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Detection of Glaucoma in Retinal fundus images using Fast Fuzzy C mean clustering

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***Abstract*- Glaucoma is one of the major causes of vision loss in today's world. Glaucoma is a disease in the eye where fluid pressure in the eye increases; if it is not timely cured, the patient may lose their vision. Glaucoma can be detected by examining boundary of optics cup and optics disc acquired from fundus images. The proposed method suggest automatic detect the boundary of optics cup and optics disc with processing of fundus images. This paper explores the new approach fast fuzzy C-mean technique for segmenting the optic disc and optic cup in fundus images. Results evaluated by fast fuzzy C mean a technique is faster than fuzzy C-mean method. The proposed method reported results to 91.91%, 90.49% and 90.17% when tested on DRIONS, DRIVE and STARE on publicly available databases of fundus images.**

***Keywords*—Cup to disc ration, optic disc, optic cup, glaucoma detection, Fast Fuzzy C Mean**

I. INTRODUCTION

Glaucoma is the second largest cause of vision loss which affects 66.8 million people worldwide [8] and about 79 million in the world likely to be affected with glaucoma by the year 2020 [12][13]. Glaucoma is a common eye condition in which vision is lost because of damage to the optic nerve. The optic nerve carries information about vision from the eye to the brain. In most cases, the optic nerve is damaged when the pressure of fluid inside the front part of the eye rises. This can lead to permanent blindness. Eye is most valuable and sensitive sense organ of our body which receive the information visually from the environment and convert them into electro-chemical impulses [7]. Increasing number of glaucoma patient needs an automatic system to detect glaucoma, so that glaucoma can be early detected and cured. The eye is nearly spherical in shape and slightly bulge in front part. In the proposed paper, glaucoma can be detected by extracting feature from the eye. Cup to disc ratio (CDR) is obtained after detection of area of optic disk and optic cup. CDR range from 0.1 to 0.3 for normal eye and value greater than 0.3 reports glaucoma infected eye.

A. Optic Disc

The ganglion cells which exist in eye leaves the eye from a point is known as optic disc. They exit because there are no rods or cones overlying the optic disc, it correlates with small blind spot in each eye. The blood which is supply to the retina is also entering from the optic disc. The human eye transfers 1-1.2 million nerve fibres to brain from the eye.

B. Optic cup

In the centre of the optic disc the two walled depression which is found is known as optic cup. The neuroretinal rim is the outermost region in the cup region where the nerve fibers bend. The structural emergence of the optic disc is changed due to the size reduction in optic nerve fibers. Figure 1 shows the optic cup.

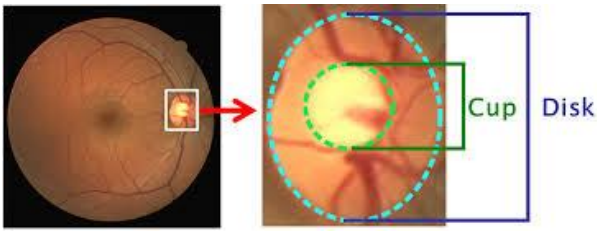


Fig. 1. Colour Fundus image and optic disc & optic cup image[11]

At present time world wide at least 66.8 million people affected with vision loss due to Glaucoma and by 2022 possibly 79 million people will be affected with Glaucoma worldwide [8][12-13].Ophthalmologist can inspect this disease and if diagnosis early can stop vision loss. Due to increase of Glaucoma patient an automatic system to detect Glaucoma is required. So that Glaucoma can be early detected and cured.The most common eye disease is Glaucoma due to damage of optic nerve the eye vision may be lost. The information is carried by optic nerve from eye to the brain. The effect of Glaucoma is ocular pressure of fluid is high in front of the eye so the chance of damage the optic nerve. This can lead to permanent blindness. Figure 3shows the early and advanced glaucoma eye vision.The vision damaged by the glaucoma can only be halted cannot be reverse. The glaucoma is identifying after calculating the ration of optic cup to disc. Early diagnosis can prevent the people from occurrence of glaucoma.

