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AI-POWERED SPECULAR IMAGE ANALYSIS FOR CORNEAL ENDOTHELIUM DYSTROPHY PROFILING

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ABSTRACT

Human cornea consists of '5' layers the thickest layer is stroma layer and densest layer is the endothelium layer, the hexagonal structured cells is occupied in the endothelium layer, The cell gets disturbed when dystrophies like fuch's dystrophy (FD), advanced fuch's dystrophy (AFD), posterior polymorphous corneal dystrophy, Irido corneal dystrophy (ICD), mild polymegathism, and corneal guttata (CG) encounters..Total '13' images are acquired from specular microscope of different dystrophies from various patients and processed into the artificial intelligent convolution filter (AICF) algorithm, which extracts mean cell area of endothelium cell, elongation of endothelial cell, Heywood circularity of endothelial, and compactness of endothelial, hexagonality, standard deviation, co-efficient of variation of endothelium layer (layer 5). The mean cell area of images I1 to I13 varies in the range of 79.5 µm2 to 3485 µm2, elongation endothelial cell varies in the range of 3.11 µm2 to 3.98 µm2, compactness factor of endothelial cell ranges 0.62 µm2 to 0.93 µm2 and Heywood circularity factor ranges 0.8 µm2 to 1.98 µm2, coefficient of variation ranges 10 µm2 to 99 µm2 and hexagonality of endothelial cell 46.6 µm2 to 65.2 µm2 are meticulously calculated. These endothelial statistical parameters represent the healthy condition of endothelial layer.

Keywords: *Fuch's Dystrophy, Corneal Guttata, Heywood Circularity Factor, Endothelium Layer, Compactness Factor*

1. INTRODUCTION

Specular microscope captured endothelium layer images for the processing.

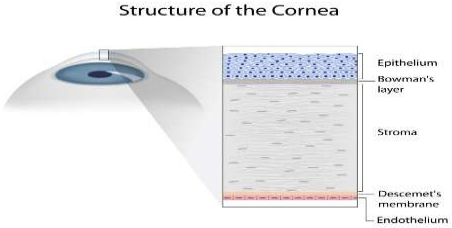

Fig 1 Corneal Layer

Considering fig 2, The images are to the geometrically equalized for standard dimensionality [5]. The 16-bit image is the input to the algorithm the endothelium image RGB linear mapping is performed to the images, for equal sizing. Zero order interpolation is performed to the images in order to resample the image and to eliminate low frequency components of the image [6]. The image is interpolated at 768*600-pixel quantities. The image feature is extracted with RGB Colour plane extraction in 2D-plane image [7]. The noise components levels are eliminated with the convolution filter with kernel sizing of '3'. The pixel quantities are identified and auto threshold with the

inter variance technique. The nearest neighbour pixel quantities are inter-variance with respect to the pixel variation of the image [8,9]. Danielsson morphology is performed to the image to enhance the characteristics, contrast level of the image. The endothelium structured contours are tracked with Danielsson morphology. Endothelium cell hexagonality is tracked and cell density, cell size, cell shape and cell area are also estimated with proposed algorithm. The processing time of the proposed algorithm is crucially important in the clinical hospitals, as it takes in 1000 milliseconds to process and extract the clinical information of the image. This algorithm provides statistical parameters within 1000 milliseconds, Due to this a drastic dropdown of time is achieved and this is very much helpful for the Ophthalmologists or clinicians in their busy scheduling time. In general the conventional morphological approaches are used to monitor the unique cells [10,11], cell density of the endothelium cells, as it is conventional in nature it takes lot of time to process the image and get the statistical parameters, apart from the cell density and unique cells it shouldn't provide the realistic data to be sufficient for the clinicians and ophthalmologists[12,13] , Among the five layers in cornea the last endothelium layer is focused in this paper, epithelium layer, stroma layer is clearly observed from the specular microscope [14] whereas the endothelium layers are difficult to process and diagnoses in nature as it extends below 12µ as shown in Fig.1 [15, 16].

2. LITERATURE SURVEY

In order to categorize AS-OCT images into three groups—healthy, early-stage FECD, and late-stage FECD—a deep learning algorithm was created. The model's potential as an autonomous diagnostic tool was demonstrated by its high accuracy, with an area under the curve (AUC) of 0.997 for early-stage detection[15]. CNNs were used to extract morphometric parameters, including effective endothelial cell density, guttae area ratio, coefficient of variation, and hexagonality, from specular microscopy images. A strong correlation between the guttae area ratio and clinical FECD [16] grading suggests that it can be used to characterize diseases. To categorize different corneal endothelium diseases, including FECD, an automatic diagnosis system using convolutional and transformer blocks was developed. The model's efficacy[17] in identifying lesion regions was highlighted by its high accuracy and generalizability across multicenter datasets. A novel approach using DenseUNets [18] with feedback non-local attention was proposed for segmenting specular microscopy images of the corneal endothelium with guttae. This method improved the estimation of endothelial parameters by effectively handling images with varying degrees of guttae presence. In order to evaluate the corneal endothelium in FECD patients, another study presented a UNet-based segmentation technique [19] that regresses signed distance maps. This technique offered accurate guttae identification and morphometric evaluations at various disease stages.

