Iris Identification Based On Appearance Based Approaches – A Survey

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ABSTRACT

Iris identification (IR) is one of the biometrics techniques used for biometric authentication based on the physiological characteristics of a human being. This survey paper aims to cover the historical developments and current gradual progress in the iris tracking research spot. This broad survey is carried out in terms of most widely used traditional image based methods and IR based methods of face detection, iris tracking, occlusion detection, red eye effect correction and driver fatigue detection with their success rate and performance analysis.

INTRODUCTION

Iris biometrics evaluates the distinctive features of the human iris to identify or authenticate the identity of individuals. Iris recognition is a highly accurate computer vision technology, which is considered to be a research hotspot. Iris detection has paramount importance in surveillance, citizen identification, ATM, E-commerce, retail, telephony, criminal identification, PC/network access, time and attendance and so on. Although it has diverse application prospects, still few challenges exist. The users must be cognitive of the way in which they interact with the system, such as precise head and eyes positioning, retaining correct distance and timing. Also precise iris identification is limited by the poor illumination conditions or noise, such as obstruction of eyelashes, eye-lids, reflection and blurring. Gradual progress of developing non-invasive iris tracking systems is being currently recorded.

Number of researchers proved acceptable success ratio on precise iris detection using various techniques and devices. The restricted background, changing illuminations and moving head angles limit the scope of its applicability. Eye detection principle is framed on the basis of the following characteristics of the eyes: Brightness and contrast between the eye sclera and iris/pupil is high, specific compact elliptical size, placed in the upper half of the face.

Fig. 1: Image 02463d1276 from the Iris Challenge Evaluation Dataset Bowyer et al. (2008).
Eye detection can be classified into the following categories: Traditional Image based methods, Iris Recognition based passive methods, Neural network based methods and others. The traditional image based methods can be further classified into appearance based, template based and feature based approaches. Major classifications of eye detection under are: Hough Transform, Kalman Filters, Markov Chain Monte Carlo Method, Support Vector Machine (SVM), Affine Transform, Canny Edge detector and Gradient Algorithm. The rest of the paper is organized as follows: Section 2 discusses the different methodologies adopted by the researchers in the past. Section 3 narrates the results along with their appropriate explanation. Section 4 concludes the paper.

**Appearance Based Approach:**

2.1 **Hough Transform:**

Mark Nixon. (1985) estimated the geometric eye spacing measurement between iris centres using Hough transform to locate analytically derived eye shapes. DEC PDF LSI 11/23 image processing system with SAIDIE image processing software was used to implement this technique. But, only limited data set was tested in this appearance based research.

An algorithm for real time detection in face images was developed in D’Orazio. (2004) using Directional Hough circular transform for detecting the eye. Tracking of another eye was performed by the same algorithm but on different direction. Real time detection was possible on persons with different eye colors, with or without glasses, changing background and partially-opened eyes. Detection of blinked eyes and rotated heads were not dealt with in this algorithm.

