image processing operations the information at edge of lens structure is lost. Hence this algorithm is more suitable for nuclear cataract.

Four different nuclear cataract images have been processed and results are as shown in figure 4. As difference between the mean intensity values is large for nuclear cataract, the images in result are showing that the lens structure is extracted.



. **Figure 3:** Input and output images for circle detection algorithm using region properties



Img4 Imgr4

Figure 4: Input and output images for Hough transform

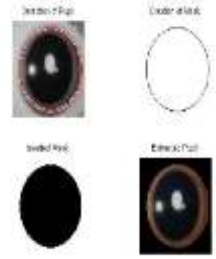
Detection	 Input Image	 Lens extraction
Categorization	 Correlation mask	 Detected cataract
Result	radius = 51.6567 Cataract % 21.0424 Correlation 0.57562	

Figure 5.a: Result obtained using Hough circle detection transform and correlation

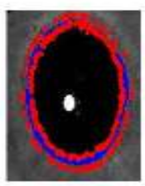
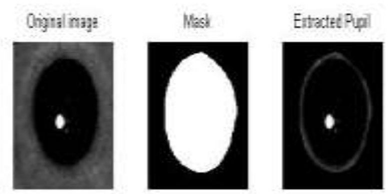
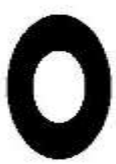
Detection	 Input Image	 Lens extraction
Categorization	 Correlation mask	 Detected cataract
Result	radius = 51.2143 Cataract % 1.9296 Correlation 0.76127 Elapsed time is 59.458529 seconds.	

Figure 5.b: Result obtained using ASM and SVM

The results of categorization using correlation are as displayed in figure 5.a and figure 5.b. The figure 5.a is showing results are for pupil detection using Hough transform and categorization using correlation. The figure 5.b is showing results are for pupil detection using Active Shape model and categorization using correlation.

III. CONCLUSIONS

The success of computer based automated technique in cataract detection and gradation is based on correct lens localization. The detection algorithm based on intensity gradient is not consistent reflection in lens and lack of retro illumination. Hough algorithm for circle detection is excellent for lens localization as the shape of lens structure is circular. Active shape model supports well and shape invariant. Various combination of Hough transform, ASM with correlation is tried for detection and categorization. From above result conclude that lens localization and cataract categorization using ASM with correlation gives better result.

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