3. METHODOLOGY

A specialized image processing method called the Artificial Intelligent Convolution Filter (AICF) algorithm was created to examine specular microscopic images of the corneal endothelium. The algorithm's objective is to help with the diagnosis and profiling of corneal endothelium dystrophies, including Corneal Guttata, Posterior Polymorphous Corneal Dystrophy (PPCD), Iridocorneal Dystrophy (ICD), Advanced Fuchs' Dystrophy (AFD), and Fuchs' Dystrophy (FD). AICF uses artificial intelligence (AI)-powered filters to quickly and accurately extract statistically significant parameters from unprocessed medical images with little help from clinicians.

In order to extract and analyze complex statistical parameters of corneal endothelial cells from specular microscope images for automated and quick dystrophy diagnosis, "AI-Powered Specular Image Analysis for Corneal Endothelium Dystrophy Profiling" combines artificial intelligence (AI) with a custom convolution filtering algorithm (AICF).In order to improve diagnostic accuracy and eliminate outlier cell structures, a particle filter is applied to segment cells with a particle size threshold (1–2.4 μm^2).

The basic steps involved in the algorithm implementation are Input image acquisition, RGB mapping + resizing, Noise reduction via convolution, Morphological enhancement, Feature extraction, Particle filtering, Thresholding, and Statistical output generation.

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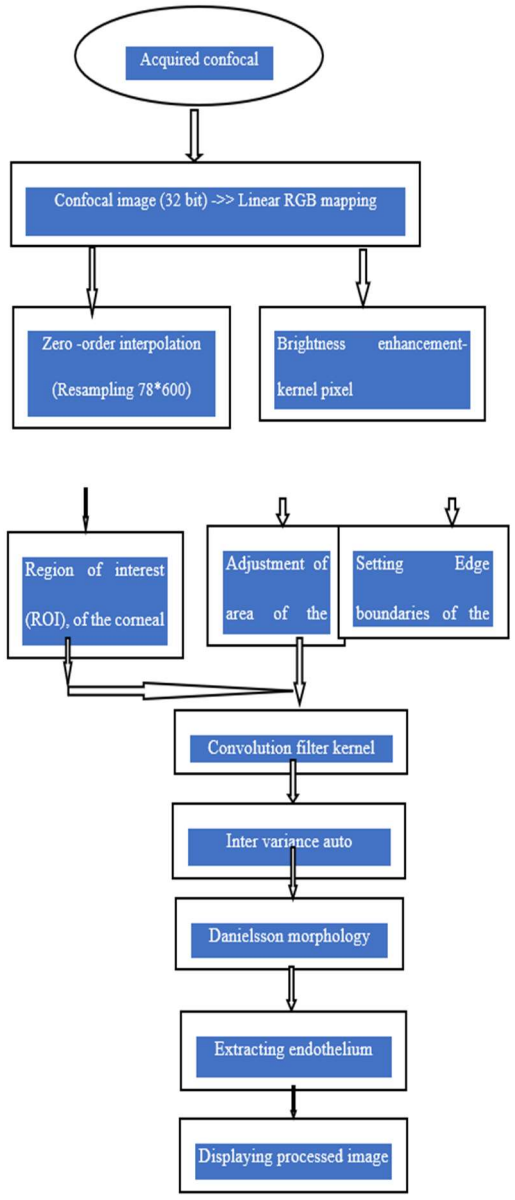


Figure 2. Proposed Algorithm For Corneal Endothelial Cell Analysis

$$K(v,u) = m * l(v,u) = \sum_{dv=-z}^{n} \sum_{du=-w}^{o} m(dv,du) l(v+dv, u+du)$$

Eq (1)

Where $K(v,u)$ is the filtered endothelium image, $m(v,u)$ is the original endothelium image, 'm' is the kernel filter every pixel in the endothelium image considered with kernel filter and its size.

Fig 3 Elongation factor

$$-n \le dv \le n$$

and

$$-o \le du \le o$$

Eq (2)

Considering figure 2, Depending on the kernel element values it effects substantially on the endothelium image. Eq(1) represents the processed image equation and Eq(2) represents the kernel size element matrix.

$$\begin{bmatrix} V_{11} & V_{12} & V_{13}.....V_{1n} \\ V_{21} & V_{22} & V_{23}.....V_{2n} \\ . & & \\ . & & \\ V_{n1} & V_{n2} & V_{n3}.....V_{no} \end{bmatrix} \times \begin{bmatrix} u_{11} & u_{12} & u_{13}.....u_{1n} \\ u_{21} & u_{22} & u_{23}.....u_{2n} \\ . & & \\ . & & \\ u_{n1} & u_{n2} & u_{n3}.....u_{no} \end{bmatrix}$$

$$= \sum_{k=0}^{n-1} \sum_{l=o}^{o-1} v_{(n-k)\,(o-l)}\, u_{(1+k)\,(1+l)}$$

Eq (3)

