Improving Off Angle Iris Recognition Performance using Masking

INTRODUCTION:

Iris recognition using frontal eye images has been explored successfully by a lot of researchers. There are certain challenges to iris recognition such as corneal refraction, 3D iris texture, limbus occlusion, and blur, which are ignored in frontal iris recognition as their effects are minimal. However, those problems associated with iris recognition are amplified when designing biometrics based on off-angle iris images. As the gaze angle of the probe increases, the Hamming scores for intra-class comparisons are increased and the Hamming scores for inter-class comparisons are decreased, which causes an increased false-match rate. In this paper, our goal is to improve the recognition accuracy for off-angle images. We first investigated the Hamming distance scores in each quadrant of the iris pattern. Second, we masked each quadrant to determine if masking improves the accuracy. Based on our results, due to corneal reflection, masking the iris pixels in the quadrant at the 6 o’clock and 12 o’clock directions improves the performance of iris recognition in comparison to using the entire iris region for recognition.

BACKGROUND INFORMATION:

Some of the major challenges to biometric systems that use iris recognition are corneal refraction, limbus occlusion, the distortions caused due to the 3D structure of the iris, the depth of blur effect, and the occlusion due to eyelids. In frontal images, the probe image and the enrollment image are captured under similar conditions. So, all the above challenges cause similar distortions to the true iris structure. This explains the small Hamming distances obtained between objects of the same subject. The subject must stand in front of a camera until a proper iris image is captured in this case. However, standoff iris recognition systems are more flexible and do not require the subject to stand in front of the camera. As a result of such a setting, iris images are captured from different angles and these gaze angles amplify the effect of the limbus, corneal refraction, and three-dimensional iris texture.

APPROACH:

To investigate the Hamming distance scores in different iris textures, we partition the iris pattern into four regions: 3 o’clock, 6 o’clock, 9 o’clock and 12 o’clock as shown in Figure 1(a). The corresponding normalized iris image is illustrated in Figure 1(b).
Figure 1: (a) Partitions in the circular iris structure (b) Partitions when translated to the normalized iris image.

The black horizontal line indicates the start of elliptical unwrapping in the normalized image. Since the iris normalization starts at the 3 o’clock direction, the normalized image is split at the 3 o’clock region into two parts. For computing the Hamming distance, we first keep one region and mask others by including masked regions in the mask of iris images. Hamming distance (HD) scores are calculated in traditional biometric systems as follows:

$$\text{HD} = \frac{\| (c_A \otimes c_B) \cap (m_A \cap m_B) \|}{\| m_A \cap m_B \|}$$

where the logical XOR ($\otimes$) compares iris codes $c$, and logical AND ($\cap$) excludes occlusion masks $m$, from the calculation. The norm ($\| \|$) counts the number of bits.

To keep one region and mask others, we exclude other regions from Hamming distance (HD) calculation using masking approach as follows:

$$\text{HDwR} = \frac{\| (c_A \otimes c_B) \cap (m_A \cap m_B) \cap (e_A \cap e_B \cap e_C) \|}{\| m_A \cap m_B \cap e_A \cap e_B \cap e_C \|}$$

where exclusion masks, $e_A$, $e_B$, and $e_C$ can be eliminated from Hamming distance calculation as additional masks.

Investigating each region one by one highlights the region that severely affected the performance of iris recognition. Therefore, we can improve the recognition performance for
off-angle iris images by eliminating these regions from the Hamming distance calculation and using the remaining portions.

**EXPERIMENTS:**

Frontal and off-angle iris images were captured from 100 individuals from -50 degrees to 50 degrees with an increment of 10 degrees. The images were captured by near-infrared sensitive IDS-U1-3240ML-NIR cameras. Since 10 images are captured from each angle, there are 10,886 images from each eye. Off-angle images were captured by a moving camera. Ground truth segmentation was created for all images in the dataset using pupil, iris, and eyelid segmentation, where iris and pupil boundaries are segmented as ellipses and the eyelid boundary is fit using two quadratic curves. In this work, we include results for off-angle images from the left eye of each subject.

Figure 2 shows the performance analysis using ROC curves for the iris recognition comparing the performance of masking one of the quadrant regions and baseline result without masking. We observed that the performance of iris masking of the 6 o’clock region was better than the baseline result where their EER scores are 0.8021% and 1.249%, respectively. This suggests that masking the 6 o’clock region could be a good way to improve the recognition performance of off-angle iris images. Masking the 12 o’clock quadrant produced a close result to the baseline with an EER of 1.251%. We also observed that masking either 3 o’clock or 9 o’clock regions degraded the recognition performance considerably where their EER scores are 4.215% and 3.167%, respectively. This indicates that iris texture in the 3 o’clock and 9 o’clock regions is less affected by the gaze angle compared with the 6 o’clock and 12 o’clock regions.

![Figure 2: Performance analysis using ROC curves for iris recognition comparing the performance of masking one of the quadrant regions.](image-url)
CONCLUSION:

This paper investigated the performance of iris recognition for off-angle iris images through masking of sub regions in the iris. The entire iris region was split into 4 sub-regions: 3 o’clock, 6 o’clock, 9 o’clock, and 12 o’clock based on their alignment. The sub-regions 9 o’clock and 3 o’clock turned out to contain the least affected iris pixels with lower EER scores. The 12 o’clock and 6 o’clock regions were affected the most with higher EER scores. This showed that iris recognition in off-angle images performs better by masking the 6 o’clock and 12 o’clock regions. The masking of 6 o’clock region provided better EER scores than the baseline result using the entire iris region. We observed that corneal refraction creates stronger distortions than limbus occlusion for off-angle images. Therefore, masking the iris pixels in the quadrant at the 6 o’clock and 12 o’clock directions improve the performance of iris recognition instead of using the entire iris.

FOR FULL WORK, please refer to: