# Measurement of the information for identification in iris images

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# Overview

- Thesis objective
- Biometric sample quality evaluation
- Measuring biometric information
  - Approach by Daugman
  - Approach by Adler *et al.*
- Experimental work
- Conclusion

# Biometric Template Uniqueness

- Question to be answered: “How secure is the certain biometric system?”
- Possible approach: Measurement of amount of information contained in a person’s characteristic
- <u>Thesis objective:</u> measurement of information for identification in irises

# Biometric Sample Quality Assessment

- Lower quality results in lesser amount of identifying information
- Humans are traditionally believed to be the best quality evaluators
- How reliable is this assumption?

<u>Quality measuring experiments :</u>

- 8 participants
- 7 identification algorithms

Data sets :

- 84 iris images
- 98 face images

# Quality Assessment by Participants

# Automatic Quality Assessment

$$MS_{i,j} = Q_i Q_j$$

$0 < MS < 1$
$0 < Q < 1$

$$\log(MS_{i,j}) = \log(Q_i) + \log(Q_j)$$

Match Score Table

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 1.0 | .9 | .8 | |
| 2 | | 1.0 | .7 | |
| 3 | | | 1.0 | |
| 4 | | | | 1.0 |

$$\begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ \vdots & & & \vdots \end{bmatrix} \begin{bmatrix} \log Q_1 \\ \log Q_2 \\ \log Q_3 \\ \log Q_4 \end{bmatrix} = \begin{bmatrix} \log .9 \\ \log .8 \\ \log .7 \\ \vdots \end{bmatrix}$$

# Quality Evaluation - Results

- Are humans consistent with each other?

  **YES**

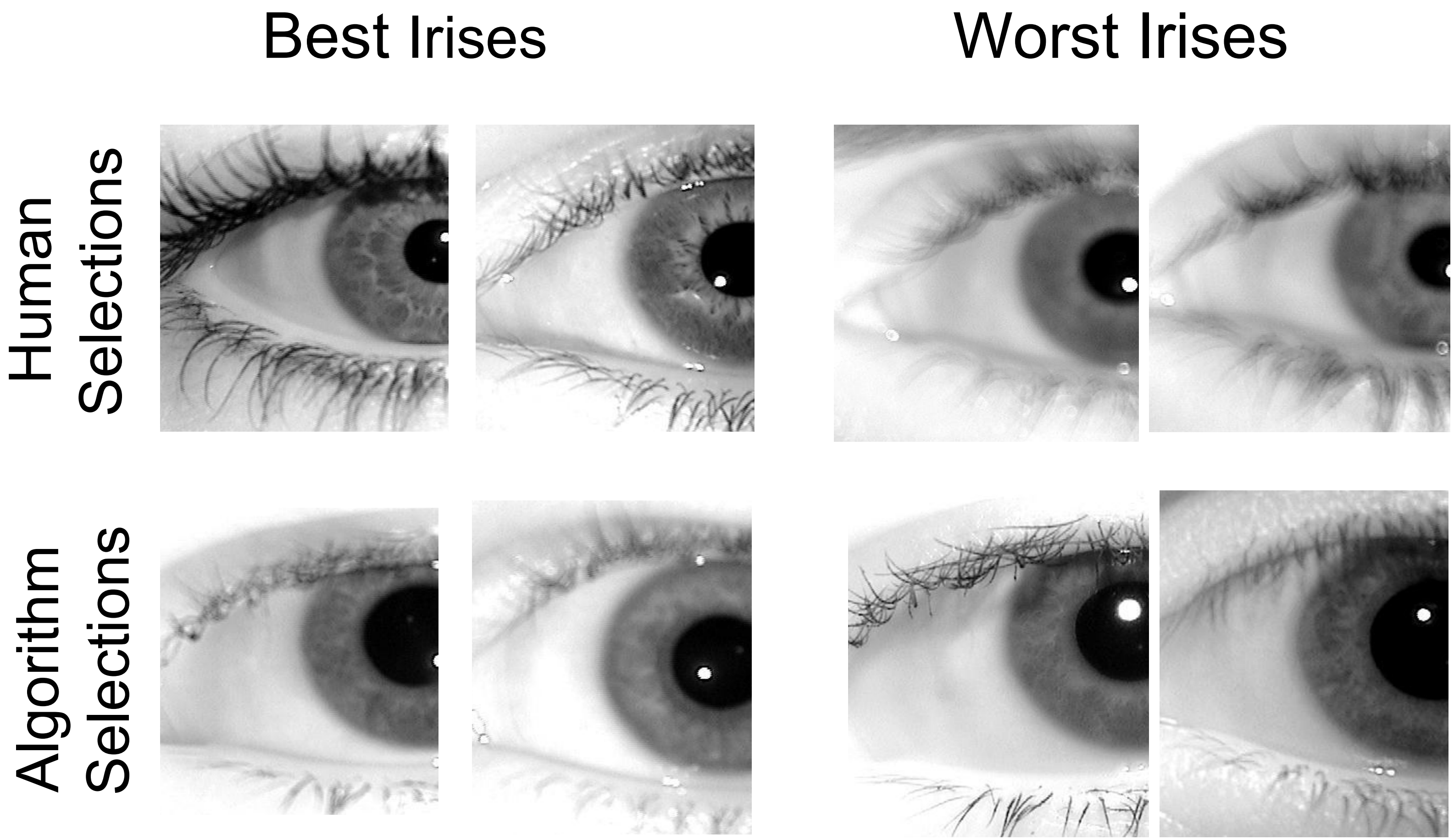
- Are algorithms consistent with each other?

