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On the Feasibility of the Visible Wavelength, At-A- Distance and On-The-Move Iris Recognition



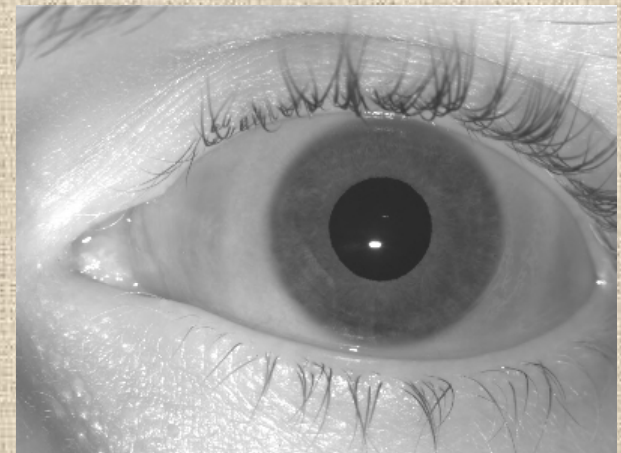
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- **Overview**

- The dramatic growth in practical applications for iris biometrics has been accompanied by relevant developments in the underlying algorithms and techniques.
- Currently deployed iris recognition systems **rely on good quality images**, captured in a stop-and-stare interface, at close distances and near infrared wavelengths (NIR, 700-900 nm).
- Active NIR lighting sources enables the utilization of imaging filters that block the wavelengths outside the desired interval.
- Captured data has **high quality** and, in these conditions, deployed systems achieve **remarkable low error rates**.





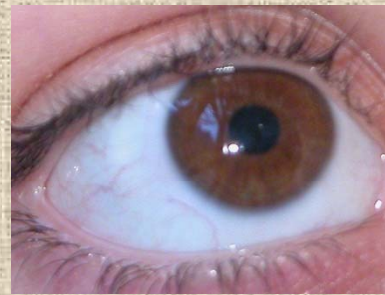
- **Iris Recognition**

- Current systems require **high illumination levels**, sufficient to maximize signal/noise ratio in sensor and to capture sufficient contrast of the iris features. However, the safety irradiance limit of illumination - defined at about $10 \text{ mw} / \text{cm}^2$ by both American and European standards counsel boards - should be taken into account.
- The **NIR wavelength is particularly hazardous** because the eye does not instinctively respond with its natural mechanisms (aversion, blinking and pupil contraction).
- If NIR wavelengths were used in the acquisition of at-a-distance iris images, acceptable depth-of-field values would demand significantly **higher f-numbers** on the optical system,
 - Squared direct correspondence with the **amount of light required** to the process.
- The **motion** factor will demand **very short exposure** times, whose again will imply higher levels of light.
- Due to the aforementioned safety reasons, the process feasibility using NIR light is strongly conditioned.



Visible Wavelength Unconstrained Iris Recognition?

- What if the iris images were captured under **natural lighting** and **unconstrained** conditions (**at-a-distance, on-the-move subjects**)? Clearly, many types of degraded images should result from these conditions.
- Is it possible to perform this type of recognition? What challenges arise from unconstrained imaging environments?
- Is it realistic to expect reliable recognition on this scenario?
- Unquestionably, these type of systems will constitute a tradeoff between the quality of the captured data and the recognition accuracy.





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- We address the feasibility of this extremely ambitious type of biometric recognition from three different perspectives:
 - **Amount of information** that is possible to capture on the described conditions. How does it varies, regarding the image acquisition distance? Do the levels of iris pigmentation strongly constraint the imaging process, as pointed on previous works?
 - **Specificity**. In order to increase the confidence of any reported match, it should be granted that these type of systems will not frequently produce false acceptances, namely when matching extremely degraded data.
 - **Sensitivity**. We estimated the probability for the occurrence of false non-matches on these type of systems. We encodes and compared signatures extracted from a set of good quality images (used as templates) and a set of degraded samples.