The eye and face detection model implemented by R.Belaroussi et al. (2005) using the fusion of multiple detectors. Face detection using the combination of three models namely, Diabolo-Auto Associateive Multi-Layer Perceptron, Hough transform and skin color model. Eye search area was detected using the product fusion of two methods, The Chinese Transform – provides VOTE, a feature map information of the eye and a Modified GMM skin color model – detects the fine center of eye using k-means algorithm. Byung Jun Kang et al. (2007) developed a robust eyelash detection based on Iris focus assessment. Eyelids, both upper and lower, located using eyelid detection mask and parabolic eyelid detection method. Local derivative mask extracted the eyelids candidate region. Convolution Kernel used for reducing eye lash detection errors. Iris boundaries were detected using circular edge detection algorithm. This method was not affected by image blurring due to focused eyelash detection. Focus valuation method was well suited for iris images and detection and removal of eyelashes enhanced the accuracy of iris detection. 0.96% detection error rate (FER and FNER) recorded for eyelashes. Here accurate iris assessment could not be dealt with included eyelashes. For iris detection, more than 0.86% of EER(Equal Error Rate) after eyelash detection and the method was compared with the EER without eyelash detection. CASIA iris database with 756 iris images from 108 eyes of 80 persons were used. SMU iris database with 198 iris images was also used. A study on eyelid localization considering image focus for iris recognition was undertaken. Eyelid detection mask with focus value detects eyelids in blurred images. Parabolic Hough Transform with rotation values provided exact eyelid localization in rotated eye images obtaining 91.33% detection rate for upper eyelid and 98.45% detection rate for lower eyelid registered. Young Kyoon Jang et al. (2008) used two circular edge detection methods to detect boundaries of pupil and iris. 2D Gabor Filter and Hamming distance for iris pattern sign generation and for pattern matching. Robust eyelid detection algorithm was presented for precise iris identification. Eyelid detection is possible even in rotated eye and defocussed eye images.

An eyelid and eyelash detection method in the normalized iris image was investigated by Tae-Hong Min et al. (2009). This research used Parabolic Hough transform model and Otsu’s thresholding method. Parabolic-Hough Transform method was used for detecting the eyelids and eye lashes. Eyelash region features extracted by using intensity and normalized SD. Automatic Otsu’s thresholding method separated the eye lash region. Circular Hough transform was used for segmentation. Performance evaluation was done with decidability, EER, DET (Detection Error Trade-off) curve shown better performance than other methods. Threshold value was not much affected by the acquisition condition of the image. Limited search area, low number of Hough parameters used. 3.348% EER (Equal Error rate) measured, which was less than other compared methods.

The fatigue features based on eye tracking for driver inattention system was proposed by Karel Horek (2011). Hough Transform and simple YCbCrColor model Segmentation were established for the eye tracking. Sobel Mask and Canny Edge Detector were used to detect the edges of the given image. Haar like features and Symmetric features were taken into considerations for feature detection. Only 10% false rate was recorded for face detection. Real time images were taken from Prosilica GC color camera with 1280*960 resolution.

Farmanullah Jan et al. (2012) did research on Iris localization in frontal eye images for less constrained iris recognition systems. Circular Hough transform (CHT) and image gray level statistics (IGS) were combined to develop two-fold strategy. Thus this method was well suited for noisy eye images by the use of two fold strategy. Detection was not affected by the changing illuminations, eyes with glasses, contact lens, hair, eyelashes, eyelids and off-axis eye images. Specular unsuppressed reflections from the input image reduced the
proposed method’s efficiency. Lower contrast level between pupil and iris affected the accuracy. Thick strip of eyelashes affected the detection rate. 100% accuracy was recorded for CASIA v1.0 database and 93.50% accuracy for UBRIRIS v1.0 database recorded. 100% accuracy was recorded for MMU v1.0 database. The MMU-Iris database with 450 images from 45 subjects was used. The CASIA iris database with 2630 images from 249 subjects and UBRIRIS iris database were also included.

2.2 Kalman Filters:

Two cascading Kalman filters were used by X.Xie et al. (1998) to track the eye movements with compensating the head movement effects. Normally iris movement is faster than the head movement. So, compensation of head movement for each frame was formulated. Eye blinks were also detected using error covariance. Here, sequential compensation produced high estimation errors. This research system was built up with ordinary PC with an image grabber and eye window model.

A research was carried out for the eye detection and tracking in image with complex background. Gaussian Mixture model and YCbCr color models were created for face detection. Harris method roughly located the eye pupil in the initial frame. Color entropy removed the non-candidate eye regions. Kalman Filter was used to propose the eye region and to track the eye movement. Images with glasses also had shown good results. Mohammed Reza et al. (2011) recorded 5.1% mean rate for both eyes wrongly detected. Final result much depended on the accuracy at each successive step in the algorithm with 91.2% mean rate for both eyes correct detection and 3.7% mean rate for single eye correct detection. Overall correct detection rate of 94.9% was recorded. Image set under complex background was retrieved from the Banka database.

