A REVIEW OF COSMETIC CONTACT LENS DETECTION IN IRIS IMAGES

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ABSTRACT

For authentication and security applications the use of iris as a biometric has been common nowadays. Acquisition of iris images is prime requirement of such large-scale applications to develop database so that identity of the people can be established. Eye specialists suggest the contact lens for correcting the eyesight. It can be used instead of the spectacles or glasses. They are however, increasingly being used for cosmetic reasons also where texture and color of iris region is superimposed with a thin textured lens. The use of a colored lens changes the appearance and texture of an eye in both the visible and the near- infrared spectrums. Detection of the presence of a contact lens is the primary step in improving the reliability of iris recognition techniques for contact lens wearers. Some soft lenses have designer patterns on them, which may be completely different from their original image. The main contribution of this paper is comparative study of different techniques used for detection of cosmetic contact lens in the Iris images.

Keywords: *Cosmetic contact lens; Lens detection; Colored lens; Image processing*

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1. INTRODUCTION

Biometrics is the metric related to human characteristics. Some features of the human body like face, hand print, foot prints, finger prints, vascular data as well as vocals can be used to measure, identify and verify the person's identity. Iris is one of the most important biometrics which is unique to every person. Iris pattern is different for all human beings. This uniqueness, stability and non-intrusiveness make it most accurate biometric. The iris is well protected from the environment and stable over time as it is an internal organ of the eye[1]. According to recent research, iris features can be affected by several covariates like pupil dilation [3] and sensor interoperability [4-7]. Iris recognition system can be forged and it can also be used for illegal means [8]. The iris recognition system can be spoofed through the use of artifacts like paper printed iris pattern, cosmetic contact lens, redisplayed videos, fake glass/plastic eye, printed contact lens, etc [2]. Among all these techniques, printed contact lens is more prominent [9-11]. When the person enrolls into an iris image capturing system, without taking off the contact lens, any other person wearing the similar contact lens can be recognized as authorized user which is the false recognition. Several researchers reported [12-13] that, "it is actually possible to spoof some iris recognition systems with well-made contact lens" [9]. Hence for proper authentication, it is important to detect the contact lens present in iris image before recognition. With advances in technology and reduction in cost, the number of users of contact lens is becoming large. The worldwide contact lens market in 2011 was about 6.8 billion [14]. Technavio's market research analysts predict the global soft contact lens market to grow steadily at a CAGR of around 8% by 2021. One of the primary issues for this market is the rapidly rising number of eye disorders**.** The majority of the eye disorders are refractive error**,** cataract, and glaucoma which lead to visual impairment or blindness. This rate of eye disorders is exponentially increasing among the population. It will facilitate the growth of global soft contact lens market [15].Generally, a prescribed contact lens should not interfere with the accuracy of the iris recognition, but colored contact lens used for cosmetic purposes certainly changes the natural iris pattern. All prescribed as well as cosmetic contact lenses degrade the iris biometric performance. Gas-permeable contact lenses degrade performance by 20-50 folds. The degradation in performance for different categories of contact lenses is consistent across multiple iris-matching algorithms [16]. Several researchers have shown that a colored textured contact lens can block the actual iris patterns and confuse an iris recognition system [17-19]. Similarities within the class and are significantly affected by colored textured contact lenses. Similarly, a lens with a painted iris disturbs the actual eye patterns and creates a different appearance which is unseen by the iris recognition systems [20].To detect whether the user wears contact lenses, and of which type, colored or transparent is important for getting the best possible performance [21].

Fig.1 Eye images with cosmetic lenses of different color and texture

Soft contact lens detection is an important and challenging problem to preventing spoofing as compared to cosmetic lens due to absence of any extra texture [21].

2. LITERATURE REVIEW

Baker et al. [5], has shown in experimental results that contacts lens wearers are14 times more likely to be falsely rejected by an iris recognition system at a Hamming distance threshold of 0.32 than noncontact lens wearers. The authors have classified contact lens wearers into four categories according to the type of lens and its visibility in the iris image. The results presented in this paper show that contact lenses of all types cause significant degradation in iris match quality. Also, the degree of degradation and the increase in the false reject rate varies with different types of contact lenses. The false accept rate is not affected by the contact lenses. However, as we showed with the category one contact lenses, some lenses produce no visible artifact on the iris, yet they clearly affect the texture in some way to degrade match quality. Additionally, the artifacts due to ill-fitting contacts would be difficult to detect as they are more inconsistent within a subject's images [5].