  **YES**

- Are humans consistent with algorithms or other quality measures?

  **NO**

# Quality Evaluation – Results (cont.)



# Discrimination Entropy Approach by Daugman

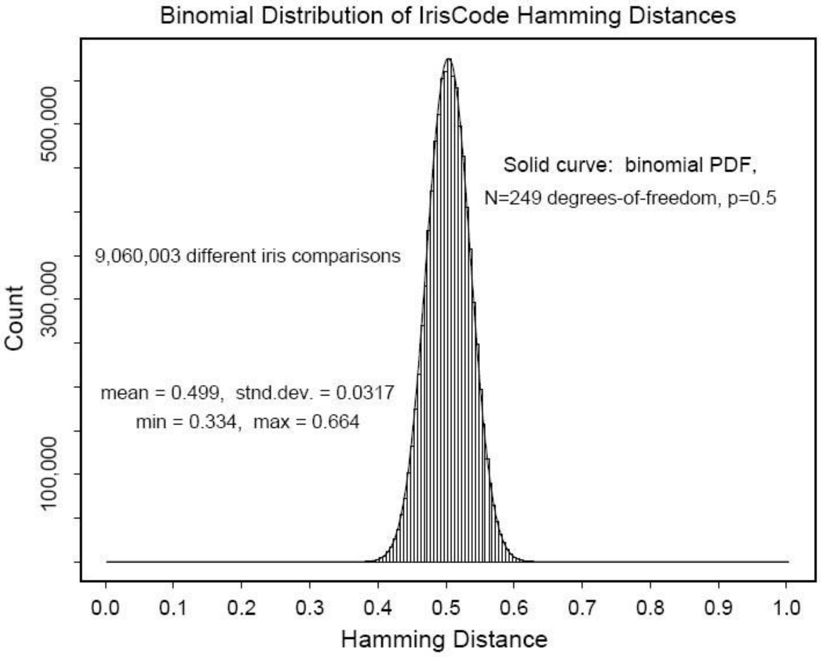
- <u>Assumption:</u>

  match score distribution ~ binomial distribution
- Degrees of freedom of the observed distribution:

$$N = p(1-p)/\sigma^2 = 249$$

- Fractional functional form:

$$f(x) = \frac{N!}{m!(N-m)!} p^m (1-p)^{N-m}$$



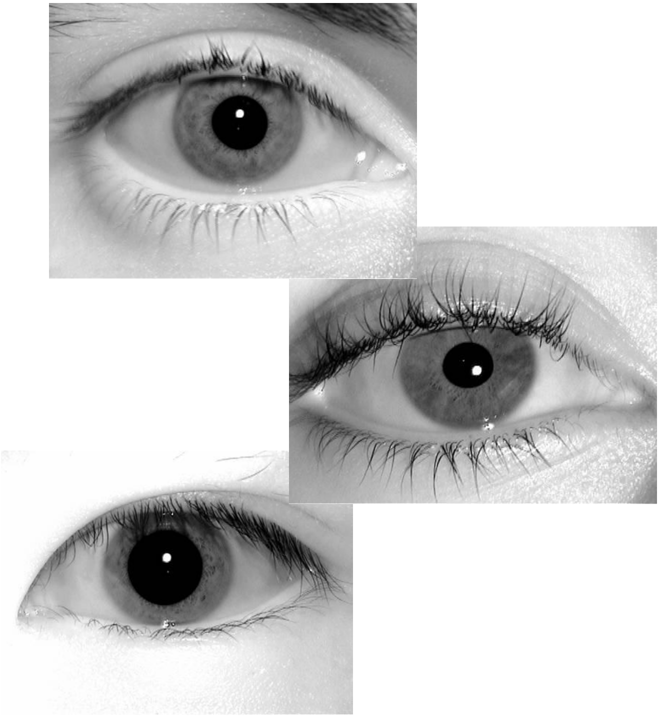
# Relative Entropy Approach by Adler et al.

