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Automatic Detection of Adenoviral Disease from Eyes Images Using HOG Technique

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ABSTRACT

Adenoviral conjunctivitis (Ad-CS) is one of the most common eye infections called "pink eye". Sclera based recognition is identification of a person using the features of sclera region of the eye. The vein pattern that appears in the sclera region is different to each person. Sclera region segmentation is shown to be of significant importance for eye and iris biometrics. The existing Grab Cut segmentation method used for sclera recognition have some drawbacks like only frontal looking images are preferred for matching and rotation variance is another problem. These problems are completely eliminated in the proposed system by using two feature extraction techniques. They are Histogram of Oriented Gradients and converting the image into polar form using the bilinear interpolation technique. These two features help the proposed system to become illumination invariant and rotation invariant. For the estimation purpose in the sclera area Otsu's thresholding method is applied. Otsu's method is a Linear Discriminant Analysis-based thresholding method. The proposed sclera recognition method can achieve better accuracy than the previous methods.

Keywords: Sclera, Segmentation, Interpolation technique and Illumination.

1. INTRODUCTION

Adenoviral conjunctivitis (Ad-CS), also known as "pink eye", is one of the most common eye infections worldwide. Ad-CS is highly contagious causing discomfort, tearing, lid swelling, photophobia, and decreased vision in the patient. Ad-CS is more contagious than other forms of conjunctivitis partly due to the virus's ability to remain infectious in the desiccated state for weeks at room temperature. The virus is transmitted directly through droplets or smears of infected bodily fluids, primarily tears or respiratory secretions, and by fomites on towels, doorknobs, soap, counters, instruments, eye drops, and eyeglasses. Patients with acute conjunctivitis are estimated to comprise as much as 2% of a general practitioners practice. Research for effective treatment of Ad-CS has been seriously hampered by the lack of clear diagnostic indicators to differentiate Ad-CS from other causes of conjunctivitis.

Since Ad-CS is highly contagious, its quarantine is crucial in ophthalmology Clinique's as well as doctor's offices that is automated and non-invasive. Hence, in this research we aim to develop an automated system that is based on facial image processing which analysis eye sclera and extracts features of critical attributes to be used in the diagnosis of the disease. Using such a system, a camera that is installed outside the doctors office may scan patients for potential risk of carrying Ad-CS. Such technology incorporates recognition of face, selection of eyes and extraction of eye sclera in a pipeline fashion, which is a typical scenario in the Internet of Things era.

Sclera is the white area which is opaque and acts as a protective covering of the human eye. The sclera completely surrounds the eye. The vein patterns seen in the sclera region are different for each person in visible wavelengths which makes the sclera to use as a biometric tool for human identification. The thickness of sclera changes with the increase in the age of a person. The features extracted from the vein pattern are used for identifying red eye. The sclera consists of four layers of tissue–the episclera, stroma, lamina fusca, and endothelium. In general, it is difficult to see a conjunctiva tissue with the naked eye. An image of an eye under visible wavelength illumination with identification of the sclera vein patterns. . The color of blood vessel in sclera area is blue for children and red for adults. The vein patterns in the sclera could be used for positive human identification. The identification of users using the sclera region has been referred to as conjuctival vasculature recognition. As the conjunctiva is the top-most transparent layer of the sclera and images of the sclera region capture more than just this top-most layer, it is more accurate to refer to the system as performing sclera recognition.

2. RELATED WORK

Face recognition and eye selection is one of the most studied areas of computer science. In existing system, Haar Feature-based Cascade Classifiers and are used to detect faces in a rectangle frame and extract eyes (Region of Interest - ROI) within the detected face.

Adaptive Neuro Fuzzy Inference System (ANFIS), this system takes disease detection through eye scanning setup a relatively expensive and complex computer vision system that requires fixed conditions to classify eye disease. They only used RGB values for the classification of eye disease.

After a pattern stabilization method which can be used in laser eye surgery. Their method was based on extracting features from sclera blood vessels and applying the image processing techniques to track the pattern on patient's eye. This approach used GrabCut segmentation algorithm to extract the sclera.

During the GrabCut segmentation process, we used rectangular mask in order to remove eyelid borders.

Face recognition and eye selection is one of the most studied areas of computer science. Currently, OpenCV is one of the most popular open source computer vision library in the field which includes many pre-trained classifiers for face and eyes detection. OpenCV's as the purpose of this research was to analyze sclera for Ad-CS, we used OpenCV's robust face recognition libraries in the proposed pipeline.

