IJCAT International Journal of Computing and Technology, Volume 1, Issue 7, August 2014
ISSN : 2348 - 6090
www.IJCAT.org

Diabetic Retinopathy Analysis using Retinal Image Matching

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Abstract - In development of automated screening systems for diabetic retinopathy, main step is Optic disc detection and vascular feature extraction. Here, we propose a method for diagnosis of Diabetic Retinopathy using optic disc and vascular features based retinal image matching. This method can be used for Person identification using retinal images or automatic detection of Diabetic Retinopathy. Optic disc and vascular features are the two important features extracted from the retinal image. On the basis of these features, corresponding images are matched. Image matching method identifies the same blood vessel in the corresponding images and compare the desired features. Initial results are good and demonstrate that the proposed method is suitable for Diagnosis of Diabetic Retinopathy.

***Keywords* - Diabetic Retinopathy, Retinal Image, Optic Disc, Vessel Bifurcation, Branch and Crossover Points, Retinal Image Matching.**

1. Introduction

Diabetic retinopathy (DR) is the commonest cause of blindness in people of working age. The global prevalence of diabetes is expected to rise to 4.4% of the global population by 2030 [12]. An effective treatment to prevent vision loss is available, but diabetic retinopathy is asymptomatic until late in the disease process. The screening of diabetic patients for the development of diabetic retinopathy can reduce the risk of blindness by 50%. Due to a large number of patients, ophthalmologists will not sufficient to cope with all patients, specially in rural areas or when the workload of local ophthalmologists is more. The damage caused by DR can be prevented if it is treated in early stages. Therefore, early detection through regular screening is of paramount importance. Therefore, automated early detection could limit the severity of the disease [3].

Latest developments in retinal image processing enable to use fundus images for earlier diagnosis of diseases. It can also be used in image matching in biometric security application and for information retrieval purposes[5].For each individual person retinal vascular pattern is unique. Hence, a suitable approach that can accuratey analyseretinal images for both purpose i.e. disease diagnosis and image matching.

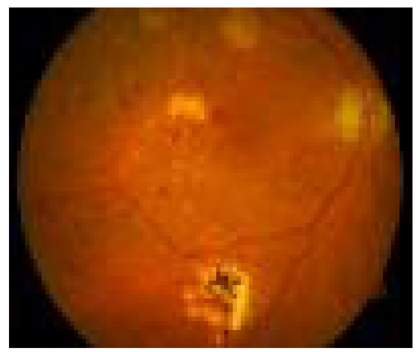
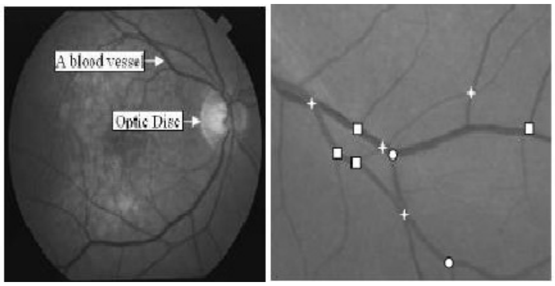


Fig.1 DR Fundus Image

For disease analysis and medical earlier diagnosis purpose , the best approach is to take patient’s retinal image within a time interval and compare those images with database images to avail or observe the changes in the vascular features in retinal image[1].As we studied previous studies, we found that many researchers has recorded that the effect of Diabetic retinopathy treatment .For these studies we considered mainly the manual or semiautomatic methods for image analysis.

These methods are very time consuming and expensive.Vascular bifurcation split the vessel into two vessels.A branch is formation of a new vessel where a minori.e. smaller width vessel grows or comes out from a major i.e. wider vessel. A crossover is a region where two vessels that means both major or minor cross each other [1].All the features like Optic disk detection, bifurcation, branch and crossover points geometry should provide higher degree in generating unique pattern for an individual person [8]. In this paper optic disc, retinal vascular bifurcation and branch points are considered as the same parameter for image matching application.



a) b)
Fig. 2 A retinal image showing the blood vessels (a) and a cropped section showing vascular Bifurcation (circle), Branch (square) and Crossover (star) points(b).