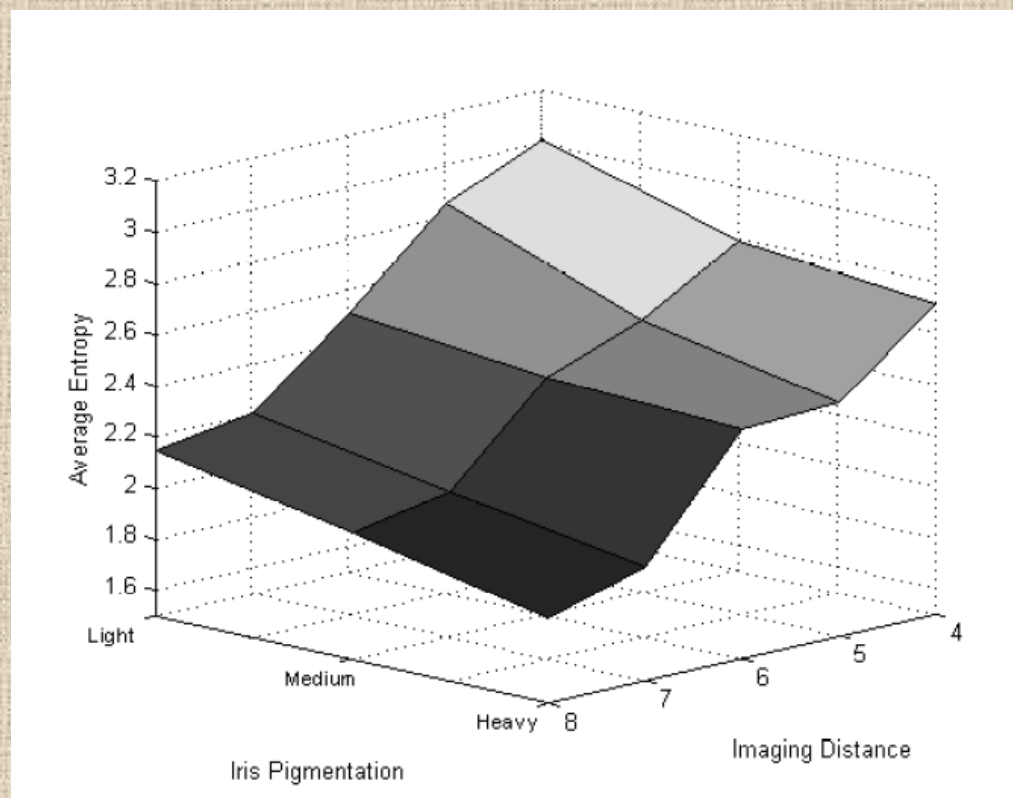
- **Amount of Captured Information:**

- We divided a set of 1 000 images into five subsets, each one including images respectively captured from distances of 4, 5, 6, 7 and 8 meters.
 - Subdivided each set according to the levels of iris pigmentation
- Most successful iris encoding methods operate locally, i.e., each signature component is extracted from a small iris region.
- Measured the amount of information locally within 7×7 windows of the normalized images. This gives an idea about the amount of information available on each region from where the signature components are extracted.
- Used the image entropy:

$$h(I) = - \sum_0^{g-1} p(k) \log_2(p(k))$$



- **Amount of Captured Information:**



- Results confirm that the levels of iris pigmentation and the imaging distance reduce the amount of information able to be captured in these conditions.
 - Equivalent measure for NIR images acquired in constrained scenarios was 3.68.

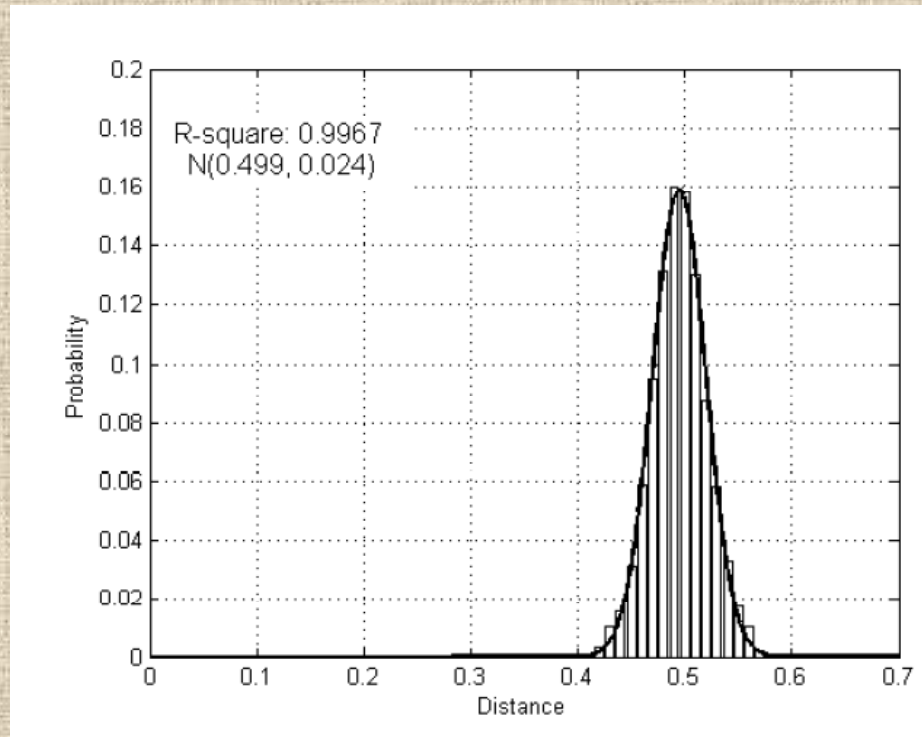


- **Specificity**

- Several works reported a very small - **almost infinitesimal** - probability of produce a **false match** in the comparison between signatures extracted from good quality data.
 - Due to the **chaotic appearance of the iris texture's** main components and to the use of the **lowest** and **middle low** frequency components.
- The goal is to assure that the comparison between templates (extracted from good quality data) and samples extracted from iris data with very poor quality or even from partial or non-iris regions will neither frequently produce false matches.
 - These would take most of the value given to any reported positive recognition.
- We built a set of sample signatures, extracted from 1 000 iris images with very poor quality, 10 000 non-iris or partial iris images and 10 000 natural and synthetic textures images.
- We performed a "1-to-all" comparison, between each sample and the set of templates, giving a total of 21 000 000 comparisons.