The kernel is place at its origin value of its current pixel quantity. The 3*3 kernel size overlay on the neighborhood pixel quantities. Each individual kernel element multiplies with pixel element which is overlay and obtained values are added. The resultant pixel quantity is the new value of the current pixel element. The kernel size is not symmetric as it is to be flipped around its horizontal axis and vertical axis before calculating the actual convolution. Usually kernel convolution requires pixel quantities required outside of the image boundaries. The extend, wrap, mirror, crop, kernel crop are the image boundary edges handling methodologies. The wrap, mirror, kernel crop are the image handling techniques used in here. Wrapping of endothelium image is conceptually done and values pixel element are dragged towards 90° wedges and opposite pixel elements are extended in lines. After then the endothelium image is conceptually mirrored at the edges, cropping of endothelium image is any pixel quantity output image requires beyond the image is skipped. This method of cropping can result the output endothelium image being slightly smaller when compared to the edges of the endothelium have been cropped. Kernel cropping extends past value output image that have been not used in normalization.

Ophthalmologists can now diagnose corneal dystrophies more quickly and accurately thanks to the design and implementation of a real-time, AI-powered, convolution-based image analysis system (AICF) that automatically extracts clinically

relevant features from images of the corneal endothelium.

4. RESULT AND DISCUSSION

Considering Table 1 total '13' images are processed into the AICF algorithm (I1 -I14) the complete

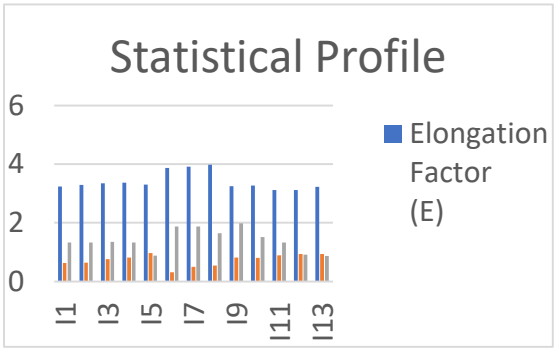


Fig 3 Elongation Factor

statistical parameters Mean cell area (µm2), Standard Deviation (SD)(µm2), Elongation factor(E), Compactness factor(C), Heywood circularity factor and co-efficient of variation, Hexagonality are extracted. The '14' images are collected from different patients the mean cell area (µm2) ranges 9.95 µm2 to 28 µm2. The image I8, I7 and I6 has highest mean cell area (µm2) compared to other cells, because the FD's and AFD's dystrophies attacks on the endothelium cells, the cell structure expands at its area-wise elongation too, the images I8, I7, I6 patients are highly countered to the FD and AFD dystrophies as shown in fig 3. Similarly, the SD of the images I1 TO I14 ranges from 79.5 µm2 to 145 µm2 the deviation of I8 is 3436.7 µm2 and deviation of I7 is 2562.3 µm2 and deviation of I6 is 5112.6 µm2 as these images are verge of dystrophic condition. The major statistical parameters in endothelium image dystrophy diagnosis is the cell elongation, compressed cell, hexagonality and circularity of the endothelium cell. CThe Elongation factor ranges from 3.24 to 4.00 the images I8, I7, I6 has elongation factor 3.98, 3.91, 3.87 as the FD, AFD encounters, leads to elongate the cell in vertical orientation.

Similarly, compactness factor(C) will drastically compresses when the endothelium cell elongates, even the circularity of the endothelium cell turns to polygon shape, FD, AFD causes the cell elongation, compactness reduces in diameter of cell and circularity of cell also turns in polygon in shape. The co-efficient of variation (%) also tabulated in the table no-1 and hexagonality of the endothelium cell is calculated with Eq 4. The hexagonality shape widely mismatches I8, I7 and I6 images.

Estimated Cell density=[10^6/ (µm^2*count)] * 4.44 Eq (4)

The specular microscopic images of different patients acquired and processed into the AICF algorithm. Considering table 2 the I1, I2, I3 images are high endothelial cell density or Normal cell density, Avg density01, Avg density 02 are FD images and their segmented images and densities of I1 (2865±10%, SD), I2 (1377±10%, SD), I3 (977±10%, SD) is shown table 2. I4, I5, I6 images are low density 01, low density 02, surface folding followed by AFD and FD images and segmented images is shown in table 2. The I4 image is AFD which indicates merging of adjacent cells which shows clearly in talble.2. And the densities of I4 (1198±10%, SD), I5 (230±10%, SD), I6 (217±10%, SD) is shown in table.2, Similarly I7, I8, I9, I10 images are mild polymegathism or early stage of FD, and Irido-corneal dystrophy, FD, snail tracks posterior polymorphous corneal dystrophy followed by densities of I7 (168±10%, SD), I8 (259±10%, SD), I9 (312±10%, SD), and I10 (286±10%, SD) is shown in table.2.and image I10 shows clearly tracks of snail in endothelium cells. I11, I12, I13 images are of corneal guttata, early stage of corneal guttata, and densities of I11 (466±10%, SD), I12 (868±10%, SD), I13(509±10%, SD) are tabulated in table 2. The I13 image is posterior polymorphous corneal dystrophy which shows all endothelium cells are heavily damaged and no shape of hexagonality could find in the image.