Fig. 2. Early and advanced glaucoma eye vision

II. RELATED RESEARCH

The glaucoma is the one of the main cause of loss of sight now a day, and if it is not initially forecast than it can cause everlasting blindness among people all over the world. Calculating the shape of optic disc and cup is not a easy task. [1] Gives the idea detecting the Glaucoma using image processing techniques. In this paper focus on pre-processing, extracting region of interest and then extracting the features. After calculating the CDR perform the classification for Glaucoma and non-Glaucoma image.

[2] Proposed a method for Glaucoma detection using correlation filter. Main focus on calculating the vertical cup to disc ratio after image segmentation

[6] Gives approach that based on linear discriminate analysis. At the pre-processing stage apply the adaptive histogram equalization and morphological operation for improve the quality of image and then further detecting the optic disc boundary. In painting technique applied for removing vessel from fundus image. [3] Suggest a technique variant level set that is used calculating the boundary of disc. After that segmentation technique applied for extracting the optic cup from retinal image.

[16] In this paper author gives three techniques in sequence. One edge detection method, optimal thresholding method and finally manual threshold analysis. For getting more precise result resizing operation is performed

[17] Author extract two important features that are ISNT quadrants and CDR value for detecting the glaucoma in fundus image. All the features are extracted and tested on three databases DMED, FAU and MESSIDOR.

[18] Proposed a method for Glaucoma detection through image processing and data mining techniques. “Automatic Detection of Glaucoma in Retinal Fundus Images through Image Processing and Data Mining Techniques“In this Glaucoma is acknowledged through cup to disc ratio and ISNT rule. This method includes segmentation of blood vessels, segmentation of optic disc through proposed maximum voting of three segmentation algorithms (K-Means, Wavelet and Histogram based), segmentation of optic cup through intensity thresholding, feature extraction from these segmented structures, feature selection to identify significant features, hybrid model involving Naive Bayes to remove noise.

The paper is organized as follows. In section first give the introduction about glaucoma detection, the brief of implementation detailed gives in section second. The proposed methodology description is explained in this section. Section second gives the detailed about the proposed methodology and algorithm for fast fuzzy C mean algorithm which is proposed for segmentation of optic disc and optic cup. The step wise result of proposed methodology shown in section three result and discussion section. The evaluated performance is also compared with existence algorithm in this section. Conclusion gives in the conclusion section.

III. IMPLEMENTATION DETAILS

This section brief the implementation details for the proposed methodology. Proposed methodology is divided in two parts. One of the part is detection of optic disc area and other part is detection of optic cup area.Cup to disc ratio (CDR) is obtained after detection of area. The CDR is used for detection of glaucoma.

To recognise the shape of the optic disc and cupin the retinal fundus image is very important for the diagnosis of retinal disease glaucoma [6]. Initialanalysis for this disease in retina can avoid the vision damage. Themethod involves in the optic disc and cup recognition is shown in Fig. 3. The outline of the process for the detection of glaucoma is as follows: first of all Image Acquisition of Retina takes place with the help of the fundus camera than Optic disc and Optic cup are detected after the detection Cup to Disc ratio is found . The Normal cup to disc ratio range is from 0.1 to 0.3. If the cup to disc ratio go above 0.3 then it specifies the abnormal condition that is the existence of glaucoma.

