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Fuzzy Inference System Aided Damage Assessment of Pterygium

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ABSTRACT: Pterygium is an abnormal, triangular-shaped growth of tissue on the surface of eye it normally extends from the inner corner towards the center of the eye and onto the cornea. In this paper we elaborate the development of a Fuzzy Inference System (FIS) model for damage assessment of Pterygium. The system is developed using more than 100 images availed from public databases. The development of the model consists of: i) Pre-processing of the images ii) segmentation to differentiate the corneal region and the pterygium tissue. iii) Extraction of features related to growth of the tissue iv) Development of FIS to assess the damage in terms of mild, moderate, severe and very high severity. The results presented in this work indicate that the features are clinically significant in the detection of severity of pterygium. Our system is able to assess the severity of the damage caused due to pterygium with an accuracy of 86.66%.

KEYWORDS: Pterygium, Fuzzy Inference system, pre-processing, segmentation, features extraction, damage assessment.

I INTRODUCTION

A pterygium is a wing-shaped fibrovascular proliferation of the conjunctiva that grows across the cornea [1]. Pterygium occurs more frequently in people who live in areas with high ultraviolet radiation. Dusty, hot, dry, windy, and smoky environments also play a part [2, 3]. Most occur on the nasal side. Pterygium is a very common degenerative condition seen in Indian subcontinent. The prevalence rate is 5.2%. Pterygium is known to affect refractive astigmatism. The induced astigmatism may become significant to cause visual distortion, even though the pterygium remains distant from visual axis induced astigmatism maybe either “with-the-rule” or “against-the-rule.”

Pterygium may be classified as progressive or stationary. A stationary pterygium shows little or no progression over a long period. A progressive pterygium behaves in a far more aggressive fashion, with an advancing margin of grayishopacification and hyperemia within the tissue [4]. Decrease in visual acuity due to pterygium can occur due to following cause:

(i) Encroachment of pterygium at pupillary area

(ii) Astigmatism

(iii) Restriction of medial rectus muscle

The progression of a pterygium onto the cornea leads to significant corneal distortion which eventually causes development of astigmatism. Pterygium induced astigmatism can be the cause of various visually significant complaints like decrease visual acuity, glare sensitivity and monocular diplopia [5]. Figure 1 shows an image of an eye inflicted with fully grown pterygium.

Figure 1: Typical fully grown pterygium

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Prevention may include wearing sunglasses and a hat if in an area with strong sunlight. Among those with the condition, an eye lubricant can help with symptoms. Surgical removal is typically only recommended if the ability to see is affected. Following surgery a pterygium may recur in around half of cases.
The frequency of the condition varies from 1% to 33% in various regions of the world. It occurs more commonly among males than females and in people who live closer to the equator. The condition becomes more common with age. The condition has been described since at least 1000 BC.
Literature survey revealed that if the growth of pterygium is not monitored or treated in its initial stages, the complications could be severe [6, 7]. Some of the complications are;

- ✓ Perforation of the globe
- ✓ Thinning of the cornea
- ✓ Intra operative bleeding
- ✓ Muscle damage
- ✓ Reversing of the auto graft