The research about iris images spoofing and effect of contact lens on iris images was initiated by Daugman[22]. In this work a process to detect cosmetic contact lenses manufactured with a "dot-matrix" type is addressed. In his method, Daugman found peaks in the Fourier power spectrum corresponding to the periodicity of the dot-matrix pattern. The detail iris pattern is encoded into a 256 byte "Iris Code" by demodulating it with 2D Gabor wavelets. Each resulting phasor angle in the complex plane is quantized to the quadrant in which it lies for each local element of the iris pattern. This operation is repeated for the entire iris image. The fact that such a "fake iris" is floating on the spherical, external surface of the cornea, rather than lying in an internal plane within the eye, lends itself to optical detection; likewise the fact that the printed iris pattern does not undergo any distortions when the pupil changes in size, like the living iris pattern. Moreover, the printing process itself creates a characteristic feature that can be detected. Consider a natural iris, and a fake one printed onto a contact lens, together with their 2D Fourier power spectra. The dot matrix printing process generates four points of spurious energy in the Fourier plane, corresponding to the directions and periodicities of coherence in the printing dot matrix, whereas a natural iris does not have these spurious coherences. The author has compared execution speeds for the critical steps in iris recognition [23].

He et al. [9] presented statistical texture analysis based method for detecting fake iris. Four distinctive features based on gray level co-occurrence matrices (GLCM) (mean and standard deviation of pixel values, contrast and the angular momentum) are used as a feature vector. A support vector machine (SVM) is used for classification. They reported the main drawback of the GLCM approach that it needs large storage space. An example of 8-bit image can be considered where the co-occurrence matrix has 65536 elements [9].

Zhaofeng He et al. [10] implemented texture based method for iris spoof detection for contact lens. Firstly, the normalized iris image is divided into sub-regions according to the properties of iris textures. Local binary patterns (LBP) are then adopted for texture representation of each sub-region. Finally, Adaboost learning is performed to select the most discriminative LBP features for spoof detection. A kernel density estimation method is proposed. It is found that LBP is efficient in texture representation and Adaboost algorithm is efficient in learning the most discriminative features for spoof detection. The division of iris into sub regions represents iris texture effectively [10].

Wei et al. [12] used three different features to detect lens in iris images. The edge sharpness detection is performed through subtraction of sum of intensity values of inner boundary of the iris from that of the outer boundary. As the second feature Iris-Textons is computed using Gabor filters along with K Means clustering algorithm. Iris classification is done using Support Vector Machine (SVM). The use of GLCM features is a novel step. Among these three approaches, the authors report that Iris-Textons and GLCM features can perform better classification [12].

Diego Gragnaniello et al. [21] proposed a new machine-learning technique for detecting the presence of contact lenses in iris images and its type. The authors extracted the regions of interest for classification, computed a feature vector based on local descriptors, and applied it to a properly trained SVM classifier. They used the dense scale-invariant image descriptor. This algorithm makes use of real segmentation algorithm which excludes eyelids, avoids normalization, and considers only information belonging to the iris and part of the sclera. Instead of LBP, scale-invariant descriptor (SID) is used. Bag of Words (BoW) paradigm is utilized [21].

Ring and Bowyer [24] analyzed the iris bit code to detect regions of local distortions which can be due to contact lenses or occlusions. The results prove that if different iris sensor is used, it can degrade the correct classification rate of a detection algorithm trained with the images from a particular sensor. The authors also considered detail analysis of how good a detector generalizes to a brand of textured contact lenses, not present in the training data. This paper shows that performance of lens detection algorithm has considerable impact of a textured lens type [24].

Zhang et al. [25] used weighted Local Binary Pattern (LBP) encoding with SIFT as feature descriptor and support vector machine (SVM) for classification of lens and non-lens iris images. In first step, Local Binary Pattern encoding sequence is obtained by calculating the SIFT descriptors at each pixel. Then, the weighted LBP maps are generated with the SIFT descriptors as weighting coefficients [26-27]. The statistical features are extracted from the LBP map and SVM is used to classify genuine and fake irises [25].

