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Scientific Discoveries and Accomplishments

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Novel and Efficient Algorithm For Classifying Mislabeled Iris Images

Figure 1: PIER device deployed in Iraq (source: securimetrics.com)

Problem definition

Currently Iris recognition has gained significant attention in the U.S. Government due to its high stability as a biometric that does not change during a person's lifetime. Iris recognition is particularly useful in scenarios where fingerprints are hard to obtain, such as in many desert war theater operational scenarios (sand, dry weather make it hard to obtain fingerprint images). In the current war against terror, the Securimetrics PIER (Portable Iris Enrollment & Recognition) device have been deployed with the U.S. soldiers in Iraq and other locations as a means to provide the war fighter the ability to enroll captured insurgents and match them in a database.

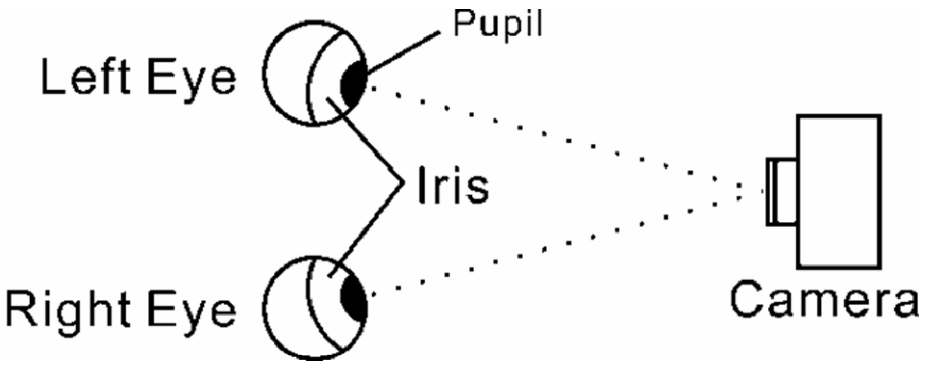
One goal of this is to be able to identify repeat insurgents and also as a means to look and see if any of these 'person's of interest' appear on U.S. soil. One of the limitations of the device deployed is the single iris capture nature, that it only captures a single iris every time. Thus the soldier must sequentially enroll each of the 2 eyes and input the name, ID # for every eye and identify which eye has been enrolled (left/right). Due to the extreme hardship circumstances under which this is performed, it is extremely easy to mis-label iris images (left noted as right and vice-versa). Thus data enrolled in large databases is mis-labelled and to provide the ability to reduce the search time by ½ (to only search left or right iris but not both) we have developed in conjunction with the Advanced Biometric Division of the National Security Agency (NSA) a very computationally efficient approach to identify left/right irises.

While we have explore eye-shape statistics and analysis, we have found a very simple feature that would literally not add any additional computation to current iris recognition systems to identify left/right irises with 99% accuracy.

When we want to make good use of the nature of plurality of iris to perform biometric recognition, the first thing we have to do is to separate the training data and test data according to person, and their left/right eye. Depending on the iris acquisition technique, the recording of the raw eye images are possible to be mixed up in some cases. If the equipment for iris acquisition is a traditional one, which requires users to lean their heads against a fixed location and then takes pictures, the probability of the error of mislabeling the left eyes into right eyes or vice versa, should be low. However, if a more user-friendly iris acquisition device is being used, for example, the "**Iris on the Move**" system, then it is highly possible to mislabel the left or the right eyes. Therefore, it would be very helpful to develop algorithm to automatic detect left eyes vs. right eyes, in order to speed up data collection process as well as discover any error of mislabeled eye images.

Relative position of the center of iris and pupil

If we consider the geometric locations of both eyes when they gaze into one object, we might find some interesting fact. Figure 2 shows an illustration of the relative position between left eye, right eye and the camera. The dotted line denotes the line of sight for each of the two eyes. The first thing we observed is, since the distance between the camera and the eyes are not infinity, the two lines of sight are not parallel to each other. Rather, they intersect with each other with an angle. The second thing we observed is, the line of sight for each eye, will definitely pass through the center of the pupil, and also the center of the iris, because the light reflected from the object must pass through pupil in order to arrive at the retina to form an image. This fact, together with the first observation, tells us there is a distinguishable feature forming something different between the left and right eye.