II RELATED WORK

In this section a few recently reported research on development of automated pterygium detection system will be disused. Pterygium is an eye disease that commonly affects people living in areas near the equator and who are expose to excessive wind, sunlight, or sand. Pterygium is a form of tissue overgrowth found in the eye. The progressive growth of pterygium would block the pupil thus degrading image formulation over retina. Recently, anterior segment photographed images (ASPIs) have been used for early detection of the disease by incorporating digital image processing (DIP). As such, Siti Raihanah Abdani et al [8] reports the early results of iris segmentation of ASPIs that can be used later for pterygium detection. The work involves using the normalized HSV colour space of the iris ASPIs. By using the subtraction method, the iris threshold value was calculated to segment the iris. It is found out that the proposed algorithm can correctly segment the iris with pterygium cases.
A novel method is proposed [9] to measure the advancement of the pterygium after its segmentation. To detect the advancement of the pterygium the authors have performed two segmentation methods. The first was the segmentation of the iris in the eye region. For this, they used the Circular Hough Transform (CHT). This algorithm was used because it was more robust, compared to other techniques, in the cases of irises affected by the pterygium. The second segmentation was the detection of the region of the pterygium of the iris. In this segmentation, they used a region growing algorithm based on Otsu's thresholding method. From the last segmentation they can calculate the advancement of the pterygium growth.
Xinting Gao et al. [10] conducted similar research on pterygium detection which only focused on cases that involved advanced cases where the pterygium have encroached into the pupil region. Thirty pterygium images and 54 non-pterygium images with cortical cataracts were tested in their proposed method. Pupil segmentation was applied by using Fisher's linear discriminant to differentiate the yellowish fibrovascular tissue and pupil from the iris using color information approach. In a significant work, [11] the refractive astigmatism and visual acuity was assessed owing to pterygium excision. In this work 52 image samples were used and this work has conclusively proved that excision reduces the astigmatism, improves visual acuity. It was also found out that the age group in the range of 40-52 years is more prone to the severe pterygium

III .METHODOLOGY

The methodology adopted in this work is schematically shown through a flow diagram in Figure 2. The steps are briefed in the following paragraph

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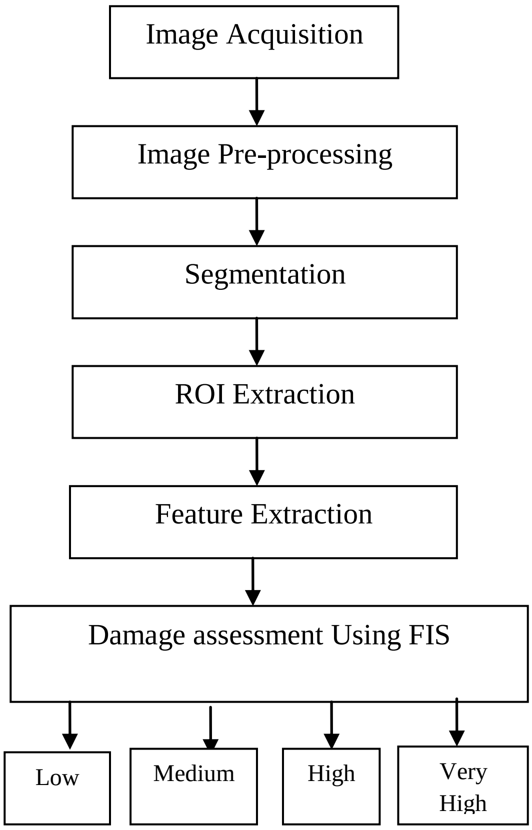

Figure 2: Flow chart showing methodology

A. *Image acquisition*

Around 100 images were collected from various eye clinics and hospitals in Tumkur and Bangalore region. Since the images so collected varied in their resolution all the images were brought to same resolution. A segment of the database is shown in the figure 3

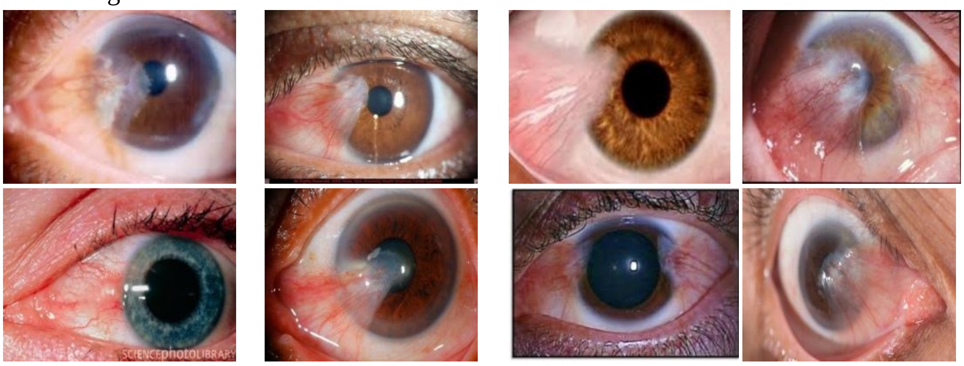

Figure 3: Segment of image database

B. *Pre-processing*

Image pre-processing is done to remove the noises present in the images. Noises may be due to poor illumination, defect in camera lenses etc. In this work, four filters namely median filter, weighted median filter, adaptive median filter and decision based median filter were tried the performance of these filters was evaluated using Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE)[12]. Further to assess the structural information content in such