Mohammed Ali Azimi Kashani et al. (2011) recorded eye detection and tracking method using bag of pixels. Bag of pixels concept separated the eye and eyebrow region from the face region effectively. Eye region extraction was done by horizontal projection of face. Gaussian mixture model and YCbCr color models were developed for face detection. Color entropy removed the non-candidate eye regions. Eye tracking was done by Kalman Filter. Computational complexity and bread aspects were much reduced. Final result much depended on the accuracy got at each successive steps in the algorithm. Correct detection rate of 94.9% was achieved. Input image set under complex background from the Banka database was used. For fatigue detection RGB color space was converted into HSL model. Horizontal projection of S-channel was filtered by the Kalman filter for eye-state determination (fatigue or not). Feasible, real time, automatic glass removal and fatigue detection system was thus developed. Eye glass removal resulted in precise eye detection. Reduced false detection was recorded after the eye glass removal. The algorithm produces 94% correct eye detection after glass removal and 86% correct detection when driver was wearing glass. Wen-Chang Cheng (2013). achieved 100% fatigue detection and alarm generation rate on fatigue state. Over 686 real time video frames with 493 eye-opened and 193 eye-closed images were used.

2.3 Markov Chain Monte Carlo Method:

Research for automatic eye glass removal was achieved by Chenyu Wu (2002), in comparatively less time. Localization of glasses was done by Markov chain Monte Carlo method. Recognition of glasses was carried out by principle component analysis and error based reconstruction classifier producing 94.2% accuracy in glass removal. Removal of glasses was done by learning based synthesisation approach. Removal on video sequences and blunness on glass removal are the main demerits. Single input image was given each time for this experiment.

A.M. Bagci et al developed eye tracking method using Markov Models. This research went through the following process. Markov Model developed for modelling the eye movement. Baum-Welch method trained the Markov model. Connected component analysis was performed for skin color detection on binary mask of face. 2-level Lloyd-Max quantization algorithm did the differentiation of skin and eyebrow regions. Bounding box calculation was performed for iris detection. Occlusion and speed head movement made wrong detection. Efficiency of computation was not satisfactory. 99.2% correct feature detection. 98.5% iris location detection, 100% classification on full frontal faces, 95% for images with glasses, was recorded. 13000 frames of size 720*480 pixels video clips of varied five subjects were undertaken for experiment.

Multimodal face detection, head orientation and eye gaze tracking model was targeted by Frank Wallhoffet et al (2006). Multi modal method was presented for face tracking, head and eye gaze estimation. Two cameras, one used visual wavelengths for face detection and another used infra-red rays for eye recording. Example based NN binary classifier for face detection and gaze detection. Maximum accuracy achieved from this Multi modal algorithm. But mouth detection could not be achieved precisely. Example-based model was more flexible and not suitable for mouth detection. Only 36% mouth detection was recorded. 72% eye detection rate was achieved. Gaze detection rate was 88% for nearer eye, 77% for very far eyes. 90% gaze detection for closed eyes. Experiment used FERET database images.
2.4 Support Vector Machine (SVM):

A research was carried out for the on-line head detection using Stereo vision system and Head-shoulder model. Face location was detected by structured based approach. Support vector machine (SVM) classified the face area at fast rate. But several faces could not be detected. False match errors were also produced due to the misclassification of eye and-brows and misclassification of eye-pairs. 92% accurate face detection was achieved. Weimin Haung et al. [2005] recorded 100% LR rate and 0% FDR for single image on video. This study considered 364 images of two databases.