Disease detection through eye scanning Laddi et al. setup a relatively expensive and complex computer vision system that requires fixed conditions to classify eye disease.

For sclera detection, Zhou et al. proposed a comprehensive sclera image quality measure which can quickly detect if the image has a valid eye, assess the image quality, evaluate the segmentation accuracy, and measure if the image has sufficient feature information for recognition. In order to improve the efficiency of sclera recognition, they used multiple directional Gabor filters for sclera vein pattern enhancement, after image pre-processing. To measure Image Quality, they provided Blink Image Detection, Blurred Image Detection.

Kaya et al. presented a pattern stabilization method which can be used in laser eye surgery in [15]. Their method was based on extracting features from scleral blood vessels and applying the image processing techniques to track the pattern on patient's eye. To obtain mask to represent the ablation pat-tern, they combined Hough transform and RANSAC (Random Sample Consensus) methods. During feature extraction, they applied SIFT algorithm on the whole image and select interest points in ROI to reduce number of key points and eliminate the edge effects.

3. CONTRIBUTION OF PROPOSED WORK

This project aim to develop an automated system that is based on eye image processing which analysis eye sclera and extracts features of critical attributes to be used in the diagnosis of the disease. The proposed system using two feature extraction techniques. They are Histogram of Oriented Gradients and converting the image into polar form using the bilinear interpolation technique.

For the estimation purpose in the sclera area Otsu's thresholding method is applied. Our sclera detection approach uses either color or grayscale images. The stairs of the sclera area detection are: selection of the area of interest (ROI), Otsu's thresholding, sclera area detection.

Two types of feature extraction are used in the proposed method to achieve good accuracy for the identification. HOG is used to determine the gradient orientation and edge orientations of vein pattern in the sclera region of an eye image. To become more computationally efficient, the data of the image are converted to the polar form. By using the proposed feature extraction methods and matching techniques the human identification is more accurate. The advantages are:

- The proposed method to achieve good accuracy for the identification.
- HOG is used to determine the gradient orientation and edge orientations.
- Efficient computational detection method.
- Feature extraction and matching techniques is more accurate.

4. SYSTEMIMPLEMENTATION

This project implementation work follows four steps are:

A. Sclera segmentation
   - Glare Area Detection
   - Sclera area estimation
   - Iris and eyelid refinement

B. Vein Pattern Enhancement
C. Feature extraction
D. Feature Matching

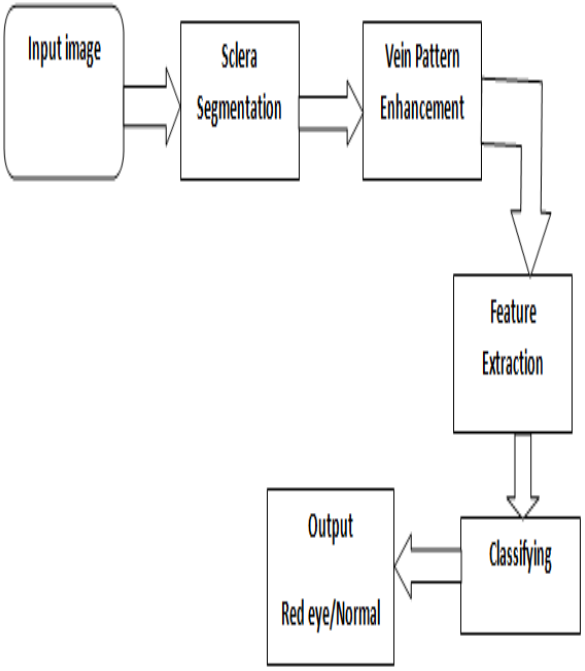


Fig 1. Overall system block diagram

A. SCLERA SEGMENTATION

Sclera segmentation is the first step in the sclera recognition. It lets in three steps: glare area detection, sclera area estimation and iris and eyelid detection and refinement.
Glare area means a small bright area near pupil or iris. This is the unwanted portion on the eye image. Sobel filter is applied for detection of glare area present in the iris or pupil. Simply it runs only for the grayscale image. If the image is color, then it needs a conversion to grayscale image and after that apply it to the Sobel filter to detect the glare area.

Sclera area estimation:

For the estimation of sclera area Otsu's thresholding method is applied. The stairs of the sclera area detection are: selection of the area of interest (ROI), Otsu's thresholding, sclera area detection. Sclera area is selected based on the iris boundaries.