- Biometric information: “decrease in uncerainty about the identity of a person due to a set of biometric measurements”

- $D(p \,||\, q)$ :
  - *p* - one person feature distribution
  - q - population feature distribution
  - preferable over *H*

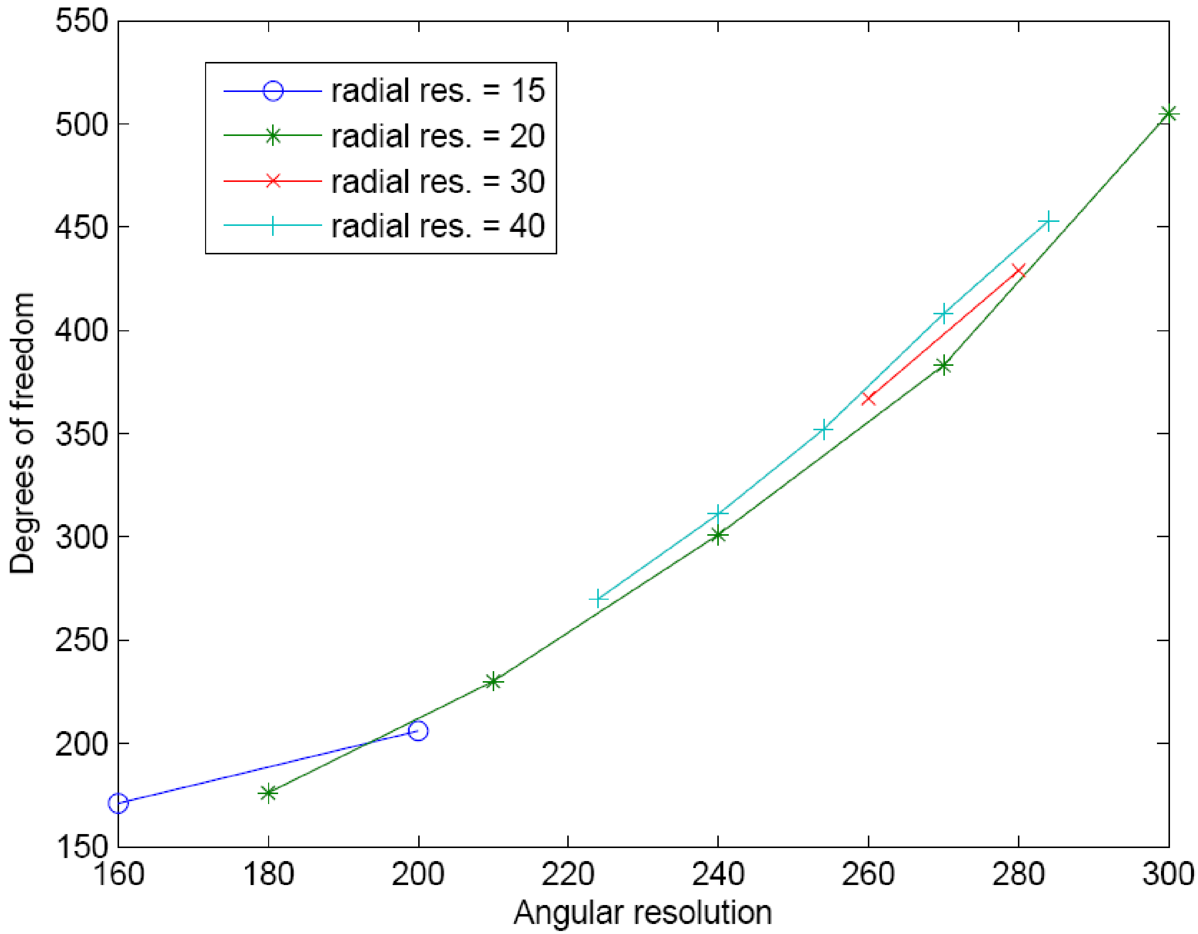
- Assumption: feature values have Gaussian distribution