Hyungkeun Jee et al (2004) conducted a research for real time, fast eye and face detection using SVM, based on inner product of Kernel methods such as Polynomial Kernel, Gaussian Kernel and Tangent Hyperbolic Kernel. Eye verification was taken by normalization and SVM. Here false positives were reduced at high rates. Comparatively better performance than other methods was proved. But there are some difficulties on training the SVM with non-face images. 92.5% eye detection was recorded and 99.2% face detection was achieved.

Support Vector Machine classifier (SVM) determined the eye candidate region. Directional circle Hough transform located the center of the eye. Log operator detected the face edges. Least Squares Fitting did ellipse fitting. Simple, fast, automatic eye localization was done for the face identification. This method is not affected by hair, gestures, eye-brows and background. It could be used in real time applications for face detection. 90% face detection on ORL database and 95% face detection on IMM database was achieved on ORL database and IMM database images. Wang Xueguang et al. (2009) utilized 500 eye images and 500 non-eye images with size of 45*70 for this experiment.

Vijayalashmi et al. (2012) developed an eye detection using Gabor filter and SVM. Lab transform extracts the face region from the input image. HSV with morphological operations extracted the eye region. Gabor Filter was used for kernel functions, followed for texture segmentation. Eye candidate regions were verified using SVM. Morphological operations removed the artifacts from the image. Better detection was shown at various rotated angles. Minimum numbers of false positives were detected. Only 89% detection rate was recorded for 90 degree rotated faces, 98% detection rate was achieved for non-rotated faces, 94% detection rate for 30 degree rotated faces, 93% detection rate for 60 degree rotated faces.

2.5 Finite State Automata Model:

A fully automatic driver visual attention tracking system was implemented by Paul Smith et al (2003) using three Finite State Automata Model. Drowsiness, eye-blinking, occlusion, closure of eyes and mouth, 3D eye gaze and eye rotation in all directions were well classified for both moving and stationary vehicle drivers. But face occlusion by hands was not correctly tracked. Eye closure was interpreted as eye rotation in some cases. 78% to 100% eye closure detection for 28 frames was recorded and 89% to 100% accurate eye tracking for the same 28 frame sequences. 30 frames per second images from video camera considered for these test cases.

2.6 Affine Transform:

Ben Yip (2005) developed face and eye rectification model using Affine transform. Affine transform matrix was used to rectify the face in video conferencing. Image warping using a novel eye model rectified gazed eyes. Color tracking algorithm determined the head top and exact location of eye positions. Affine transform calculated the difference between front view and top view of face. Real time face and gazed eye rectification using software approach with a single camera. Precise head area calculation could not be recorded. The algorithm is not much perfect, in terms of performance. Live video conference video was given as input.

2.7 Canny Edge detector:

S.Asteriadis et al. (2006) efficiently used Canny edge detector for eye region edge selection from the face region, PCA to get eigen vectors for vector magnitude map and vector slope map. Binarization of eye image was done by using Otsu’s thresholding method. Eye detection in low resolution images possible using geometric edge information. 100% eye detection and eye center localization was possible on closed eye images on BioID database. The method produced 99.1% eye region selection, 98.8% eye center detection in BioID database, 98.5% eye region selection and 98% eye center detection in XM2VTS database. Inputs were taken from BioID database - 1521 frontal images and XM2VTS database - 600 images.

A research was conducted to develop the reduced complexity eye detector for color images using Harris corner, color heuristics and edge maps. Harris corner detector was used for finding skin patches. Unsupervised method was followed for skin detection in color images. Normalized RGB (NRGB) Color Space Model was used for skin color selection. Canny edge detector or Sobel edge detector was used for edge edge detection. Morphological applications of Close Filter made smooth edged, noise free gray map. Real time, fast, robust eye detection was achieved using combination of heuristics such as color, edge, corner features of eyes. Lihui Chen et al. (2006) showed that lower complex and less computational cost was needed to implement this unsupervised method. Noises were reduced and close regions are merged in the gray map itself. 100% detection rate in AR
database was recorded. 89.5% detection rate in Champion database was recorded. 117 images were used from AR database, 100 images from Champion database.