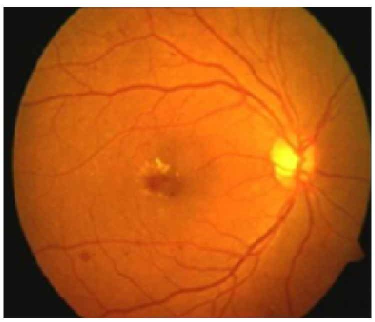


Fig. 3 Optic disc location in the retinal Image.

2. Proposed Method

In this paper, we mainly focus on optic disc detection, retinal bifurcation, branch and crossover points to construct the feature vector. The vascular features along with the vessel-segments hierarchical position provide a unique pattern for each of the blood vessels in the retina for each person. So, first time when patient will come for retina screening then its image will register in database and next time whenever screening will done for same person then we can match earlier image from database and current image. Fig. 4 shows the design flow of Image registration and Fig. Shows the design flow of Diabetic Retinopathy disease detection using retinal image matching.

2.1. Image Capture

The first stage in fundus digital image analysis is image capture. Fundal images capture is normally acquired by a fundal camera that has a back-mounted digital camera. The fundal digital camera operates in the same manner as a conventional camera. This digital cameras uses an image sensor.

2.2. RGB Splitting

Image-processing operations transform only the grey values of the pixels so that separate the 8 bit Green channel from 24 bit color image because green channel offers the highest intensity contrast between the vessels and the background. Green channel separated by using following steps :
1. Traverse through entire input Image.
2. Extract 8-bit R, G and B values from 24-bit Color Value.
b = pix & 0xff;
g = (pix >> 8) & 0xff;
r = (pix >> 16) & 0xff;
The Green channel separated in this step is used for further steps. Interested Region is selected from retinalimage and transfer to next step Median Filtering.

2.3. Thresholding

Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images i.e. image with only black or white colors. In this project Otsu's thresholding method is used. In image processing, Otsu's method is used to automatically perform clustering-based image thresholding or the reduction of a gray level image to a binary image. The algorithm assumes that the image to be threshold contains two classes of pixels or bi-modal histogram then calculates the optimum threshold separating those two classes so that their combined spread is minimal.

Otsu's Thresholding Algorithm Steps:

1. Compute histogram and probabilities of each intensity level.
2. Set up initial $\omega_i(0)$ and $\mu_i(0)$.3. Step through all possible thresholds t=1…maximum intensity
   a. Update ω_i and μ_i
   b. Compute $\sigma_{2b}(t)$.
3. Desired threshold corresponds to the maximum $\sigma_{2b}(t)$.
4. We can compute two maxima and two corresponding thresholds. $\sigma_{2b}(t)$ is the greater max and $\sigma_{2b}(t)$ is the greater or equal maximum.
5. Desired threshold = (threshold1 + threshold2)/2.

2.4. Optic Disc Detection

The optic disk appears as a bright yellowish or white region in color fundus images. The shape of optic disc is more or less circular, interrupted by outgoing vessels, although sometimes due to the nature of the photographic projection it has the form of an ellipse. By applying a threshold we can separate part of the optic disc and also the some other unconnected bright regions from the background. For this purpose an optimal thresholding technique based on Otsu method is used to separate brighter regions from dark background. To get an optimal thresholding, histogram derived from the source image I will scanned from highest intensity value l2 to lowest intensity value. This scanning pixels with the same intensity. The following figure shows the design flow of Image registration.

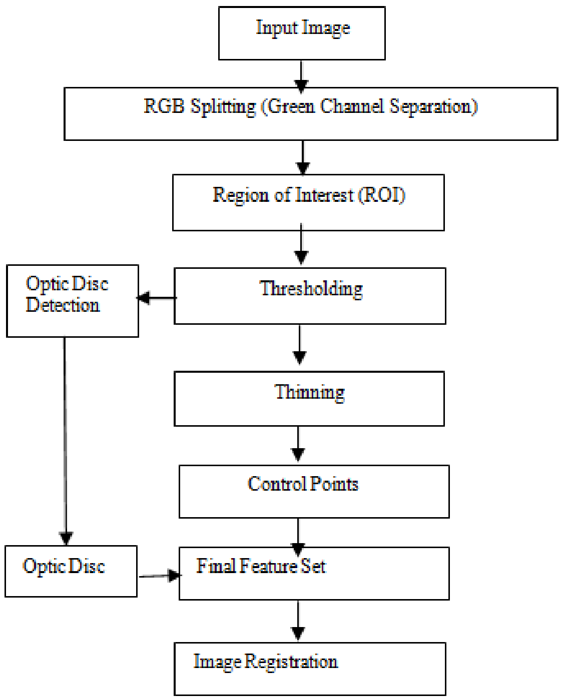


Fig. 4 Design flow of Image Registration

The initial threshold T_k for stops at the intensity level l_1.It consist of at least a thousand step k=1 is taken as the mean of t_2 and t_1 which results in subset of histograms. A step for the calculation of optimal threshold is given by the following part.