# Experimental Setup



- Dataset:
  - obtained using L.G. iris camera
  - 12 eyes, 30 samples each
- Software:
  - Masek and Kovesi (2003)
  - open-source iris recognition software

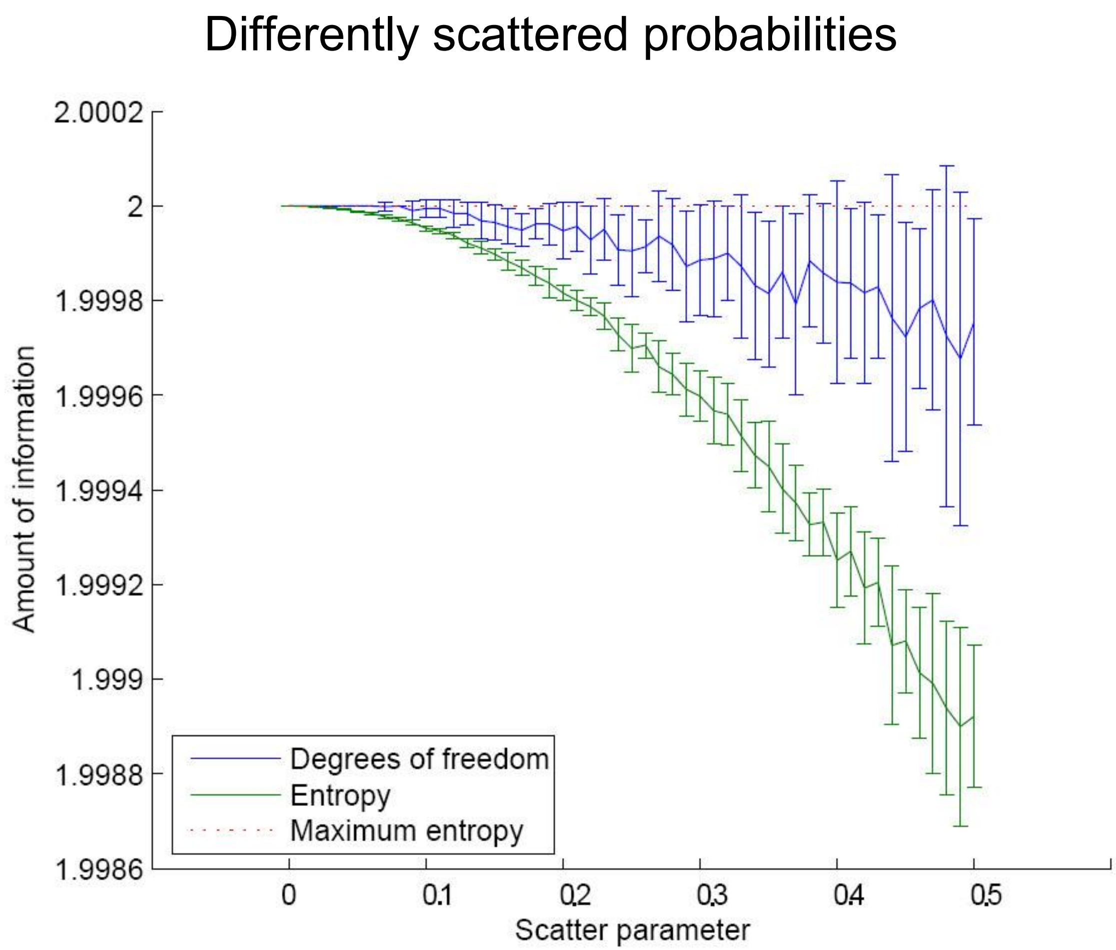
# Discrimination Entropy: Experimental Results



# Discrimination Entropy: Statistical Analysis

- Discrimination entropy vs. $H(p)$
- Procedure:
  - Define a template as a binary string of length **M**
  - Assign a probability to each template ($2^M$ values)
  - Calulate $H(p)$ of the template
  - Calculate HD distribution and fit the binomial curve
  - Compare the results

