

Collection and Segmentation of Non-Orthogonal Irises for Iris Recognition

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1. Introduction

Despite its high recognition rate, one of iris recognition's major disadvantages is that it requires the users be fully cooperative: their eye must be close enough to the camera and they must be still enough for a high quality iris image to be collected. In fact, current commercial systems require the iris to be orthogonal to the imaging device, looking directly into the camera for the most part, since their recognition algorithm must first detect the pupil which is assumed to be a circle. This is only the case if the eye is looking directly at the camera lens. This makes it difficult or impossible for identification to occur if the image is taken from a non-orthogonal angle. A non-orthogonal iris image is defined as an image where the iris is not looking directly into the camera [1-3].

This paper describes two areas of research at the United States Naval Academy: devising a method to collect and organize a database of high quality non-orthogonal irises, and segmenting the iris from a digital image of an eye that is not looking directly into the camera. The results of this research will aid in the development of an algorithm to use non-orthogonal images in an iris recognition system.

2. Collection of Non-Orthogonal Irises

For this portion of the research, a database of iris images taken at known off-axis angles was created by using an available near-infrared camera to obtain images. This is accomplished by having the subject face the camera and move his or her eyes to specific points which correspond to known off-axis angles while iris images are being captured; here, non-orthogonal images can be obtained from moving the eye laterally and vertically with the camera stationary.

Once the geometry is determined, a MATLAB graphical user interface (GUI) is used to acquire the raw iris data. The GUI that will be used to collect this database is based on the GUI used to collect our orthogonal iris database (see Fig. 1), which currently contains approximately 3000 images of the irises of 65 individuals. It uses the near-infrared camera from the LG IrisAccess[®] 3000 entry control system in addition to the Matrox Meteor II frame grabber and the MATLAB Image Acquisition Toolbox to collect the data. The operator of the GUI is able to specify from which eye the iris is being collected, if the subject is wearing glasses or contact lenses, as well as the direction and angle the iris looking and other pertinent information about the collection [4].

3. Segmentation of Non-Orthogonal Irises

This area of research expands the functionality of iris recognition technology by the development of a set of new algorithms to isolate the iris in a non-orthogonal state within the digital image. In these algorithms, segmentation proceeds as follows: first, the pupil is isolated using bit-plane processing [1]. Next, the limbic boundary is determined in the cardinal directions using local statistics, and an ellipse is calculated that fits those points. A circular iris is never assumed during boundary calculations [5]. After the inner and outer iris boundaries are calculated, an "iris mask" is created. The mask is used to identify pixels in the image that contain the iris data. These pixels can then be passed to subsequent algorithms that perform actual identification.

The functionality of this segmentation algorithm was

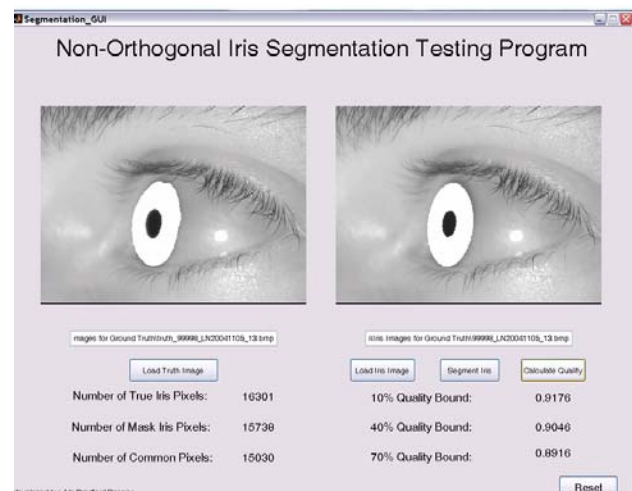


Fig. 2: Segmentation Testing GUI.

tested using the in-house database collected at the United States Naval Academy. Images that were both orthogonal and non-orthogonal in nature were used to collect quantitative results [5] and a MATLAB GUI was developed to measure the success of the segmentation algorithm (Fig. 1). This GUI takes the ground truth iris pixels (which are determined manually off-line) and compares this set to the set of iris pixels that the segmentation algorithm finds to determine the degree to which the segmentation was successful. Penalties for segmenting outside the boundaries of the true iris are assessed as part of the quality determination [5]. The segmentation quality was calculated using:

$$SegmentationQuality = \frac{\sum(TP \cap MP) - K \cdot (\sum MP - \sum(TP \cap MP))}{\sum TP}, \quad (1)$$

with the variables defined as:

TP	True Pixels	A binary image indicating the locations of the iris pixels in the “truth” mask
MP	Mask Pixels	A binary image indicating the locations of the iris pixels segmented by the algorithm
K	Penalty	The error penalty factor assessed for incorrectly identified iris pixels.

The penalty factor, K , is used to help correctly assess the performance of the segmentation algorithms. The error penalty is based on the number of pixels that differ between the “test” and the “truth” iris masks. The application of the penalty factor to the number of error pixels helps weigh the algorithm’s performance with respect to the number of extraneous pixels incorrectly determined to be “true” iris pixels.

4. Segmentation Results

The segmentation quality was calculated for both orthogonal and non-orthogonal iris images. Figure 2 shows the performance of the segmentation algorithm on 236 non-orthogonal images when assessed with a 10% error penalty. The Quality Bound is shown on the y-axis as a value between 0 and 1. Each image was assigned an image number, and the image numbers are shown on the x-axis (each image’s segmentation quality result is represented by a diamond shape). The 10% error penalty quality bounds cluster primarily above 0.8000 for the non-orthogonal images. Using 0.8000 as an assumed minimum segmentation quality for future non-orthogonal iris recognition algorithms, 66% of the images tested would be sufficient for recognition. Stated alternatively, two-thirds of the non-orthogonal iris images tested – images that are not recognized as containing iris data by commercial systems – can now be segmented as the first step for iris recognition.

5. Conclusion

With the heightened interest in security at locations such as national borders and airports, there is an ever-present need to be able to identify people who might be a threat to national security. Iris recognition, specifically covert recognition, is desirable so that potentially, people on a watchlist can be positively identified without knowing it. To be able to do this, an algorithm to identify non-orthogonal iris images may be needed. The development of a database of non-orthogonal images for use in testing, and a non-orthogonal iris segmentation algorithm is necessary to accomplish this task.

6. References

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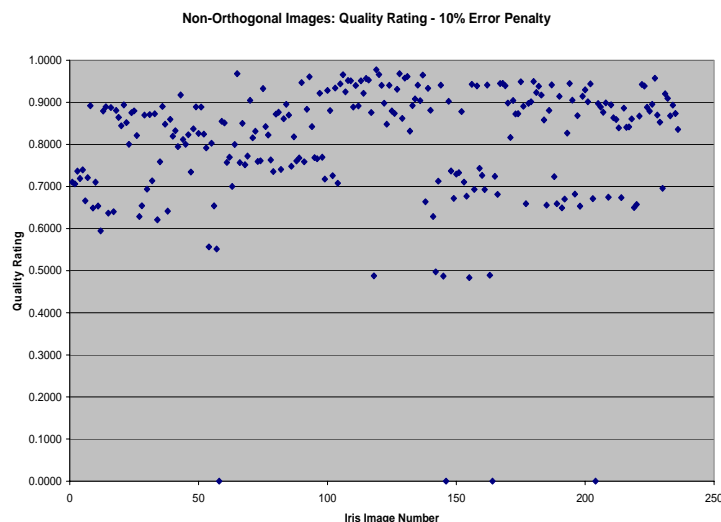


Fig. 3: Non-orthogonal segmentation quality scores (10% penalty factor).