All the images (I1 to I13) are dystrophic image and gathered from different patients the normal cell density of the endothelium layer is 2000 cells/mm2 to 3200 cells/mm2[ ], < 2400 cells/mm2 are dystrophy images, when dystrophies attacked to the endothelium layer, endothelium cells are drastically reduced depending on the severity of the dystrophy as shown in fig 4. The images I1 to I13 are the dystrophic images clearly can observe with cell densities. The cells > 2400 cells/mm2 are normal cell density [19,20] and cell density is calculated as with Eq [4].

Table.1-Various Statistical parameters of the processed image

Image No	Mean Cell Area(µm^2)	Standard Deviation (µm^2)	Elongation Factor (E)	Compactness factor(C)	Heywood circularity factor(H)	Coefficient Of variation %	Hexagonality =[(C*H) / E]*100 %
I1	9.95	79.5	3.24	0.62	1.32	10	46.6
I2	13.06	34.6	3.29	0.636	1.32	42	47.9
I3	11.36	690.7	3.35	0.76	1.34	62	57.9
I4	05.26	516.7	3.37	0.81	1.32	55	47.7
I5	53.19	7416.2	3.3	0.96	0.876	81	55.0
I6	58.13	5112.6	3.87	0.31	1.87	99	53.5
I7	75.7	2562.3	3.91	0.49	1.875	49	64.5
I8	68.75	3436.7	3.98	0.54	1.64	67	56.4
I9	45.55	2813.0	3.25	0.81	1.98	61	64.9
I10	41.7	3322	3.27	0.80	1.51	70	55.2
I11	26.8	3485	3.11	0.89	1.32	85	65.2
I12	27.7	2493	3.12	0.93	0.91	73	52.4
I13	23.8	2286	3.23	0.93	0.86	69	62.4

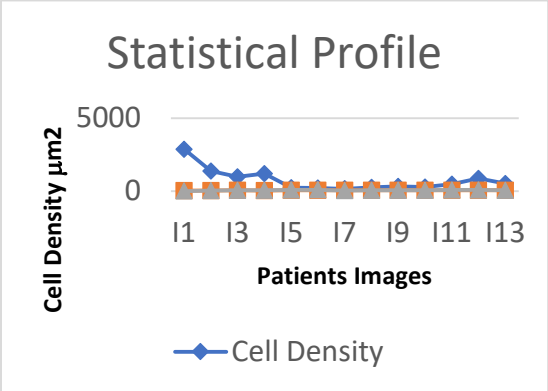


Figure 4 Patient's images (I1-I13) vs Cell Density

The limitations of the proposed work are, it is difficult to verify the AICF algorithm's superiority because the study does not compare its performance (accuracy, sensitivity, and specificity) with that of manual methods or current state-of-the-art AI, Unseen data is used to test the system, which is essential for assessing its practicality means external validation is not done because AICF algorithm mainly focused on extraction of mean cell area of endothelium cell, elongation of endothelial cell, Heywood circularity of endothelial, and compactness of endothelial, hexagonality, standard deviation, co-efficient of variation of endothelium layer (layer 5).