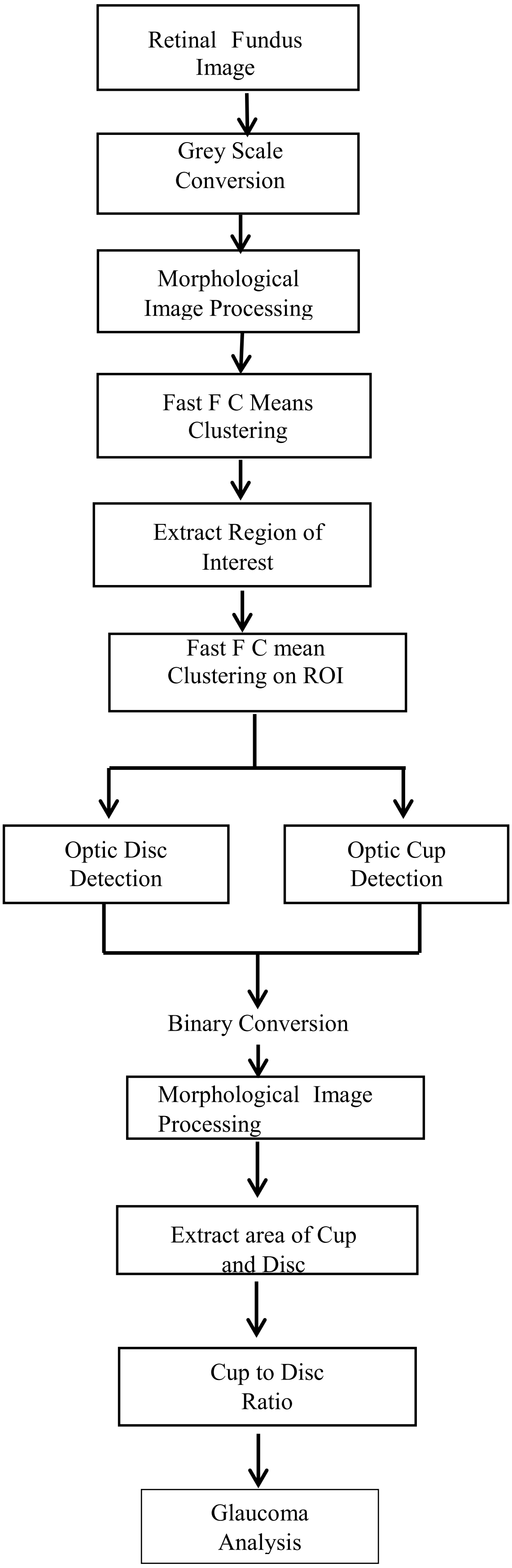


Fig. 3. Proposed frameworks

- **Image Acquisition of Retina**

The images are acquired using the fundus camera because fundus photographs are used to capture the back of eye i.e., fundus

There are three modes [14]:

(1) Colour: to examine in full colour, white light is illuminated.

(2) red-free in which the differencebetween structure and other vessels is improved by eliminating the red colour through filtering the imaging light; and

(3) Angiography in which the contrast of vessels is improved by intravenous injection of a fluorescent dye.

Fig.4. Fundus image

Pre-processing

Removal of noise is necessary from the acquired image for detecting the optic cup and disc. So first perform the pre-processing for extracting the relevant features.Initially RGB image is converted into the gray scale image. Morphological operation applied on the gray scale image. Gray scale image is converted into the binary image before applying the morphological operation. Morphological image processing follows the aim of removing these imperfections from the image. Dilation operation is applied on the image for increasing the boundary of regions of foreground pixels.The image after greyscale conversion does not have perfect boundary. Dilation gradually enlarge the boundaries of regions of foreground pixels .Suppose f(x) is a grayscale image Let f be a greyscale image is denoted as f(x): E→T, where x is the pixel coordinate. In the case of discrete valued images, T ={tmin, tmin+1... tmax} is an ordered set of gray - levels. Typically, in digital 8-bit images min t =0 and max t

=255. Besides, let B(x) be a subset of Z2 called structuring element centred at point x, whose shape is usually chosen according to some prior knowledge about the geometry of the relevant and irrelevant image structures.

$[\delta_B(f)](x) = \max_{b \varepsilon B}(x) f(x+b)$

Closing image

Closing is an important operator from the field of mathematical morphology. In image processing closing is used for removal of small holes. It is used to improve pixels on the boundary. The closing of a set (binary image) A by a structuring element B is the erosion of the dilation of that set.

$A \bullet B = (A \oplus B) \ominus B$

FAST Fuzzy C MEANS CLUSTERING

With efficient approach of fuzzy c-means memory efficientimplementation, Segment N dimensional gray scale image into different c classes.

Segment N-dimensional gray scale image into c classes using a memory efficient implementation of the fuzzy c-means (FCM) clustering function [9]. The computational effectiveness is reach by using the histogram of the image intensities during the clustering process instead of the raw image data,but in our method rather than using the function fuzzy c mean we used fast Fuzzy c means function the only difference is the number of parameters. The Fast fuzzy c mean algorithm is implement using the mathematical expression shown from (1) to (11).