1. Initial estimation of T_k is calculated at step k as above

$$T_k = \frac{l_1+l_2}{2}$$

2. At step k, apply the threshold. This will produce two groups of pixels: G_o consisting of all pixels belonging to object region and G_b consisting of all pixels belonging to background region.
3.Compute the average intensity values and for the pixels in G_o and G_b respectively.
4. Update the threshold.
5. Repeat steps 2 through 4 difference in T in successive iterations are smaller than a predefined value.

Thus Optimal threshold calculated results in maximization of gray level variance between object and background of image. In this way, we get brighter region of optic disc.

2.5. Blob Detection

Blob detection implies visual modules that are targeted at detecting regions in the image which are usually contrasting in properties like brightness or color as related to the surrounding. We use it as it provides vital information about regions, which can't be obtained from edge detectors or corner detectors [2]. Basic algorithms steps are

a) Filter with Gaussian at different scales.
b) Subtract image filtered at one scale with image filtered at previous scale.
c) Look for local extrema.

A pixel is bigger i.e. Smaller than all eight neighbors, and all nine neighboring pixels at neighboring scales. The following figure shows design flow of early stage Disease Detection Other than optic disc.

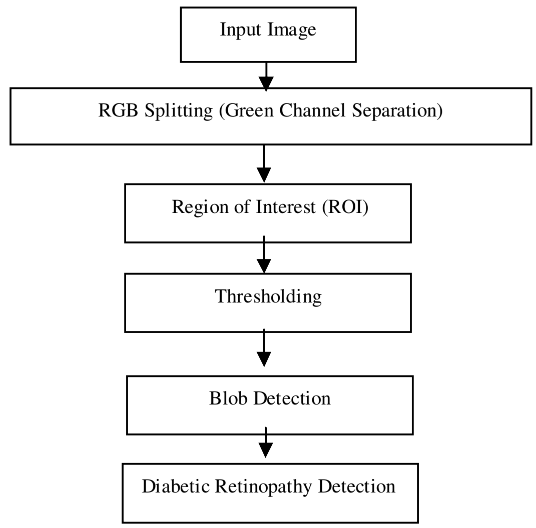


Fig. 5 Design flow of Early Stage Disease Detection

If there is any white region found in retinal image then blob is detected. In this way by using blob detection we can detect diabetic retinopathy in early stages of the disease.

2.6. Vascular Features Extraction

For image matching, we consider the vascular invariant features i.e., the features invariant to rotation, translation or scaling. The features are: vessel-segment's bifurcation or branch point, information on crossover existence in a vessel segment, crossover location in the vessel-segment and acute angle between the parent and smaller daughter vessel-segments. These invariant features provide a unique pattern for any individual's retina.

In this paper, first we apply thinning operation on retinal images. Thinning is amorphological operation which is used to remove selected foreground pixels from binary images, somewhat like erosion or opening. It can be used for several applications, but it is particularly useful for skeletonization. In this mode, it is commonly used to tidy up the output of edge detectors by reducing all lines to single pixel thickness. Thinning is normally only applied to binary images, and produces another binary

IJCAT International Journal of Computing and Technology, Volume 1, Issue 7, August 2014
ISSN : 2348 - 6090
www.IJCAT.org

image as output. Stentiford thinning algorithm is used in this paper [11]. After applying stentiford thinning algorithm, we can easily extract vascular features by considering vessel centerline image, edge image and fragmented centerline image. So that the vascular bifurcation and branch points are the control points which are connected to blood vessel use for image matching. By using control points and optic disc we can match the retinal images.