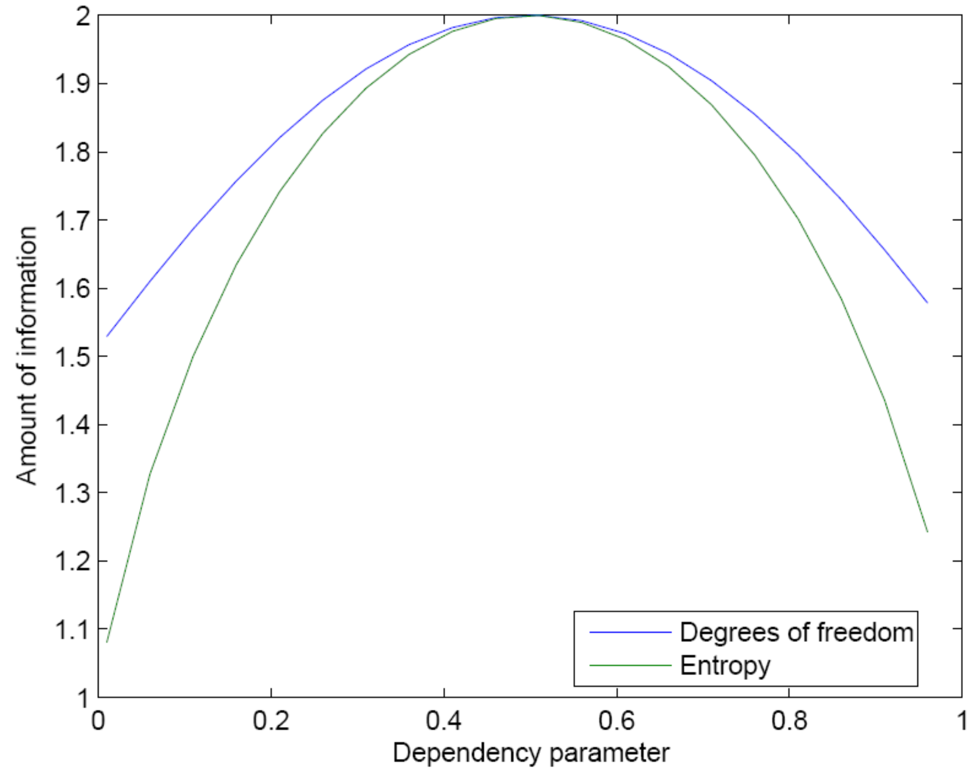
# Discrimination Entropy: Statistical Analysis - Scheme 1



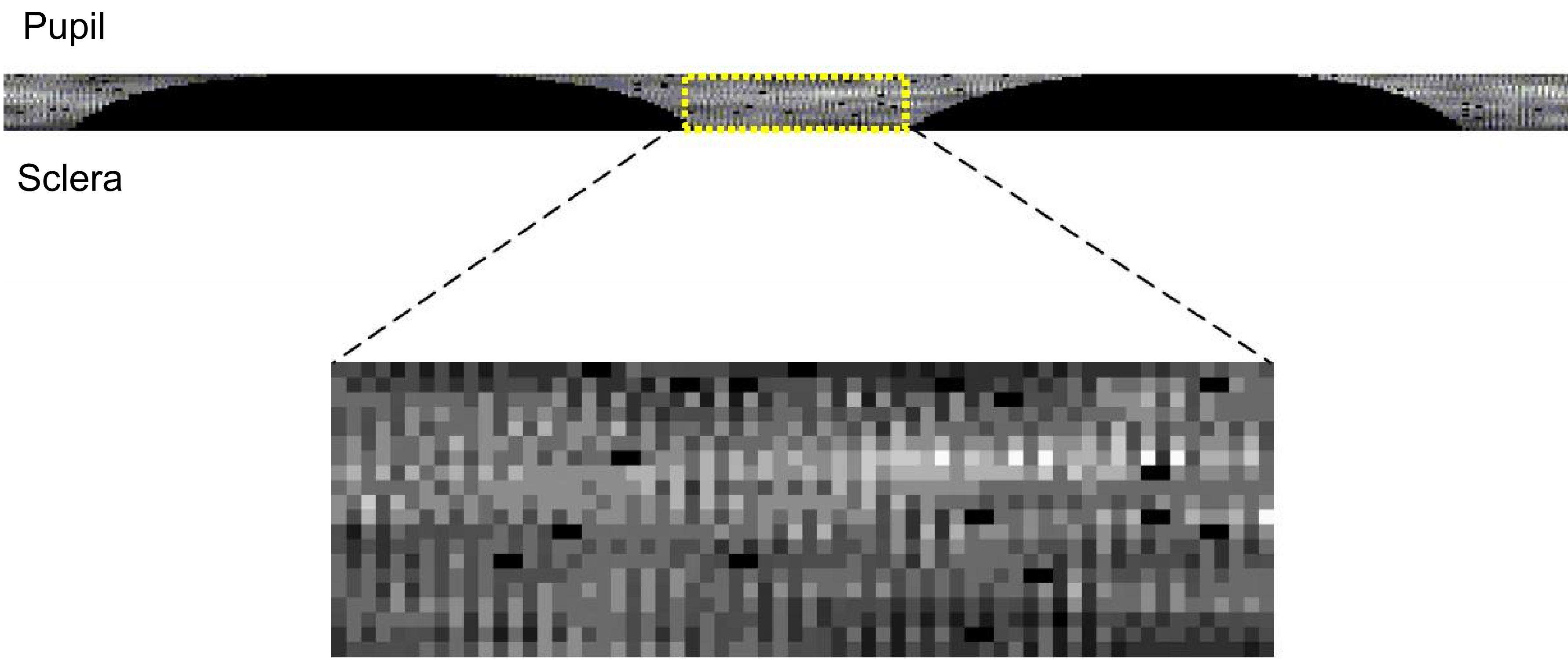
# Discrimination Entropy: Statistical Analysis - Scheme 2