Table 2-Different Patients Cell Densities And Segmented Images

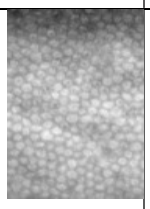
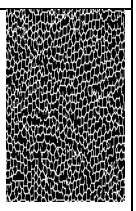
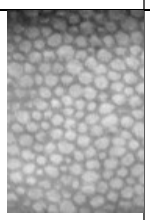
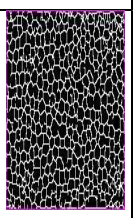
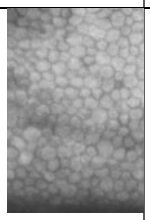
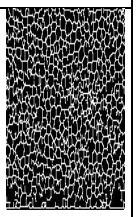
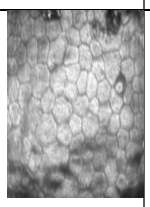
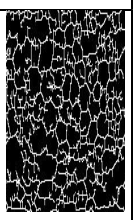
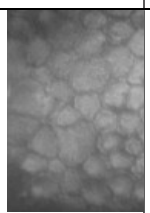
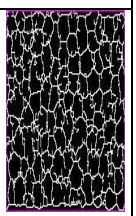
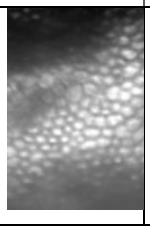
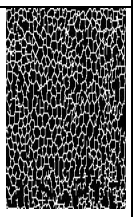
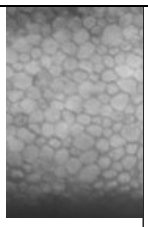
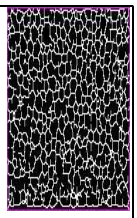
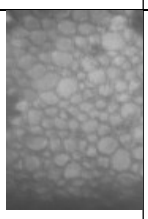
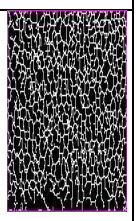
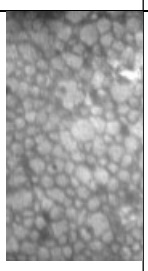
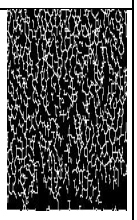
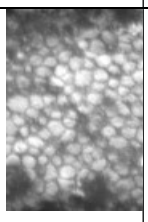
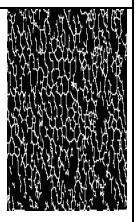
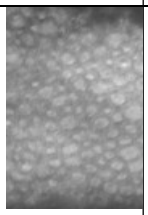
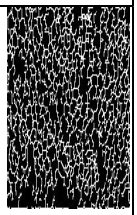
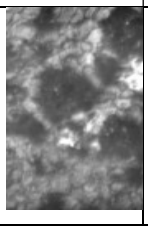
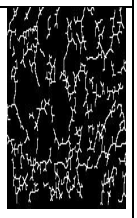
S. no	Type of cornea/ Patient	Cell Density/mm^2±SD	Specular microscopic Image	Segmented endothelium Image
I1	High ECD	2865 ±10%		
I2	Average Density 01/FD	1377 ±10%		
I3	Average Density 02/FD	977± 10%		
I4	Low Density 01/AFD	1198 ±10%		
I5	Low density 02/ICD	230± 10%		
I6	Surface folding/ FD	217± 10%		
I7	Mild Polymegathism /FD	168± 10%		
I8	ICD	259± 10%		
I9	Fuch's dystrophy	312± 10%		
I10	Snail Tracks/ PPCD	286± 10%		
I11	Corneal Guttata 1	466± 10%		
I12	Early stage of Corneal guttata	868± 10%		
I13	PPCD	509 ±10%		

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Table 3 Particle Filter Parameter Ranges And Mean Value

S.no	Parameter range		Current parameter		Mean value
	Min value	Max value	Min value	Max value	
I1	1	2.4	1.05	1.92	1.21
I2	1	2.4	0.75	1.6	1.21
I3	1	2.4	0.94	1.63	1.18
I4	1	2.4	1.02	1,64	1.22
I5	1	2.4	1.05	2.23	1.23
I6	1	2.4	1.04	2.21	1.15
I7	1	2.4	1.02	2.03	1.19
I8	1	2.4	1.06	1.73	1.24
I9	1	2.4	1.08	2.08	1.26
I10	1	2.4	1.04	1.70	1.18
I11	1	2.4	1.04	1.98	1.16
I12	1	2.4	1.02	1.65	1.21
I13	1	2.4	1.01	2.3	1.18

Considering table 3, Total '13' images are processed in proposed algorithm, several statistical parameters are extracted from algorithm, the particle filter is applied to the processed images, The minimum particle range is '1'and maximum particle range is '2.4', All '13' images were processed through the particle filter, the minimum particle range and maximum particle range would be in between 1 to 2.4. The I1 minimum value is 1.05 μm^2 and maximum value is 1.92 μm^2, I2 minimum value is 1.6 μm^2. All '13' images are processed through particle filter. The resulted particle ranges in between 0.75 μm^2 to 2.87 μm^2, The mean value would lie in the range of 1.15 to 1.24. The minimum particle size is fixed as '1' and maximum particle size is fixed as '2.4' μm^2. The cell structures which is in the range of 1 μm^2 to 2.4 μm^2 extracted and further processed. The cell structure below 1 µm2 and beyond 2.4 µm2 are discarded. Normal images had minimum value 1 to 1.5 µm2. The abnormal images has more than 1.5 µm2, The more the value of particle size the more dystrophic in nature it is. The normal image usually lies in the range of 1 to 1.5 µm2, with the particle filter function can clearly distinguish the normal images and abnormal images. Table 4 shows variation of mean, SD, Area for (I1-I13)

Patients Images	Mean value	Standard Deviation	Area mm^2
I1	0.64	2.2	0.2611
I2	0.9	3.04	0.2611
I3	0.88	3.33	0.2611
I4	0.35	2.15	0.2611
I5	0.47	2.45	0.2611
I6	0.54	2.36	0.2611
I7	0.62	2.17	0.2611
I8	0.52	2.65	0.2611
I9	0.48	2.48	0.2611
I10	0.60	2.68	0.2611
I11	0.43	2.62	0.2611
I12	0.55	2.59	0.2611
I13	0.61	2.56	0.2611

Considering table 4 all the images are interpolated with quadratic interpolation, The area doesn't change or unaffected during the process. All '13' images mean value is range in between 0.30 μm^2 to 0.64 μm^2, the standard deviation 2.5 μm^2 to 3.3 μm^2, the area of all images is 2.655*105 which remains unchanged due to interpolation of the images.