For Dataset partitioning the standard Fuzzy C-Mean objective function $\{g_x\}_{x=1}^{N} \subset M^d$ into c clusters given by

$$J_m = \sum_{a=1}^{b}\sum_{d=1}^{e} u_{ad}^{c} \| m_d - x_a \|^2 \quad (1)$$

$$U_{ab} = \frac{(\| m_b - v_a \|^2 + \frac{\gamma}{X_R}\sum_{r \in N_b} \| x_r - v_a \|^2)^{\frac{1}{m-1}}}{\sum_{k=1}^{c}(\| m_b - v_k \|^2 + \frac{\gamma}{X_R}\sum_{r \in X_b} \| x_r - v_k \|^2)^{\frac{1}{m-1}}} \quad (2)$$

$$v_1 = \frac{\sum_{b=1}^{e} u_{ab}^{m}(m_b + \frac{\gamma}{X_R}\sum_{r \in x_b} m_r}{(1+\gamma)\sum_{b=1}^{e} u_{ab}^{m}} \quad (3)$$

$$J_m = \sum_{a=1}^{c}\sum_{b=1}^{e} u_{ab} \| m_b - v_a \|^2 + \gamma \sum_{a=1}^{c}\sum_{b=1}^{e} u_{ab}^{m} \| \overline{m_b} - v_a \|^2 \quad (4)$$

$$u_{ab} = \frac{(\| x_b - v_a \|^2 + \gamma \| \overline{m_b} - v_a \|^2)^{\frac{-1}{(m-1)}}}{\sum_{a=1}^{c}(\| x_b - v_a \|^2 + \gamma \| \overline{x_b} - v_a \|^2)^{\frac{-1}{(m-1)}}} \quad (5)$$

$$v_i = \frac{\sum_{j=1}^{n} u_{ab}^{m}(x_b + \lambda \overline{x_b})}{(1+\gamma)\sum_{b=1}^{e} u_{ab}^{m}} \quad (6)$$

$$u_{lb} = 1 - \eta \sum_{a \neq l} u_{ab} == 1 - \eta + \eta u_{lb} \quad (7)$$

$$u_{ab} = \eta u_{ab}, a \neq \eta, 0 \leq \eta \leq 1 \quad (8)$$

$$f_s = \sum_{a=1}^{c}(\sum_{b=1}^{e}(u_{ab})^m)(v_a - \bar{v})(v_a - \bar{v})^T \quad (9)$$

$$\beta = \exp(-f_s) \quad (10)$$

$$\bar{v} = \frac{\sum_{a=1}^{c}\sum_{b=1}^{e}(u_{ab})^m x_b}{\sum_{a=1}^{c}\sum_{b=1}^{e}(u_{ab})^m} \quad (11)$$

The proposed technique Fast Fuzzy-Mean for detection of optic cup and optic disc apply the following steps:

1. It set the value of c initially that is positive integer greater than 1 specifying the number of clusters.

2. It set the q that is fuzzy weighting exponent. q Must be real number q=2 is the default setting. Increasing q leads to an increased amount of fuzzification, while reducing q leads to crispier class memberships.

3. It takes the input of two dimensional images in integer format.

4. Set the loop counter b=0

5. Calculate f_s and $\bar{v}$ using (9) and (11)

6. Compute the β using (10)

7. Update the membership matrix using (2) or (5)

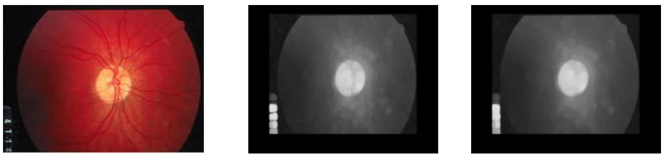
8. Modify the degree of membership using (7)

9. Update the cluster centre matrix (3) or (6)

10.if $\max\left\{u^{(b)} - u^{(b+1)}\right\} < \varepsilon$,stop otherwise set b=b+1 and go to step 4