Templates with varying dependencies between their bits

$$\begin{bmatrix} P(00) & P(01) \\ P(10) & P(11) \end{bmatrix} = \frac{1}{2}\begin{bmatrix} d & 1-d \\ 1-d & d \end{bmatrix}$$



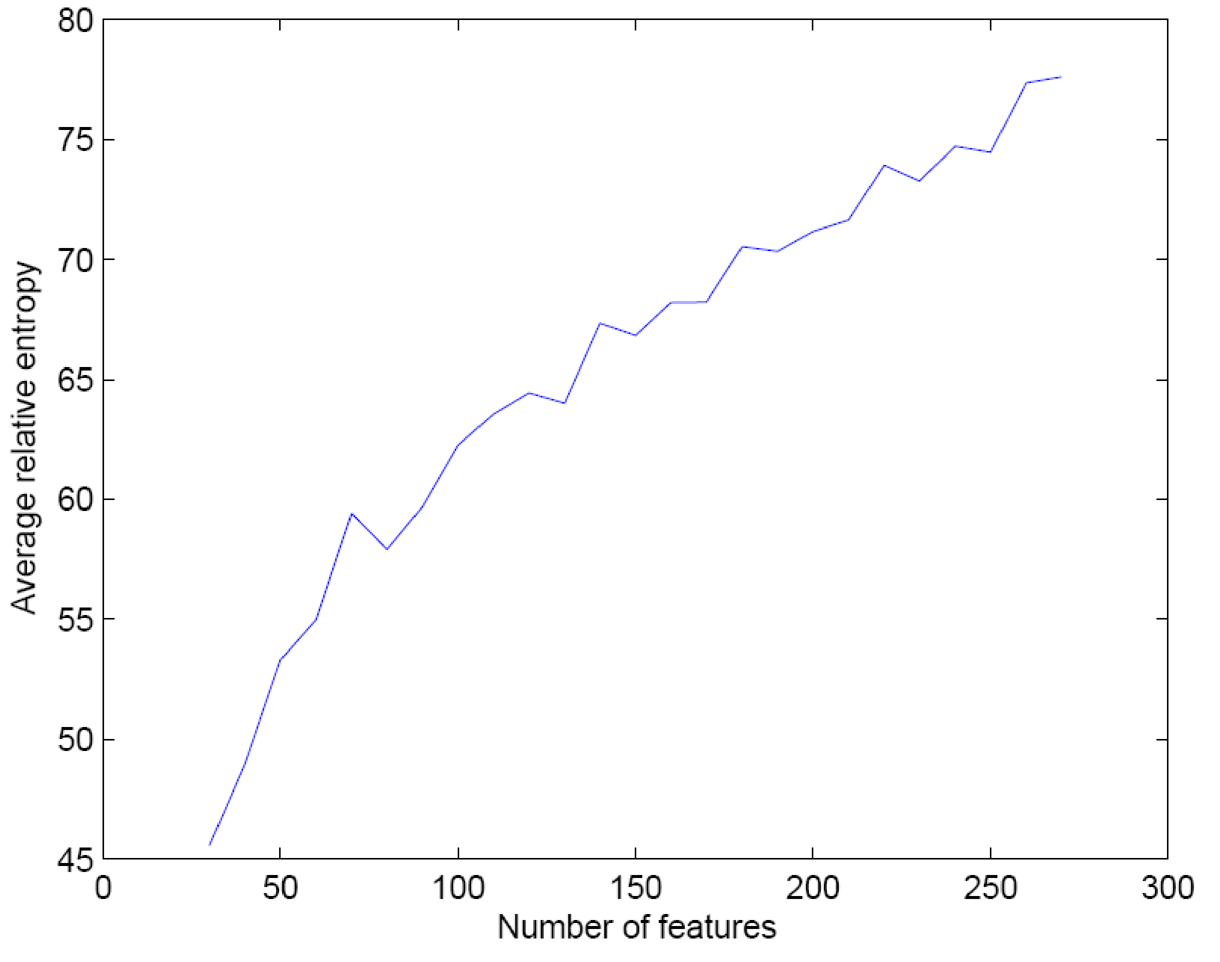
# Relative Entropy: Feature Entropy



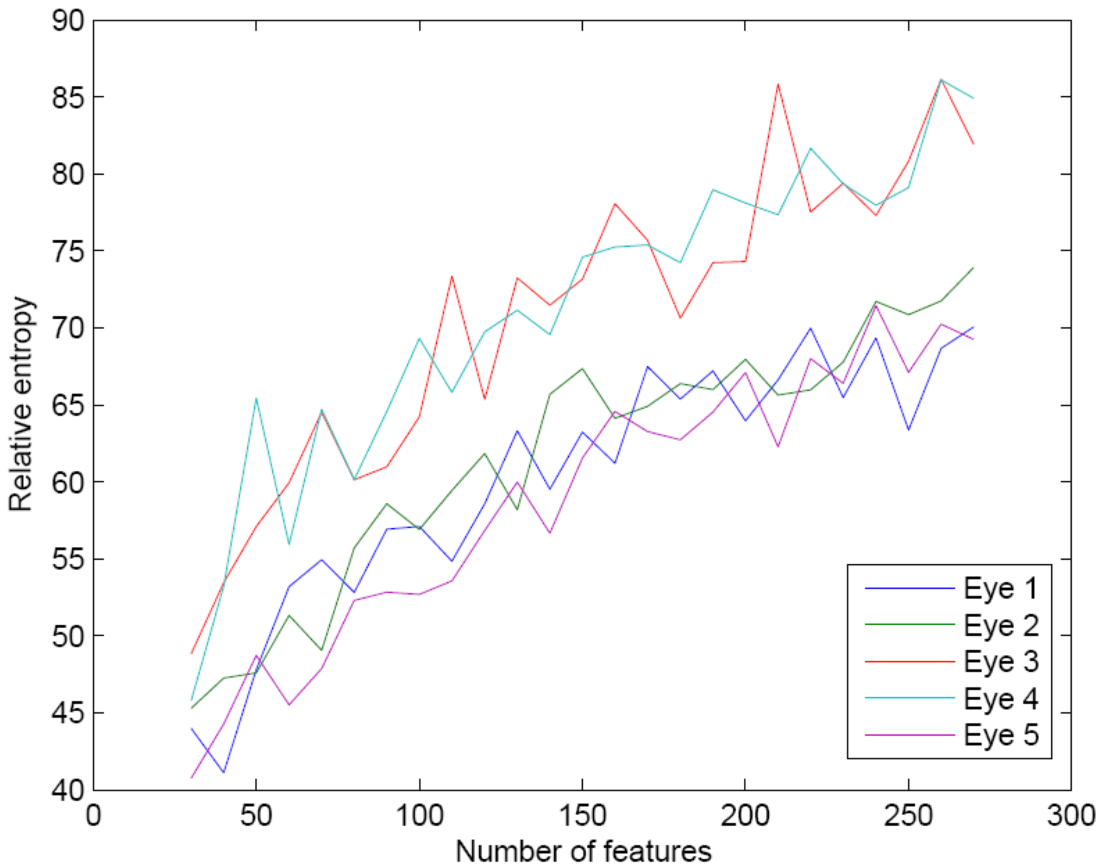
# Relative Entropy: Iris Template Entropy

Template dimensions :