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filtered images, first order entropy is estimated. The results showed that decision based median filter as best one both in terms of high PSNR and low MSE. Therefore, this filter is finally adopted for all the images.

C. *Segmentation*.

The general idea behind the proposed method is to detect and identify pterygium region based on the segmented iris. For the normal case, the segmented iris will look like a perfect circular shape, whereas for the iris with pterygium, the segmented iris will have some imperfection due to the tissue overgrowth that has encroached into the iris, thus affects the detected iris shape.

The three-step frame differencing technique was introduced in the corneal segmentation module. The output image successfully covered the region of interest with an average accuracy of 0.9127.

D. *ROI Extraction*

Since this work involves damage assessment of pterygium affected region, the region of interest remains to be cornea portion along with pupil area. This extent of area is cropped.

E. *Feature Extraction*

The features that are extracted are Area of pterygium, Major axis and minor axis of pterygium, and redness of the extra growth tissue. The so extracted features are stored in the table for the further assessing the damage due to pterygium using fuzzy inference system.

IV. DAMAGE ASSESSMENT USING FIS

The FIS is developed with 4 inputs and 1 output with the minimum of 77 rules (training data). Here, the inputs are: Area, major axis minor axis of pterygium, redness of pterygium. The output will be in terms of mild, moderate, severe and very severe. The segregation will be based on the training data. The developed FIS model is shown in the figure 4. The Figure5 will give the sample set of fuzzy rules.