J. S. Doyle et al. [28] discussed on three aspects related to automatic detection of textured contact lenses in iris recognition images. Their results show that accurate iris segmentation is not required in order to achieve high accuracy in detection of textured contact lenses. The large-scale and long-term iris recognition applications deal with images acquired from different sensors, hence the textured lens detection algorithms should generalize well to use with images from a novel iris sensor. A third aspect is concerned with generalization of textured lens detection to a brand of lenses not used in the training phase. This issue is important as every iris recognition system has a threat of brands of textured contact lenses. The textured lens detection algorithm trained on a larger number of brands of textured lenses improves generalization. The dataset used to study these aspects has images from various manufacturers of textured lenses. This paper also addresses the cross-sensor effects considered previously by J.S.Doyle et al [28-30].

Pedro Silva et al. [31] focused on detection of iris images with textured (colored) contact lenses, soft contact lenses, and no lenses. The authors suggested use of convolutional network to build a deep image representation along with a fully-connected single layer where softmax regression is used for classification [31].

The generalization capability of many of these approaches is not sufficient because they are developed for detecting specific lens texture patterns. These are evaluated only on the same lens types. In practical applications unseen lens patterns will be experienced. J. Komulainen et al [32] carried out detail study of the effect of different iris image preprocessing techniques and introduced a new approach for more generalized cosmetic contact lens detection. They proposed the use of Binarized Statistical Image Features (BSIF).The experimental analysis on various datasets has shown that the BSIF description extracted from preprocessed Cartesian iris texture images provides better generalization capabilities for unseen texture patterns and different iris sensors. These results support the point that textural differences between genuine iris texture and fake ones are best described by preserving the regular structure of different printing signatures without transforming the iris images into polar coordinate system [32].

Ken Hughes et al. [33] presented a generalized method of detecting cosmetic contact lenses, which requires only a “snapshot” instance of imaging. The “snapshot” is a pair of images, from which the shape of the surface of the iris texture region is estimated. In the absence of contact lens or the presence of clear contact lens, the iris region has planar surface. In the presence of cosmetic contact lens, the iris region has a convex surface. Thus classifying the estimated surface shape for the iris region can provide information about presence of contact lenses. This approach is in the context of 3D shape [33].

Balender Kumar et al. [34] proposed a method to detect soft contact lens in images of the eye obtained using NIR sensor. A small annular circular area near the boundary of outer iris is considered for detecting the lens border and lens perimeter is traversed for locating candidate points. Authors have proposed soft contact lens detection algorithm which uses multiscale line tracking (MSLT). Output of MSLT gives lines of variable size and diameter based on the visibility of the contact lens border. MSLT algorithm provides a binary image with clearly visible lens border lines on the sclera portion [34].

Lovish et al. [35] created a contact lens dataset containing 12823 images acquired from 50 people. For every subject images images are collected without lens, with soft lens and with cosmetic lens class. The authors proposed cosmetic lens detection approach based on Local Phase Quantization (LPQ) and Binary Gabor Pattern (BGP). The results proved that due to blur tolerance of LPQ and robustness of BGP, cosmetic lens detection can be done accurately [35].

Niladri Puhan [36] et al. proposed solution on spoofing done through semitransparent contact lens. This method considers iris texture differences between two iris regions due to pupillary light reflex. The texture dissimilarity is calculated in the iris region. This can be superimposed by a contact lens. The lens exists from the expanded pupil to outer iris boundary. Normalized hamming distance is used to find the dissimilarity. Simulation results show that live iris textures produces larger values of Hamming distance with the decreasing values from inner to outer iris boundary [36].

3.CONCLUSION

The presence of a cosmetic contact lens is an important issue in iris recognition as it disturbs the natural iris patterns. Differentiating between without lens and transparent lens iris images is a challenging problem. There is a need for a better lens classification approach that can delineate different lens classes correctly. This paper analyzes the different techniques of contact lens detection in iris images. Increased accuracy of lens detection algorithms can improve the verification accuracy of iris recognition systems.

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