IV. RESULTS AND DISCUSSION

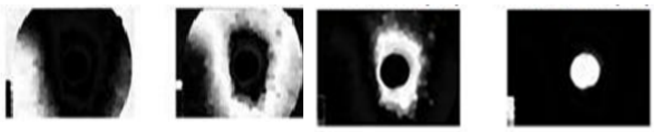
To evaluate the glaucoma diagnosis performance of our proposed method, we perform experiments on three glaucoma fundus image datasets DRIONS, DRIVE and STARE. The STARE database contains 20 images. The images were acquired using a Topcon TRV-50 fundus camera with 35-degree FOV. Images have size of 605*700, RGB format and 24 bits. The DRION database contains 110 images. The images were acquired using a colour analogical fundus camera, approximately centred on the ONH and they were stored in slide format. Images have size 600*400, RGB format and 8 bits/pixel. The DRIVE database contains 40 images. The images were acquired using a CANON CR5 with 45-degree field of view (FOV). Images have size of 768*584, RGB format and 24 bits. Fig. 5. shows the result that obtained after performing the morphological operation dilation and closing operation .In retinal image analysis for detecting the optic disc and cup is necessary, so this can be achieved after eliminating the noise. Morphological is one of the better techniques through for removing the noise.



(a) (b) (c)

Fig. 5. (a) Input Fundus Image (b) Dilated Image (c) closing image

Segmentation of optic disc and optic cup is very important for detecting the optic cup and disc. In this paper proposed algorithm is fast fuzzy C mean algorithm for retinal image segmentation. It gives the better result rather than fuzzy C-Mean technique.Fig. 6. (a) to (d) shows the result after after applying the Fast Fuzzy C-Mean technique. Every image in Figure5 represents the membership map of optic disc. The input image for Fast Fuzzy C-Mean algorithm is obtaining image after removal of noise from Figure 5.



(a) (b) (c) (d)

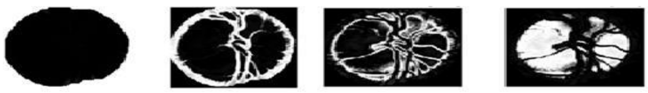
Fig. 6. (a)-(b)-(c)-(d) Membership map of optic disc from class 1 to class 4 .

The Fig. 7. shows extracting region of interest image from the original image.For further processing for extracting the optic cup we take image from Fig. (6)-d.This image work like as filter .Applying masking operation of Fig. 7.(a) image on to Fig. 7(b),then we obtained the image as shown in Fig. 7.(c) for optic disc.

(a) (b) (c)

Fig. 7. (a) Binary image of optic disc (b) original image (c) Resultant ROI of optic disc

In this paper we proposed Fast Fuzzy C-Mean technique; again apply on the resultant image on Fig. 7(c) .In Fig. 8.(a)-(d) represent the resultant image after applying the Fast Fuzzy C-Mean technique. Here in this Fig.8 all image show the different membership image. For detecting the optic disc we take the class 4 membership image Fig. 8(d) .



(a) (b) (c) (d)

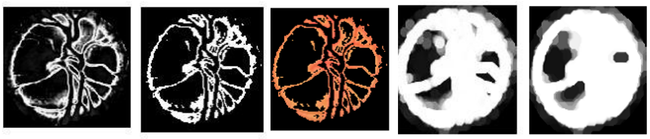
Fig. 8. (a)-(b)-(c)-(d) membership map of optic cup from class 1 to 4

Now Fig. 9(a) is converted to binary image then perform the masking operation on original image with Fig.9 (b) after operation obtained Fig.9(c). Fig. 9(d) and Fig.9(e) represent the result after dilation and closing morphological operation applied for detecting quality image of optic cup.

(a) (b) (c) (d) (e)

Fig. 9. (a) Class 4 membership of optic cup (b) binary image (c) Mask image optic cup (d) dilated image(e)close cup

For detecting the optic cup we take the class3 membership as Fig.8(c).Fig.10 (a) shows the input image for extracting the optic disc. Fig.10 (b) shows the image convert into binary and further apply making operation with original image result show as Fig.10(c) after that morphological operation again applied as dilation and closing for detecting proper region of optic disc.