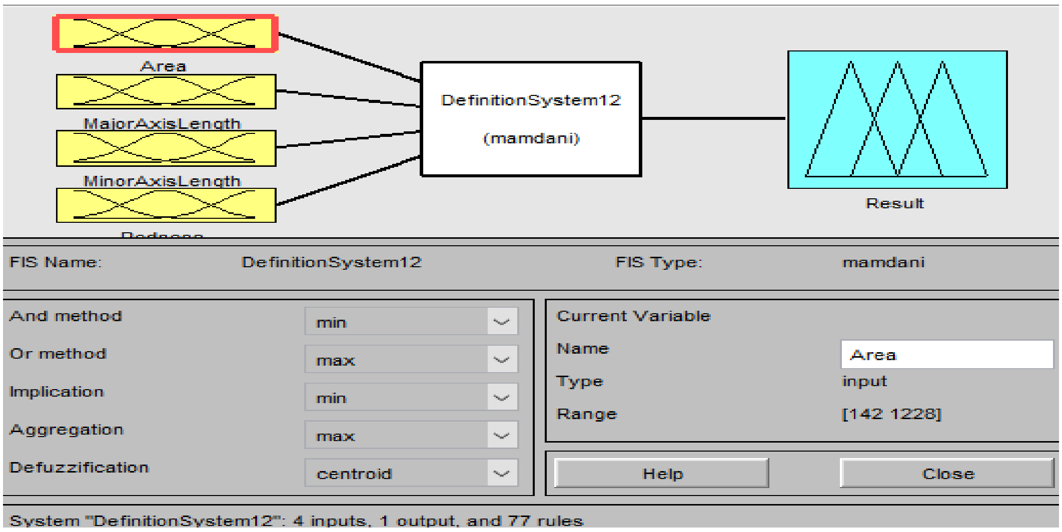

Fig 4: Fuzzy Inference Model

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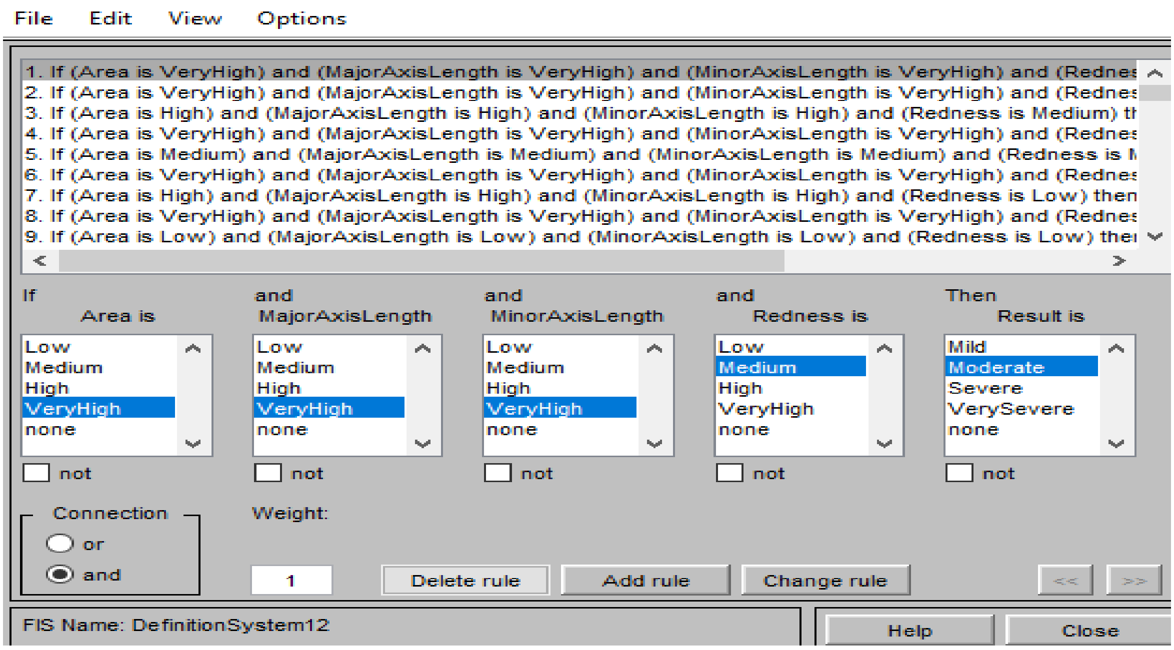

Figure 5: Fuzzy rules

V. EVALUTION OF THE SYSTEM

The evaluation of the Fuzzy Inference System helps us to make the system more realistic, efficient. For this purpose 30 pterygium images are considered, which were not used during the development of the fuzzy inference system. To evaluate the system percentage of correct identification of severity specificity, sensitivity and accuracy were estimated. The sensitivity is defined as percentage of correctly identified instances and specificity is defined as percentage of incorrect identified instances. Accuracy is the overall success rate of the classifier. These metrics are computed by using the following equations. The computed values are shown in Table 1.

$$\text{Sensitivity} = \frac{TP}{TP+FN} \quad \text{---- (1)}$$

$$\text{Specificity} = \frac{TN}{TN+FP} \quad \text{--- (2)}$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+FN+TN} \quad \text{--- (3)}$$

Where TP=True Positive, TN=True Negative, FN=False Negative, and FP= False Positive

Table 1: Evaluation of the system

Sl.no	No. of test Images	TP	TN	FP	FN
1	30	22	4	02	02
Percentage					
Sensitivity		Specificity		Accuracy	
91.66		66.6		86.66	

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VI.CONCLUSION

This paper presented development of damage assessment system with reference to Pterygium. The hypothesis of this work has been the real damage comes from extension of the mucous membrane to abstract the vision. Therefore, in this work it is striven to approximately estimate the different stages of damage.

This work involves the novel features such as Area of pterygium, Major axis and minor axis of pterygium and Redness of the pterygium .The development of damage assessment system which founded on fuzzy logic, the system was developed using 100 images. The evaluation of the system yielded satisfying results confirming applicability of the fuzzy inference system in such damage assessing processes.

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