2.7. Retinal Image Matching

Retinal Image matching can be done using Template matching.Template matching is a technique in digital image processing which find small parts of an image which match a template image [9].The following figure shows the design flow of diagnosis of diabetic Retinopathy using retinal image matching.

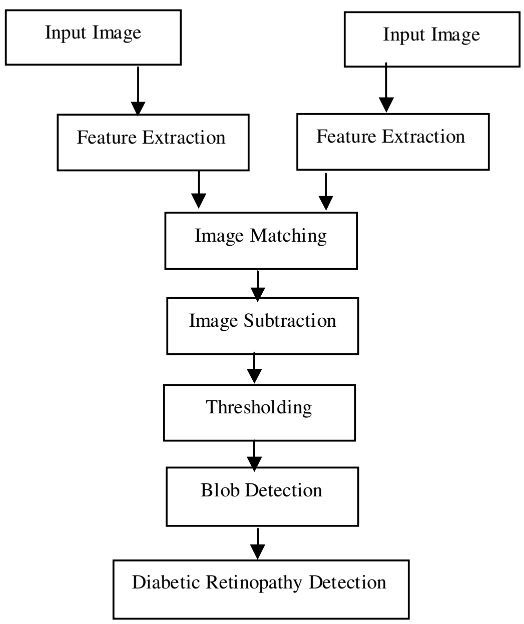


Fig. 6Design flow of DR disease detection using retinal image matching.

In template matching , the registerd image and new retinal image of same person can be matched using optic disc, vascular bifurcation and crosspoints.

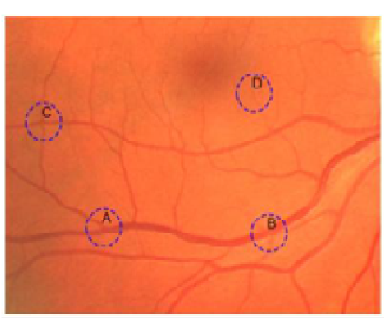


Fig.7 Retinal Vascular Structure

After template matching, these two images are subtracted and by appling thresholding if template is not matched and we get blob then we can say that the retinal image is affected by Diabetic Retinopathy.

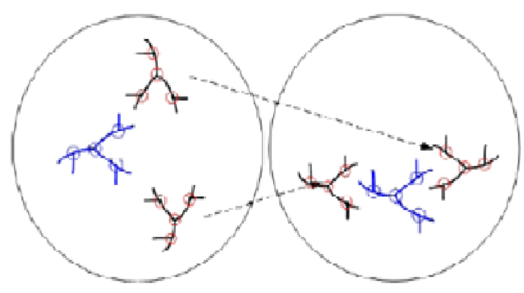


Fig. 8Structure matching based on bifurcation structures and Crossover points.

3. Results

Retinal image of Normal Person :
As we take the retinal image of a normal person , we can see no defects in it.There is no chnages in vascular features. The following figure 9 shows retinal image of normal person .

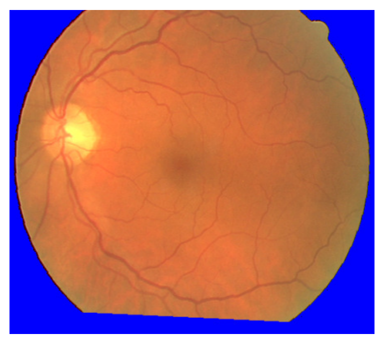


Fig. 9 Normal retinal Image

Retinal image affected by diabetic Retinopathy :
The following fig. 10 shows retinal image of DR patient, which clearly shows defects and distrubances in it. The causes may be different but commonest cause is DR.

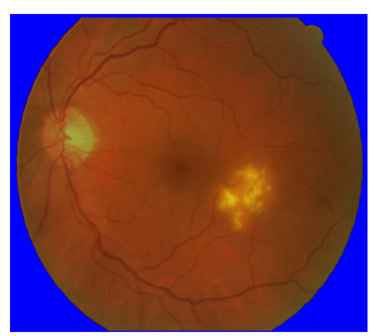


Fig. 10 DR retinal Image

Result of Channel Extraction :

As we apply RGB splitting to retinal image of DR patient , we get the above image which is green color channel image, which can be used for analysis because green channel offers the highest intensity contrast between the vessels and the background.