- **Specificity**



- Obtained results confirm that is **almost impossible** to obtain a similarity score lower than 0.3 when comparing iris templates and iris data with poorest quality or non-iris data.
 - **Main Result:** If such recognition systems report any match, it should be genuine.



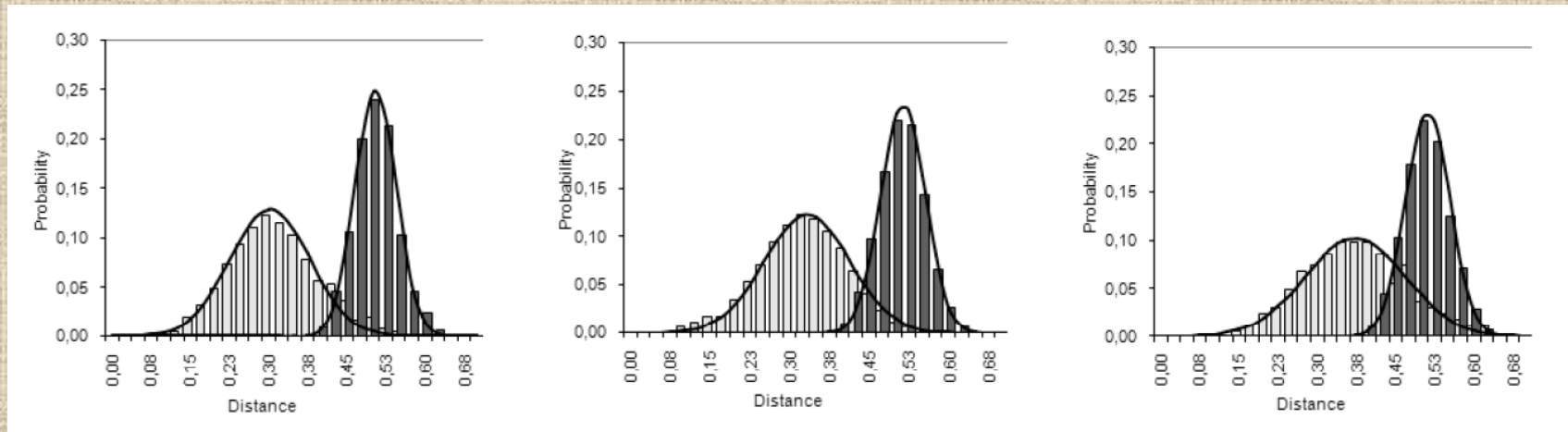
- **Sensitivity**

- It was largely reported that the **levels of iris pigmentation** are a strong obstacle to its proper VW imaging.
 - Heavy pigmented irises, that constitute the large majority of the world population, would demand strong amounts of light to be acquired with sufficient discriminating information.
- Our goal was to perceive **how much** the levels of iris pigmentation increase the recognition challenges.
- This was made through an analysis of the **separability** between the intra- and inter-class comparisons regarding the levels of iris pigmentation, which gives an approximation for the sensitivity that recognition systems achieve on the correspondent type of irises.
- The used separability measure was the **PR decidability**, through a Fisher-ratio test:

$$\tau = \frac{\mu_E - \mu_I}{\sqrt{\frac{1}{2}(\sigma_E^2 + \sigma_I^2)}}$$



- **Sensitivity**



- Results show that the separability between intra- and inter-class comparisons decreases in direct correspondence with the levels of iris pigmentation (light, medium and heavy pigmented respectively in the left, middle and right figures).
- The respective separability measures were: 2.350, 1.994 and 1.317.
- Usually, it is considered that a good PR system should have separability values higher than 3.



- **Sensitivity**

- On the other hand, it should be stressed that obtained similarity values are **far not chaotic**, and an evident discrimination between intra- and inter- class comparisons **can be observed**.
- If the standard dissimilarity value of 0.33 is used to accept a match between signatures, **81%**, **65%** and **43%** of the intra-class comparisons respectively for "light", "medium" and "heavy" pigmented irises are below that limit.
 - This gives an approximation about the **rate of recognized subjects** with the corresponding levels of iris pigmentation.
- It should be taken into account, that this type of image acquisition could be performed **covertly** and the whole recognition process be made **without any type of human effort**.