An eye detector based on cues and heuristics with a good accuracy and complexity trade-off by Christos Grecoset al. (2008) Normalized RGB (NRGB) color space model was developed for skin region selection. Harris corner detector was developed for finding skin corner patches. Gaussian filter was used for smooth edged map. Canny edge detector or Sobel edge detector were used for detecting the eye edge. Morphological close filter was included for merging close regions, removing noise and edge smoothing. False positive were highly reduced due to merging of Harris corners. 100% detection rate in AR database and 91.5% detection rate in Champion database were achieved. AR database with 117 images and 100 images of Champion database were utilized.

2.8 Gradient Algorithm:

Tsunyoshi Moriyama et al. (2006) studied meticulously detailed eye region model and its application to analysis of facial images. Cylindrical 3D head model based head tracker was used to retrieve 3D head movements. Lucas-Kanade gradient descent algorithm tracked the motion of eyes. Eye feature analysis was performed, based on generative eye region model. Precise eye tracking was recorded among various eye appearances and eye motions. Both qualitative and quantitative attributes were considered for testing. 3D head motion was captured then image stabilisation, eye registration and eye motion recovery were achieved. Meticulous eye appearance differentiation was achieved, in terms of both eye structural and motion parameters. Large number of images were tested from two independent databases. Small amount of head motion, faces without glasses were only tested.

Discussions:

The outcome of related survey shows that the modern era needs the widespread adoption of biometric systems in all sectors where security and confidentiality are the key aspects. But the performance of such systems is still far away from 100% accurate state.

The existing challenges that have been still faced in the biometric identification and verification systems are: poor quality templates (both enrolment and verification) from which sufficient biometric data cannot be extracted, non-cooperation of users due to lack of cognizance or fear or physical disabilities, the debate on privacy invasion, enrolling/verifying in unconstrained environment – factors such as dim illumination, varying background, inappropriate poses, distance etc., changes on some biometric characteristics during one’s life time, very high expensive acquisition hardware/biometric-matching applications, issues on inter-accessing biometric databases among countries/territories, lack of encryption methodologies to efficiently resist imposters, limited number of vendors/very less competition in the biometric market, time constraints – large scale biometric identification/verification systems to be deployed for public beneficial programs, need long elapsed time for all phases including analysis, deployment, enrolment, verification, maintenance etc., overall, none of a biometric technique is 100% secure.

The above mentioned problems can be tackled in this promising field, on taking precise effort and work. The proper and careful designing of biometric systems can immune all aspects of spoofing. The deployment multi-biometric systems, where pitfall of one can be overcome by others by strictly: implementing secure biometric protocols, providing enough confidence and training/instructions/prompts to the users, liberating the access of biometric databases, more publicly, concentrating on getting ever constant biometric traits as samples, by addressing the social, cultural issues, installing biometric systems where security outweigh the privacy concerns, contribution of more vendors in market on developing biometric hardware / processing software and granting more fund for biometric based projects from government and private sectors.

Conclusion:

The literature survey of iris identification and related techniques was thus undertaken. A broad and depth study on iris identification in the research area, was carried out. The findings and results were simply provided in the result-table for further reference. The upcoming research will follow the concept, which was conceived from this literature survey. The careful study of the limitations and strength of biometric systems shows the urgent need of improving the efficiency rate of biometric systems. Among various unique biometric patterns, the strongest ever changing iris characteristics (trabecular-mesh) can be utilized for efficient tracking. The research can be more pointed on efficient retrieval of iris patterns in unconstrained conditions, using image processing techniques. Because, the major limitation is, acquiring clear input from acquisition device in unconstrained environment. The biometric data retrieval from low quality image is still an attention getting concern. Research can be directed towards the progress of pattern recognition from such images which have insufficient biometric data.
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