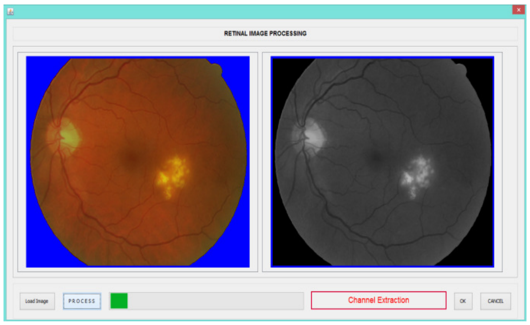


Fig. 11Green channel extraction

Result of Thresholding :
After green color channel separation when we apply histogram equailization and then thresholding then we get following results which is shown in figure 10.Here Ostu's thresholding metod is used.

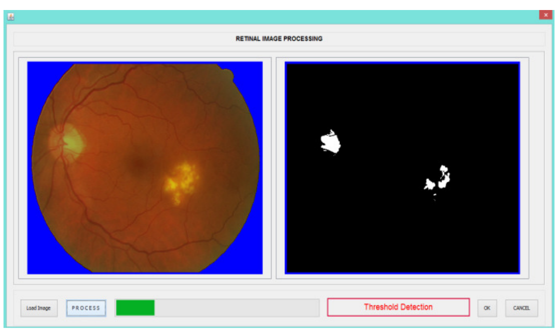


Fig. 12 Result of Thresholding

After applying a threshold we get separate part of the optic disc and also the some other unconnected bright regions from the background. Here ,optimal thresholding technique based on Otsu method .The following figure 13. shows the optic disc detection from retinal image.

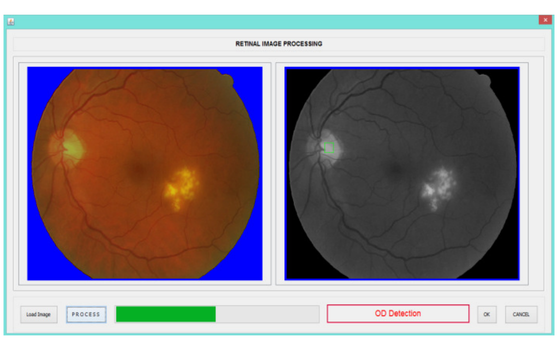


Fig. 13 Optic disc detection

If optic disc is detected alongwith another white region in same retinal image, then we can say that blob is detected..The following figure 14 shows early detection of diabetic retinopathy.

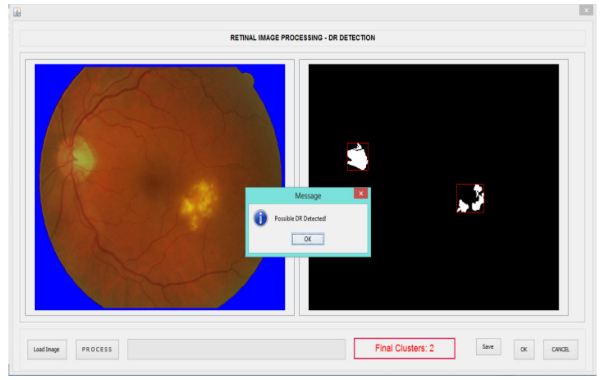


Fig. 14 Optic disc detection alongwith Blob detection

If blob is present then we can say that it is DR affected Image. Blob indicates early detection of DR.After optic disc detection, if there is no blob found in image then we need to extract another important feature is vascular feature from retinal image.For this purpose we applied stentiford thinning algorithm.The following figure 15Shows the control points like crossover points or branches,crossover locations etc. and figure 16 shows optic disc and control points are the strong control points.