When the region of interest is selected, then apply Otsu's thresholding for obtaining the potential sclera areas. The correct left sclera area should be placed in the right and center positions and correct right sclera area should be placed in the left and center. In this way non sclera areas are wiped out.

Iris and eyelid refinement:

The top and underside of the sclera regions are the limits of the sclera area. And then that upper eyelid, lower eyelid and iris boundaries are refined. These altogether are the unwanted portion for recognition. In order to eliminate these effects refinement is done in the footstep of the detection of sclera area. Fig. 5 shows after the Otsu's thresholding process and iris and eyelid refinement to detect right sclera area. In the same way the left sclera area is detected using this method.

In the segmentation process all images are not perfectly segmented. The feature extraction and matching are needed to reduce the segmentation fault. The vein patterns in the sclera area are not visible in the segmentation process. Vein pattern enhancement is to be performed to get vein patterns more visible.

B. VEIN PATTERN ENHANCEMENT

The segmented sclera area is highly reflective so vessel structure seen in the sclera region is difficult to see. In order to reduce these illumination effects and establish it as an illumination invariant system, it is important to raise the vein pattern. Gabor filters are used to the enhance vein pattern in the sclera. Referable to the multiple orientations in the vein pattern, a bank of Gabor filter is used for vein pattern enhancement. The image of the detecting sclera region is filtered with the Gabor filters with different orientations.

Vein pattern have different thickness at different times, this is because of dilation and constriction of vessels. In order to avoid this effect morphological operations are used. Morphological operations can thin the detected vessel structure and remove the branch points.

C. FEATURE EXTRACTION

Feature extraction is mainly applied in pattern identification in image processing to reduce the dimension of an image. When an image is directly utilized for processing, it is very hard to treat the large input data of an image. And then that input data are transformed to its reduced form of features which is experienced as the feature vector and is known as feature extraction. In the proposed scheme, two characteristics are taken out from the vein pattern of the sclera region. They are Histogram of Oriented Gradients (HOG) and converting rectangular image into its polar form using bilinear interpolation.

D. FEATURE MATCHING

Feature matching is an important and final step in the recognition process. In the proposed method the two types of features are used to get the desired result, to see whether the result says that is correctly identified pink eye or not. This can be done with the help of features extracted from the vein patterns seen in the sclera region.

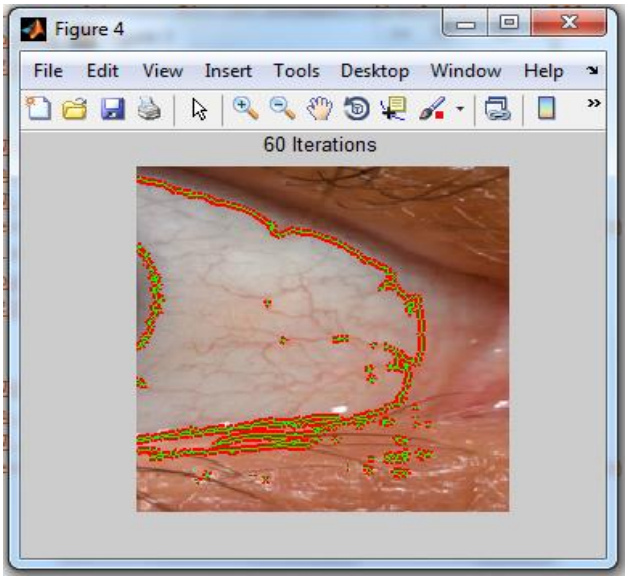
5. EXPERIMENTAL RESULT

In this study, we used 18 healthy and 12 Ad-Cs eye images for the training set. For the feature set, we calculated Redness, Vascularization and GLCM (Only Contrast, Standard Deviation and Angular Second Moment values are used for GLCM).