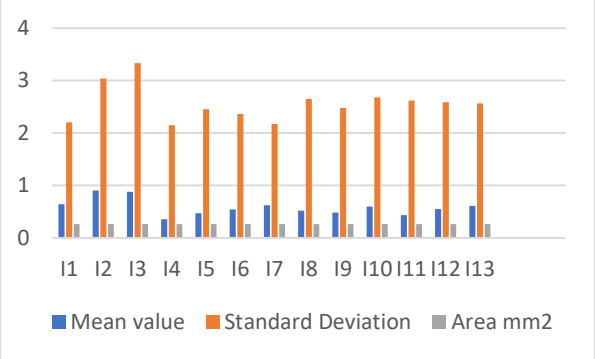

Figure 5 Variation of Mean, SD, Area for I6-I10

Considering Table 5 auto metric threshold, All '13' images are processed, The lower threshold limit is '10' and upper threshold limit is '245', The minimum is '10' the upper is '245'. All the images are processed and lies in the range of 10 to 245 all the images has different thresholding values, The image I1 is 120, image I2 is 125, Image I3 is 130. All images lies in the range of 10 to 245. The dystrophic images like fuch's dystrophic image, advanced dystrophic image, posterior polymorphous corneal dystrophy, Irido corneal dystrophy, corneal guttate diseases encounter the endothelium layer causing which cell densities may change, Significantly the cell density is reduced. The mean values are also get nominal values. For normal images the mean, SD, lies in the nominal value.

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Table 5 shows Auto metric threshold (I1-I13)

Patients Images	Lower limit	Upper limit	Result
I1	10	245	119
I2	10	245	117
I3	10	245	117
I4	10	245	118
I5	10	245	118
I6	10	245	119
I7	10	245	120
I8	10	245	121
I9	10	245	116
I10	10	245	115
I11	10	245	120
I12	10	245	117
I13	10	245	118

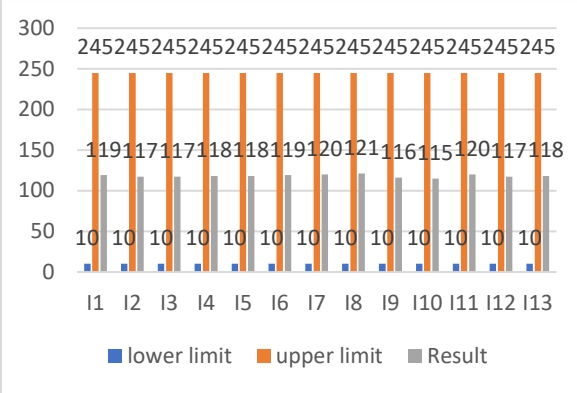

Figure 6 Metric Threshold of I6-I10

Figure 4 shows '13' different patients images vs cell density, high endothelium cell density usually observed in normal images, the cell density is 2865±10% SD, which is in normal range, ≤ 2400 cells/mm^2 considered to be abnormal images, any dystrophy may cause change in cell density. >2400 cells/mm^2 are considered to be normal images. The figure 4 shown images '1' is normal range remaining '12' images are dystrophic images (I2-I13) images cell density is <2400 cells/mm^2 which are abnormal in nature.

Figure 6 &7 shows cell particle minimum range and maximum value which is standard measurements, the minimum value is 1 µm^2 and maximum value is 2.4 µm^2, below 1 µm^2 and above 2.4 µm^2, cell particle diameter is discarded. The Total '13' images are processed, the minimum value for I1 is 1.05 µm^2 and maximum value is 1.92 µm^2, the I2 0.75 µm^2 and maximum value is 1.6 µm^2. All images minimum range is > 1 µm^2 and < 2 µm^2, and maximum range is >1.5 µm^2 and < 2.4 µm^2 as shown in figure 8. The mean value of the I1 is 1.31 µm^2, I2 (1.21 µm^2), I3(1.18 µm^2), I4(1.22 µm^2), I5(1.23 µm^2),I6(1.15 µm^2),I7(1.19 µm^2),I8(1.24 µm^2),I9(1.26 µm^2),I10(1.18 µm^2),I11(1.16 µm^2),I12(1.21 µm^2). I13(1.18 µm^2) as shown in figure 9. The mean value of I1 is 1.31 µm^2 for normal images, I2 to I13 images has less mean value < 1.31 µm^2 for abnormal images.