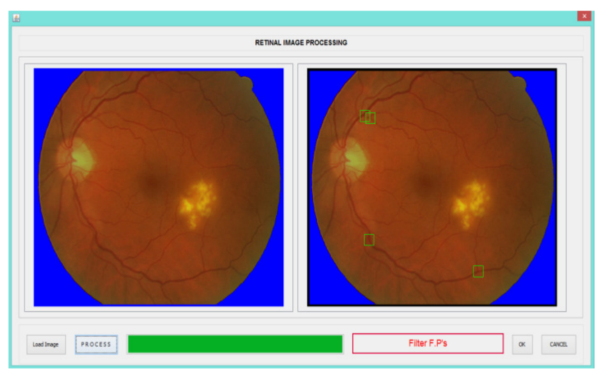


Fig. 15 Control Points

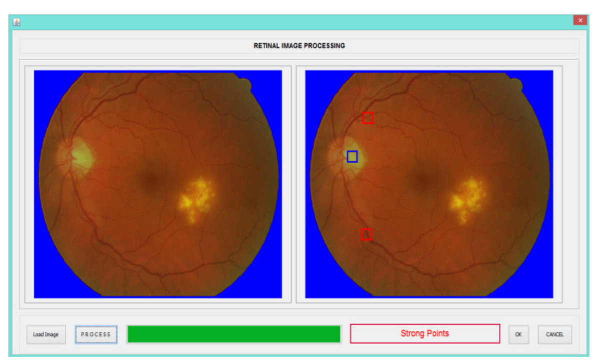


Fig. 16 Final Control Points

IJCAT International Journal of Computing and Technology, Volume 1, Issue 7, August 2014
ISSN : 2348 - 6090
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After feature extraction we can register this retinal image in database and when patient will come for next retinal screening then new retinal image is processed and then new processed image and registered image can be match with the help of feature points and analyses the changes in new retinal image which leads the Diabetic Retinopathy. The retinal image matching with the help of Feature points is shown in following results.

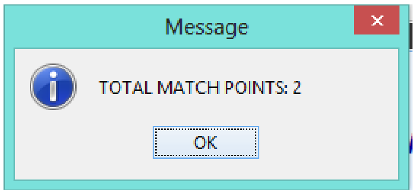

Fig. 17 Message display for matchingpoints

Image Subtraction:

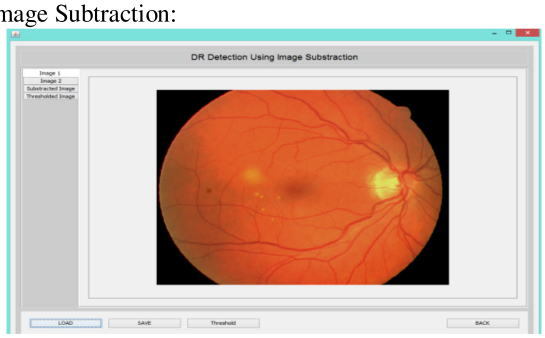

Fig. 18Registered Retinal image as input image1

Fig. 19Retinal new image as input image2

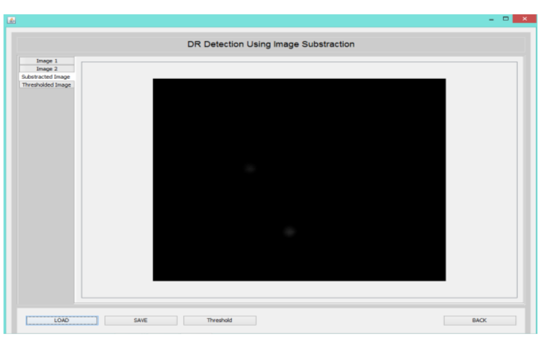

Fig. 20 Result of subtraction of Image1 and Image2

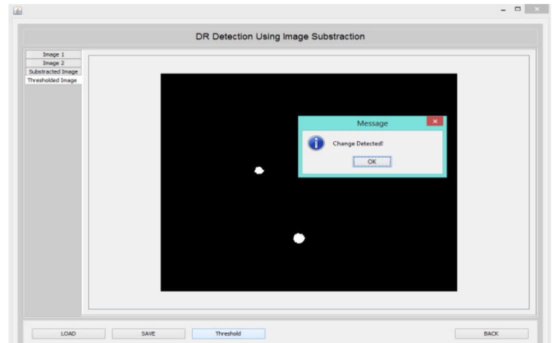

Fig. 21 Result of thresholding after subtraction

4. Conclusion

This paper presents feature based retinal image matching. The method is highly suitable for diabetic retinopathy analysis. It is efficient in matching the retinal images and searching the corresponding vascular features set. Applying the method, the medical practitioners can examine significantly changes on different vascular features for each of the vessel-segments in retinal fundus images. For biometric security application, this method requires simple modification. We are in process of gathering multiple images forthe same person to have a large scale analysis and next validation of the method.

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