(a) (b) (c) (d) (e)

Fig. 10. (a) class 3 membership image (b) binary image (c) result of after apply mask to original image(d) dilated image (e) closing image

In the paper through proposed technique we can obtain the quality image of optic disc and cup. To detecting the accurate size of optic cup and disc is very important. For identification of glaucoma measure the area of cup and disc and find the cup to disc ratio. Here we get the CDR value 0,626358. So this value represent the eye is affected with glaucoma because value is greater than 0.5.To find the accuracy we first of all require four accuracy parameters: True negative (TN): This variable holds the outcomes of the state which do not identity the glaucoma when the glaucoma is absent. False positive (FP): This variable holds the outcomes of the condition which identify the glaucoma when the glaucoma is absent. False negative (FN): This variable holds the result of the condition which does not identify the glaucoma when the glaucoma is present. Performance is evaluated on following parameters.Sensitivity: It measures the capacity of a method to identify the glaucoma when the circumstance of glaucoma is present

Sensitivity=TP/ (TP+FN)

Specificity: It measures the capacity of a method to appropriately eliminate the condition when the condition of glaucoma is absent.

Specificity=TN/ (TN+FP)

Predictive value positive: It is the proportion of positives that resemble to the presence of the condition.

Predictive value positive= TP/(TP+FP)

Predictive value negative: It is the proportion of negatives that correspond to the absence of the condition

Predictive value negative=TN/ (TN+FN)

Accuracy: It represents the proportion of true positive results in the selected population.

Accuracy= (TP+TN)/ (TP+FN+TN+FP)

Here Table1 shows the value of True positive, True negative, False positive and False Negative on DRIONS, DRIVE and STARE dataset.

TABLE1. Show the performance parameter of databases.

Performance parameter	**Efficiency(percentage)**		
	DRIONS	**DRIVE**	**STARE**
True positive	95.90	90.58	90.18
True negative	65.85	68.58	70.18
False positive	10.59	8.56	7.13
False negative	3.63	4.85	3.21

The proposed methodology shows the performance in terms of sensitivity,specivity,predictive value positive and negative and accuracy on different dataset DRIONS, DRIVE and STARE as in Table2. As we observe in Teble3 compared with other related work, proposed technique gives the good result that tested on publically dataset DRION,DRIVE and STARE.

TABLE2. Shows the comparative accuracy of three database (i) DRIONS (ii) DRIVE and (iii) STARE

Accuracy parameter	Efficiency(percentage)		
	DRIONS	**DRIVE**	**STARE**
Sensitivity	80.23	80.56	79.53
Specificity	86.14	88.93	90.77
Predictive value positive	90.05	91.36	92.67
Predictive value negative	94.77	93.14	95.65
Accuracy	91.91	90.49	90.17

Table 3
Comparison with previous techniques

Method	Pre-processing Techniques	Classifier	Success Rate
PCA [19]	Top down and Bottom Up processing	Bayes	75-80%
Ellipse fitting Method [18]	Noise Removal,ROI extraction	Depends on Value of CDR	86%
CDR ISNT Rule [20]	ROI extraction	Fuzzy C Mean	90%
CDR Computation Proposed Methodology	ROI extraction Morphological operation	Fast Fuzzy C-Mean Technique	DRIONS 91.91 DRIVE 90.49 STARE 90.17

V.CONCLUSION

In thispaper, a systematic way of detection of glaucoma has been evolved. It is evaluated that to identify the cup to disc ratio it is essential to find out the area of disc and cup. However detection of the area is quite complex task because there are several blood vessels which are changing the area of cup and disc. So the initial task was to remove the blood vessels so that the boundary of cup and disc can be detected for that we apply pre-processing on the fundus images. Then, instead of applying the algorithm on the whole image we find out the region of interest and implement the method on that candidate region. Therefore the running time of the method significantly drops. The fundus images which are publically available such as DRIONS, DRIVE and STARE are evaluated using the above mentioned technique. The accuracy of the algorithm is 91.91%on DRIONS, 90.49% on DRIVE and 90.17% on STARE database. The suggested method is simple and straight forward to implement. However the only limitation of this method is the boundary of cup and disc can be found more precociously so that the accuracy of the ratio can be improved.The proposed method can further be improved by finding the area of cup and discmore accurately for enhancement of the accuracy. We can also use the region of interest and the area of cup and disc in future researches.

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