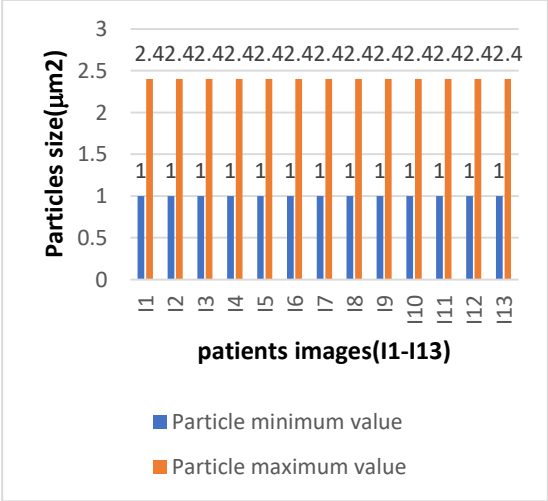

Figure 7 Patients images vs particle min size

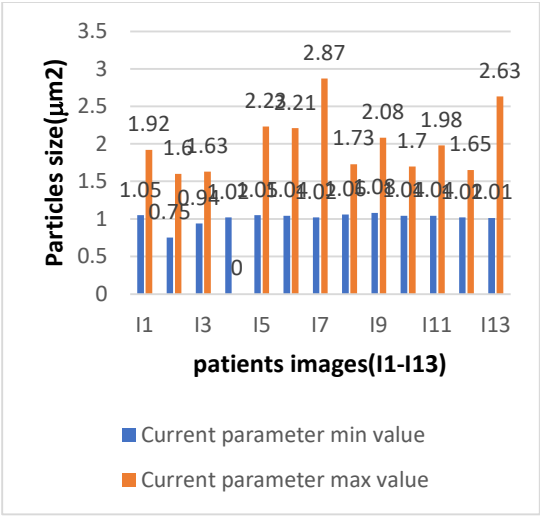

Figure 8 patients images vs particles size

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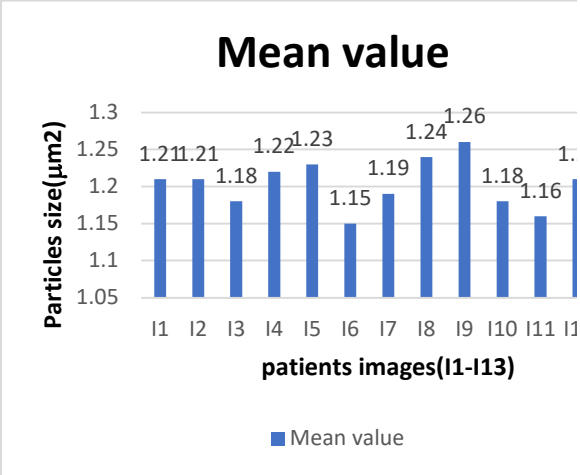

Figure 9 Patients images vs particles mean value

Fig 9 shows noise components present in specular images, the '13' images peak signal-to-noise ratio in dB is projected in tabular column. The corresponding MSE (Mean square error) value is also calculated with the following equations (5) and (6).

$$MSE = \sum_{i=0}^{y=1}\sum_{j=0}^{z-1}[I(i,j) - I^{|}(i,i)] \qquad (5)$$

$$PSNR\ db = 10\ log\ 10\frac{255^2}{MSE} \qquad (6)$$

No. of rows (y), No. of columns (z)
the input of the image I (i,j).
the output of the image $I^{|}$(i,j).

The I1 image is normal image as the cell density is high, the noise component is less i.e., 36.8 dB, And corresponding MSE value 0.28. All other images I2 to I13 are abnormal images which has more noise components, I2 (51.2 dB), I3 (50 dB), I4(55.1 dB), I5 (52.3 dB), I6(51.3 dB), I7(51.7 dB), I8(52.3 dB), I9 (52.0 dB), I10 (53.4 dB), I11 (52.9 dB), I12 (51.8 dB), I13(50.6 dB) as shown in images I2 to I13 are varying less cell density as they were dystrophic images and noise components are high as shown in figure 10&11.

Table 6 shows PSNR vs MSE Values of (I1-I13)

S.No	PSNR Value dB	MSE Value
I1	36.8	0.28
I2	51.2	0.38
I3	50.2	0.32
I4	55.1	0.48
I5	52.3	0.40
I6	51.3	0.41
I7	51.7	0.41
I8	52.3	0.40
I9	52.0	0.40
I10	53.4	0.45
I11	52.9	0.40
I12	51.8	0.41
I13	50.6	0.34

The images mean values, Standard deviation and area of the images. I1 to I13, SD varies ranges from 2.00 µm^2 to 3.00 µm^2, and area remains unchanged as all the images are interpolated with quadratic interpolation.

