Innovative Method To Detect Lens Opacity Using Radon Transform

Santosh Sonawane, Amol Jagadale, Dattatray Jadhav

Abstract: Emerging technological development in biomedical imaging sensors and advanced computational platforms are making real time detection and analysis systems much popular in field of medical diagnosis. Research work presented in this paper elaborates method to detect cataract using the slit lamp eye lens images. As the cataract is being observed in almost all age group people, researches are finding fast and accurate methods for its diagnosis and categorization. This initiative by researchers will be advantages for developing countries as low cost alternative for diagnosis of eye disease. The eye lens with cataract is opaque different in structural and color features from lens without cataract. Active shape model is preferred for localization irregular shape objects, which is used for lens localization. Approximate lens circle is extracted, cropped and resized to fix size. Radon transform is used for extraction features of lens image. Cataract is detected using structural features of lens image. The radon transform is suitable for recording angular structural features extraction. Lens images with different type of cataract such as no cataract, nuclear senile cataract and cortical cataract is processed. Structural features are extracted and correlated with features for input image to be diagnosed for its categorization.

Index Terms: Cataract, Lens images, Active shape model, Random Transform, Detection, structural features, Categorization

1. INTRODUCTION

BLINDNESS acquired due to undiagnosed or delay in diagnosis of lens opacity is major problem in fast growing population of developing countries. Computer aided automated systems are playing key role in real time analysis of biomedical images [1, 2]. Detection of lens opacity at earlier stage can protect eyesight or give guidelines for corrective action. Automated system in diagnosis of disease based on images are becoming much popular due to correct and fast detection of causes of disease. This is possible due to various imaging system in like MRI and City scan. Due to high resolution of microscopes and digital cameras, it is also possible to diagnose at cell level. Developing countries are lagging in field of cutting edge technologies due to availability

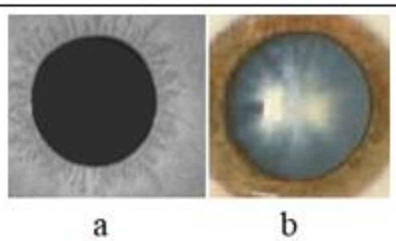

Fig. 1. Eye lens images without and with cataract

of less funding. Hence, there is always search of low cost alternative for medical diagnosis, drugs, and remedies [3]. Research work presented in this paper is innovative idea todetect cataract based no lens image using Radon features. he digital camera mounted on slit lamp and software withdesktop personal computer will be high-end diagnostic platform. As well, it is running on portable computing platform with algorithm developed in python and Open-CV will be a low cost alternative. Images in figure1 display eye lenses without and with cataract.

2 METHODOLOGY

Image based detection and diagnosis of fundus, and retinopathy is much popular in detection of vision problems. Advances in image processing, pattern recognition, and neural network are making algorithms faster. Proposed system uses a digital eye images to detect cataract, which is also called as lens opacity causing blindness [4, 5]. Various steps in cataract detection area explained in figure 2.

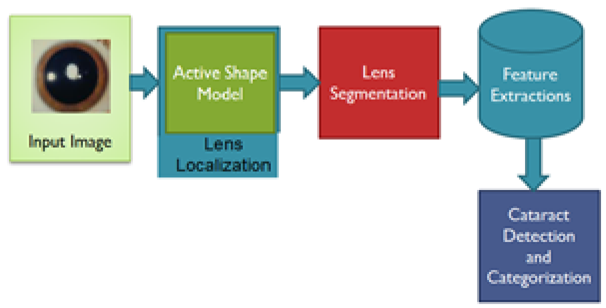

Fig. 2. Process of cataract detection

Methodology works in two, major steps such as lens localization, and cataract feature extraction. The features are used as basis for categorization of different types of cataract.