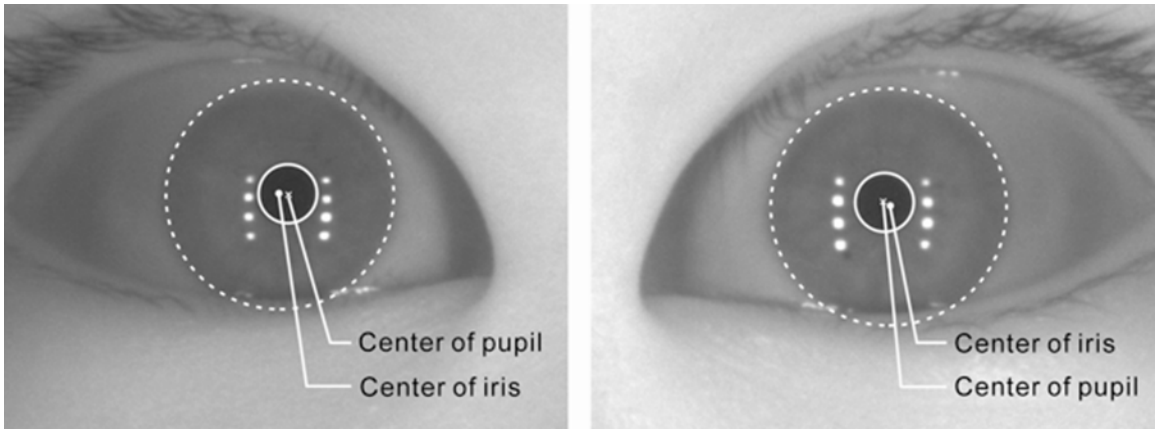


Figure 3: The relative position of center of pupil and center of iris. The left figure shows a right eye image and the right figure shows a left eye image. The figure shows example images of left and right eye when looking at the same camera.

Fig. 2. Relative position between the iris camera, left eye and right eye.

Performance Evaluation

This proposed iris classification (left vs. right) algorithm developed is evaluated on four different Iris databases: ICE 2005 database and also verified to work with IOM, PIER and LG iris systems. For each eye image in ICE 2005, iris segmentation is first performed. The iris segmentation algorithm used in this experiment is documented in. The iris segmentation algorithm works pretty well. All of the segmentation results have been manually reviewed and the ratio of incorrect segmentation is 1/2953=0.0339%.

Table 1: Classification result of the proposed algorithm on ICE 2005 database

All images	Misclassfication	Cannot Decide	Optimistic ErrorRate	Pessimistic ErrorRate	Average ErrorRate
2953	27	172	0.91%	6.74%	3.83%
LeftEyes	**Misclassfication**	**Cannot Decide**	**Optimistic ErrorRate**	**Pessimistic ErrorRate**	**Average ErrorRate**
1528	15	78	0.98%	6.09%	3.53%
RightEyes	**Misclassfication**	**Cannot Decide**	**Optimistic ErrorRate**	**Pessimistic ErrorRate**	**Average ErrorRate**
1425	12	94	0.84%	7.44%	4.14%

The results in Table 1 show that for some experimental settings, there is a great performance gap between Optimistic assumption (we can identify when the system is unsure, thus those un-decided images are not included in the test set (~approx 4%) and Pessimistic assumption (that the unsure images were wrongly classified which is extreme error case). The proposed algorithm we can identify images which the system is not able to decide either way, and based on images that it can make a decision it performs with a 99% accuracy, which is extremely high and would literally involved adding 5 lines of code to implement this on real-time systems. In future we will also explore tear-duct detectors.