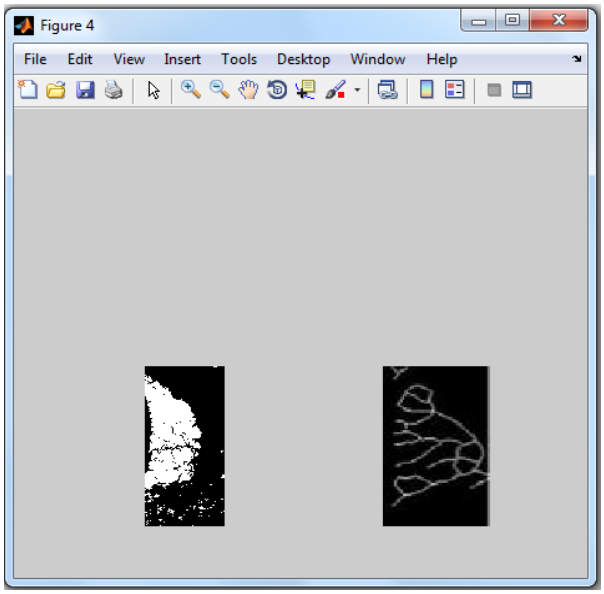
Healthy and Ad-Cs eye images in the training set. Clearly, the measured redness and vascularization values are significantly higher for the Ad-Cs than the healthy eyes. However, standard deviation for GLCM was lower for Ad-Cs than the Healthy ones to our surprise. We noticed that GLCM values vary significantly among the training set for both the Ad-Cs and Healthy ones. Using Bayes and Random Tree methods of ML with 6-fold cross-validation, we could only achieve up to 86% prediction accuracy. Next, we excluded GLCM feature from the training set and using Stochastic Gradient Descent (SGD) method with 6-fold cross-validation, 29 samples are correctly and 1 sample is incorrectly classified with a accuracy 96.7% accuracy.