The metric threshold of an images I1 to I13, the threshold value of all the images lies in the range of 10 to 245. The lower limit is '10' and upper limit is '245', every individual image has unique thresholding value.

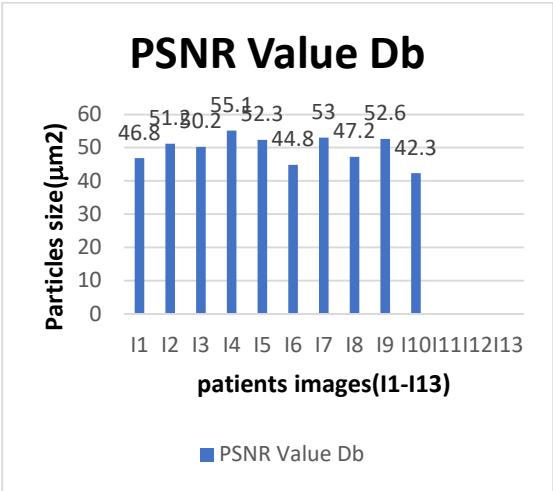

Figure 10 PSNR value of (I1-I13)

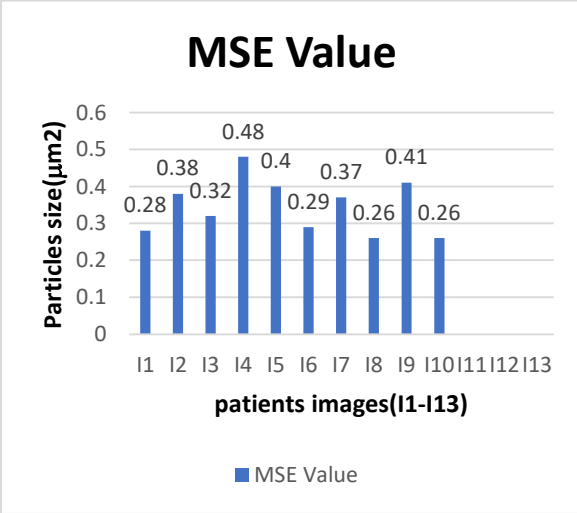

Fig 11 MSE value of (I1-I13)

The I1 (119), I2(117), I3(117), I4(118), I5(118), I6(116), I7(115),I8(119),I9(120), I10(120),I11(116), I12(118), I13(117) are the individual threshold value. >119 for I1 Image, >117 for I2 image, >118 for I3 image, >118 for I5 image, >116 for I6 image, >113 for I7 image, >118 for I8 image, >120 for I9 image, >120 for I10 image, >116 for I11 image, >118 for I12 Image, >117 for I13 image are considered to be bright object pixels and less than that threshold value are considered to be dark object pixel identification.

5. CONCLUSION

Total '13' images are acquired from specular microscope the complete cell statistical information is extracted. The FD, AFD, ICD causes the endothelium cell severely damages. The mean cell area, SD, Elongation factor, compactness factor, Heywood circularity factor is calculated. The elongation factor for I8, I7, I6 images are very high as the images are severely damaged images and similarly C, H, also extracted. The hexagonality of endothelium cell is also calculated with the standard equation. All these statistical parameters are very much helpful for the ophthalmologists/clinicians. In order to estimate the dystrophies accurately an ACF methodology provides all the necessary statistical information and artificial intelligence is adopted to the convolution filter to establish standard automatic system to explore the above statistical information without manual intervention and also the time taken to process the images are 1000msec, and ACF helps ophthalmologists/clinicians accurately diagnosis the endothelium cell structure. It almost reduces 10 to 15 mins of time to ophthalmologists/clinicians to detect the dystrophies in a busy clinical scheduling time.

All '13' images from different patients are acquired from specular microscope, High ECD, Average density, low density, surface folding, mild polymegathism, snail tracks, corneal guttate, early stage of corneal guttate images are processed in algorithm and extracted clinical parameters. The mean cell area of the images ranges from 5.26 μm^2 to 75.7 μm^2, SD (μm^2) ranges from 79.5 μ^2 to 7416.2 μm^2, Elongation factor ranges from 3.3 μm^2 to 3.98 μm^2 and compactness ranges from 0.31 μm^2 to 0.96 μm^2, Heywood circularity ranges from 0.86 μm^2 to 1.98 μm^2, co-efficient of variation ranges from 10 to 99, hexagonality ranges from 46.6 to 65.2 for different dystrophic images. The minimum cell density 168±10% SD, and maximum cell density 2865±10% SD meticulously calculated. The cell particle diameter is also estimated with particle filter by processing through the convolution filter. The PSNR and MSE values of 36.8 dB to 55.1 dB and 0.28 to 0.45 estimated meticulously with the help of metric thresholding technique the minimum lower limit of '10' and maximum higher limit of '245' and individual thresholding value which is in the range of 10 to 245 estimated meticulously as shown in fig 10 and 11, The average processing time of 1000 ms for every image to be processed through algorithm has impending.

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