2.1 Extracting Lens

Eye image is acquired using high resolution digital camera. The camera mounted on slit lamp microscope is most preferred to achieve further resolution. Eye lens is inner most circular object in eye image surrounded by iris. In image most of the times it appears as ellipse. Detecting elliptical eye lens, surrounded by larger radius iris is image processing challenge in lens extraction [6, 7]. From review of research work, it is understood that lens can be segmented based on image properties like intensity gradient, circular shape, region properties, and color parameters [11, 12, 13]. Proposed algorithm uses Active shape model to extract lens. The lens with cataract is differed in color, structure, and some time in

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shape compared to lens without cataract [8, 9, 10]. Hence, the model used must compensate this changes as well as resolution variations. I(x,y) is acquired input color image in

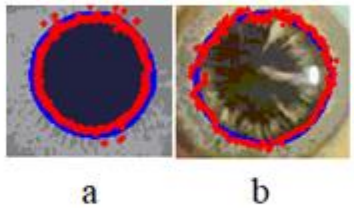

Fig. 3. Lens extracted using Active shape model

RGB format using the slit lamp camera with 24 bit resolution per pixel. Further it is processed to convert it to gray scale image.

$$g(x,y) = 0.298 I_r(x,y) + 0.587 I_g(x,y) + 0.11 I_b(x,y) \quad (1)$$

Where g(x,y) is gray scale image and $I_r(x,y)$, $I_g(x,y)$ and $I_b(x,y)$are red, green, and blue planes of input color image.
The input image is cropped manually to remove most of iris part to reduce computational overheads. The input gray scale image is cropped and resized to 120 x 120 pixels so as to adjust pupil radius between 60 to 65 pixels. It is assumed that the cropped image z(x,y) contains lens and part of iris. Active shape model is point distribution model and deformable. The shape is approximated by equation as mentioned below.

$$X = \overline{X} + \varphi b \quad (2)$$

Where $\overline{X}$ is mean shape, b is vector of shape parameters, ф is set of Eigen vectors. It requires prior training, hence it is trained with ten preprocessed images of clear eye lens. In this experimental work each image is labeled manually with twenty- five landmark points to create model. This helps in further representing the image in the model space. Cropped input images are used for further processing with process of initialization. Model is placed over lens region of interest. The land mark points are moved along normal to lens edge calculating the derivative to find best match point. At end of detection and categorization process the algorithm returns the boundaries of detected region as displayed in figure 3. This information is used to create the mask for segmentation of object. Eye lens is segmented for further processing.

2.2 Approximation for Scale Invariance

Extracted lens is approximate circle with radius function of image dimension, resolution and camera focusing. To adjust the image center and lens center the image is further processed. The lens center, length of major axis, and minor axis, these parameters are obtained using region properties. Smallest of these lengths is considered as approximate lens radius. Considering this as lens radius, image is cropped from center towards circumference equal to radius length. This makes image center and lens center same. Now, the cropped image is resized to fix dimension of 80 X 80 pixels. The processed images are as displayed in figure 4. The algorithm makes the overall system scale invariant.

2.3 Feature Extraction using Radon Transform

Preprocessed and normalized input images with above algorithm is processed for feature extraction. Images and lens are concentric. Radon transform is most suitable for extracting features of circular object. Radon transform is projection of image intensity along radial line oriented at predefined angle. In presented research work the radon transform returns column vector for each sample of angle. The variation in angle in degree is from 0 to 179. The angular vector is rotated counter clockwise for set of angles. Axis of rotation and image center of lens is same.

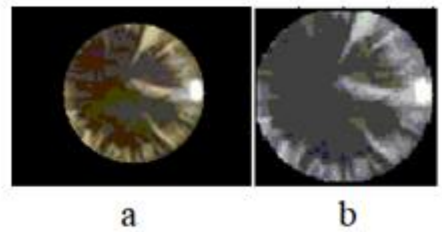

Fig. 4. Lens image, cropped image & resized image

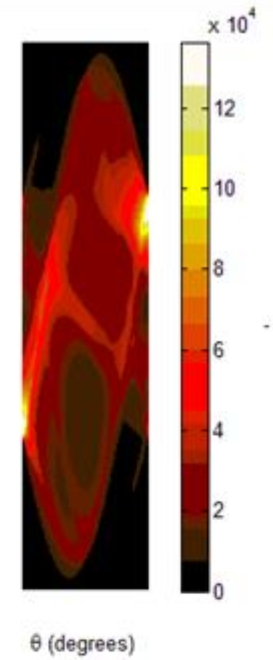

Fig. 5. Radon transform of resized lens

Any straight line in Cartesian coordinate may be described by slope intercept form as described below

$$y = ax + b \quad (3)$$

As well in normal representation as

$$x\cos\theta + y\sin\theta = \rho \quad (4)$$

The projection of a parallel-ray beam is modelled by a set of normal lines.