Output of Normal Image

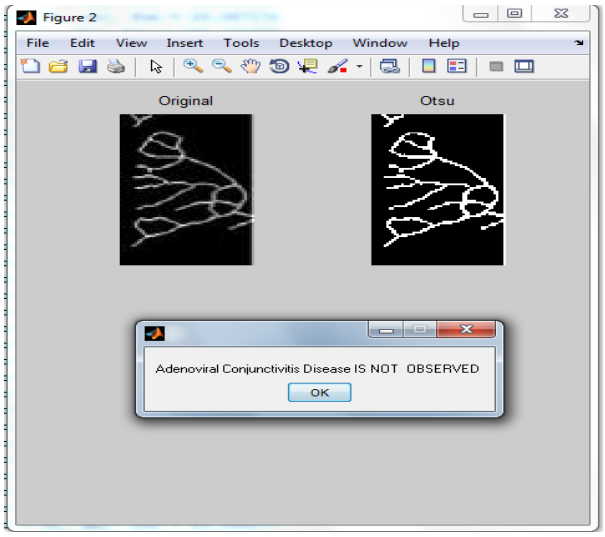
Sclera Region Segmentation



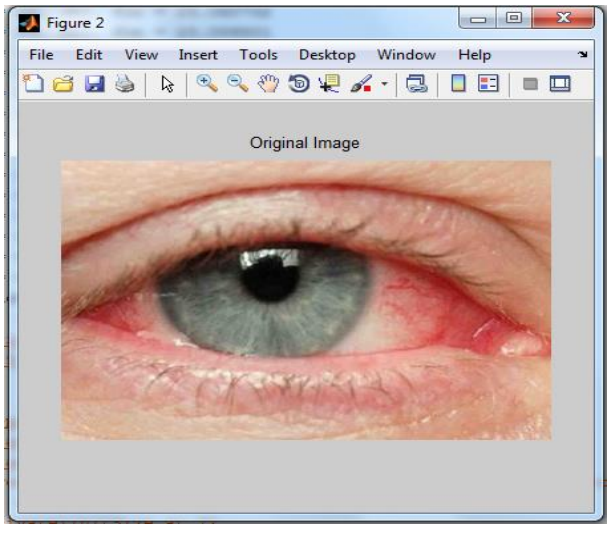
Vein Enhancement



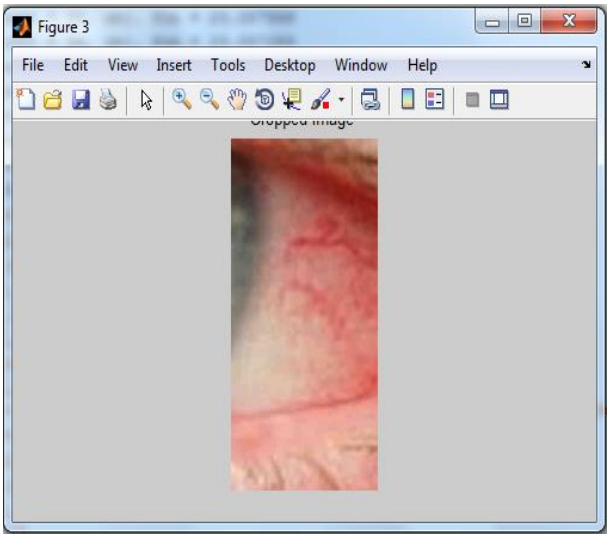
Classification



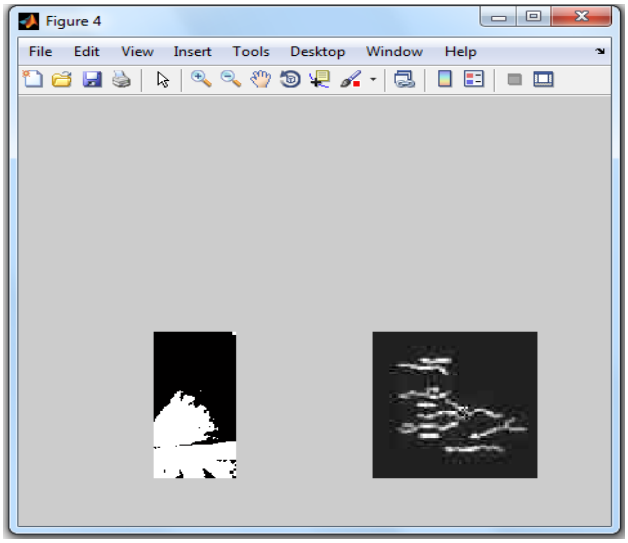
Red Eye Image



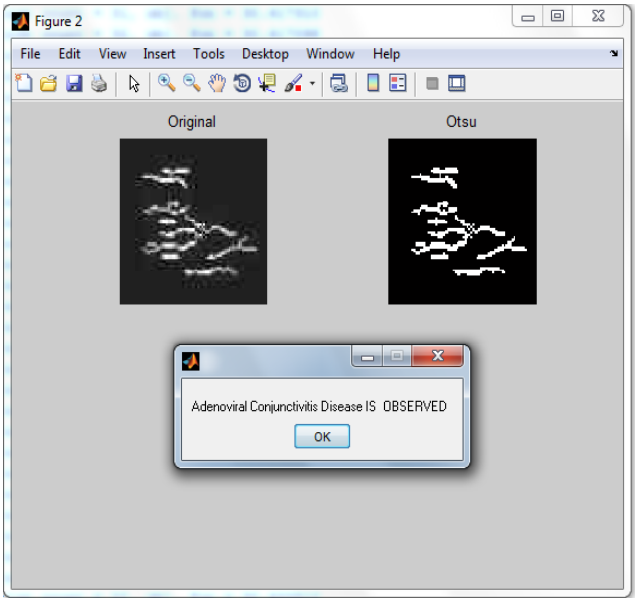
Sclera Region Segmentation



Vein Enhancement



Classification



The performance of sclera recognition is evaluated in the feature matching process. Test results are obtained for sclera recognition, which it is more accurate than the other methods of biometric identification of people. In this case false accept rate and false match are minimized. For this the proposed system provides more precise designation. These experimental results help to confirm that the sclera vein patterns are unique to each individual and recognition is more possible with this method. Firstly, the images in the database are trained, that means extract the features of all images present in the database. And so, the query image is tested for matching. From this step whether the person is correctly matched or not can be recognized. The proposed method yields a more beneficial outcome that it can identify people in off angle position. The Histogram of Oriented Gradients (HOG) can work out these troubles. The illumination normalization is performed with the help of these features. Train the images in the database. The beginning measure of training involves preprocessing. Only in this case the preprocessing step is totally wiped out by the HOG process. It normalizes the illumination effect in its process itself.

6. CONCLUSION

In this work, completely automated based on their sclera Vein patterns. The proposed method outlooks the perfect identification when a diminished region of sclera vein pattern is visible. The existing system focused only on the frontal looking sclera recognition; where off angle iris image segmentation and recognition are challenging topic. With these vein patterns recognition is possible. This proves the system is rotation invariant. The images acquired in the recognition process are from the UBIRIS database. These types of images are captured in visible light. This will increase the usable range of biometric systems in surveillance and non-compliant situations. The normalization of images is possible in the extraction of features using Histogram of Oriented Gradients (HOG). Thus, preprocessing step is totally rejected in this scheme and the system becomes illumination invariant. The experimental result shows that the suggested scheme can improve the accuracy of recognition and make the sclera recognition a viable choice for non-compliant recognition applications.

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