An arbitrary point (ρ_i, θ_k) in the projection signal is given by the ray-sum along the line

$$x\cos\theta_k + y\sin\theta_k = \rho_i \quad (5)$$

The ray-sum is a line integral is represented as

$$g(\rho_i, \theta_k) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} f(x,y)\,\delta(x\cos\theta_k + y\sin\theta_k - \rho_i)\,d_x d_y \quad (6)$$

For all values of ρ, θ radon transform is obtained. The representation of the Radon transform $g(\rho_i, \theta_k)$ as an image with ρ, θ as coordinates is called a signogram. Further the feature matrix is reduced using discrete cosine transform. The coefficient matrix is used as two-dimensional vector for comparison.

2.4 Cataract Detection with Support Vector Machine Regression

The Support vector machine based regression is used for detection of categorization. Separating the set of training vector x belonging to separate y classes is given by

$$D = \{(x^1 y^1), \ldots\ldots (x^l y^l), x \in R^n, y \in \{1, 1\} \quad (7)$$

Hyper plane selected is as below

$$\langle W, X \rangle + b = 0 \quad (8)$$

The SVM is trained using coefficient matrices for references images of different classes such as no cataract, nuclear cataract, and cortical cataract. The coefficient matrix of input image is calculated and appropriate class is estimated.

3 RESULTS & DISCUSSIONS

Eye images obtained from volunteers with and without cataract at a regional hospital. The data set of 400 images is tested, and results are also verified with ophthalmologists. Results obtained from system and ophthalmologists are compared in Table1.

For set of 400 input images, the proposed system is tested for detection of cataract. The equations used to calculate sensitivity, specificity and accuracy are stated below.

$$Sensitivity = \frac{TP}{(TP + FN)} \quad (9)$$

$$Specificity = \frac{TN}{(TN + FP)} \quad (10)$$

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)} \quad (11)$$

Where TP: "True Positive" means cataract is correctly classified

TN: "True Negative" means the Non cataract is correctly

TABLE 1

COMPARISON OF CATARACT CLASS DETECTED BY SYSTEM AND OPHTHALMOLOGIST

Image No.	Lens Centers		lens radius
Ims001	59.9283	60.8347	34.8446
Ims002	66.7424	65.0375	33.1394
Ims003	71.7618	53.3532	32.8132
Ims004	80.4826	61.4652	31.9499
Ims005	61.6424	68.7404	32.3999
Ims006	70.1190	61.9849	31.8312
Ims007	58.9683	61.5945	35.0988
Ims008	58.9273	61.7342	33.7441
Ims009	68.4731	57.2760	35.2837
Ims010	65.9237	60.1586	35.0177

classifiedFP: "False Positive" means Non cataract is incorrectly classified as having cataract FN: "False Negative" means cataract is incorrectly classified as no cataractAs compared to the results other detection and classification

TABLE 2

CONFUSION MATRIX CREATED FOR SET OF INPUT IMAGES

		Predicted Cataract by proposed algorithm	
		Yes	No
Actual observation	Yes	245	5
	No	10	140

methods, the system gives 96.25% accuracy. The sensitivity and specificity of system are 98% and 93.33% respectively. System uses Active shape model based lens localization and preprocessing to extract lens from eye image adjusting lens center and image center to same location.

4 CONCLUSION

The use of active shape model based lens localization and preprocessing to extract lens from eye image, adjusting lens center and image center to same location makes system 1invariant to scale. Radon transform based angular ensemble parametric representation makes it rotation invariant. The Support vector based classification minimizes intra and inter grader variation in cataract detection. The integration of accurate lens localization, feature extraction, and SVM regression enhances overall detection accuracy to 96.25%. Further speed of detection can be enhanced by use of Hough circle detection algorithm for lens localization.

TABLE 3

RESULT OBTAINED ON BASIS OF CONFUSION MATRIX

Total Number of Images	Cataract Affected	Sensitivity	Specificity	Accuracy
400	250	98	93.33	96.25

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