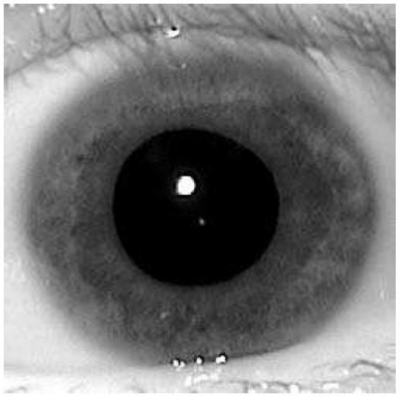
20 x 480



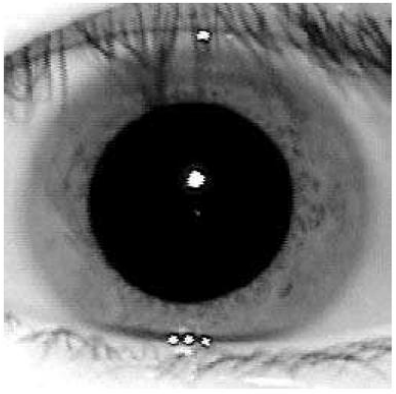
# Relative Entropy: Iris Template Entropy (cont.)



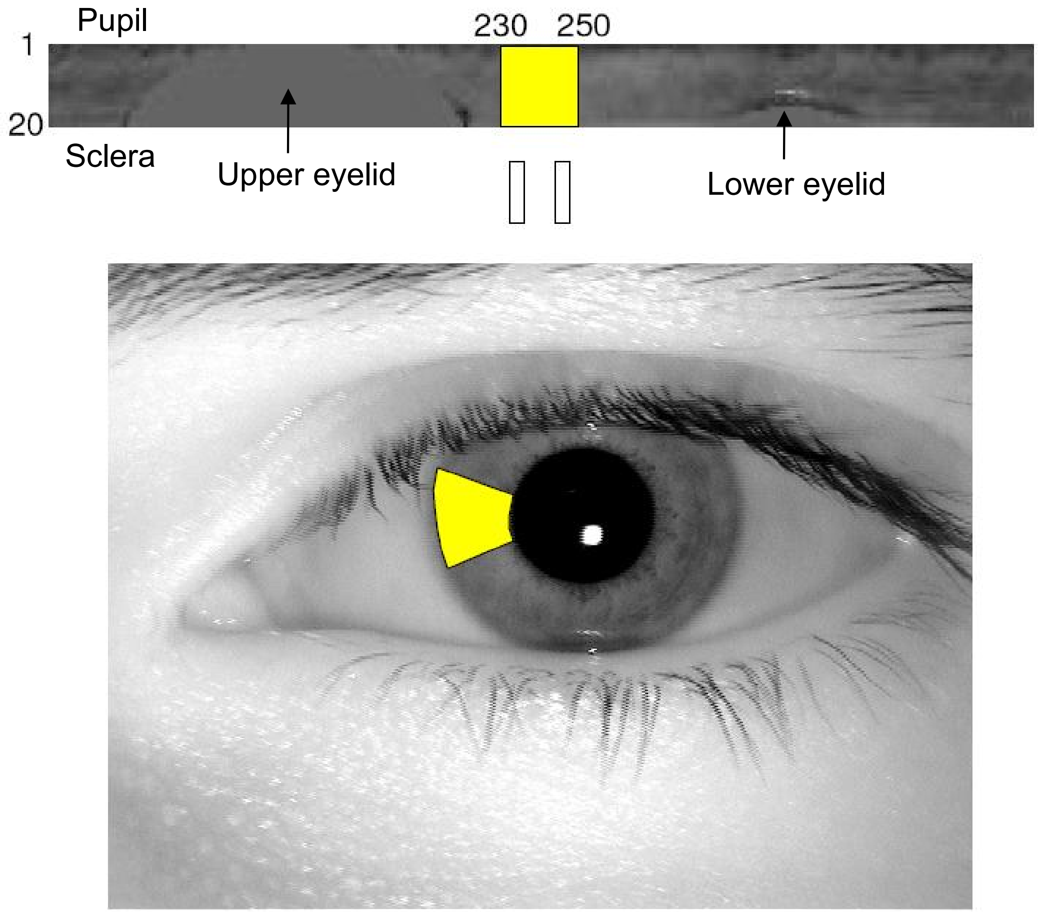

Higher information content



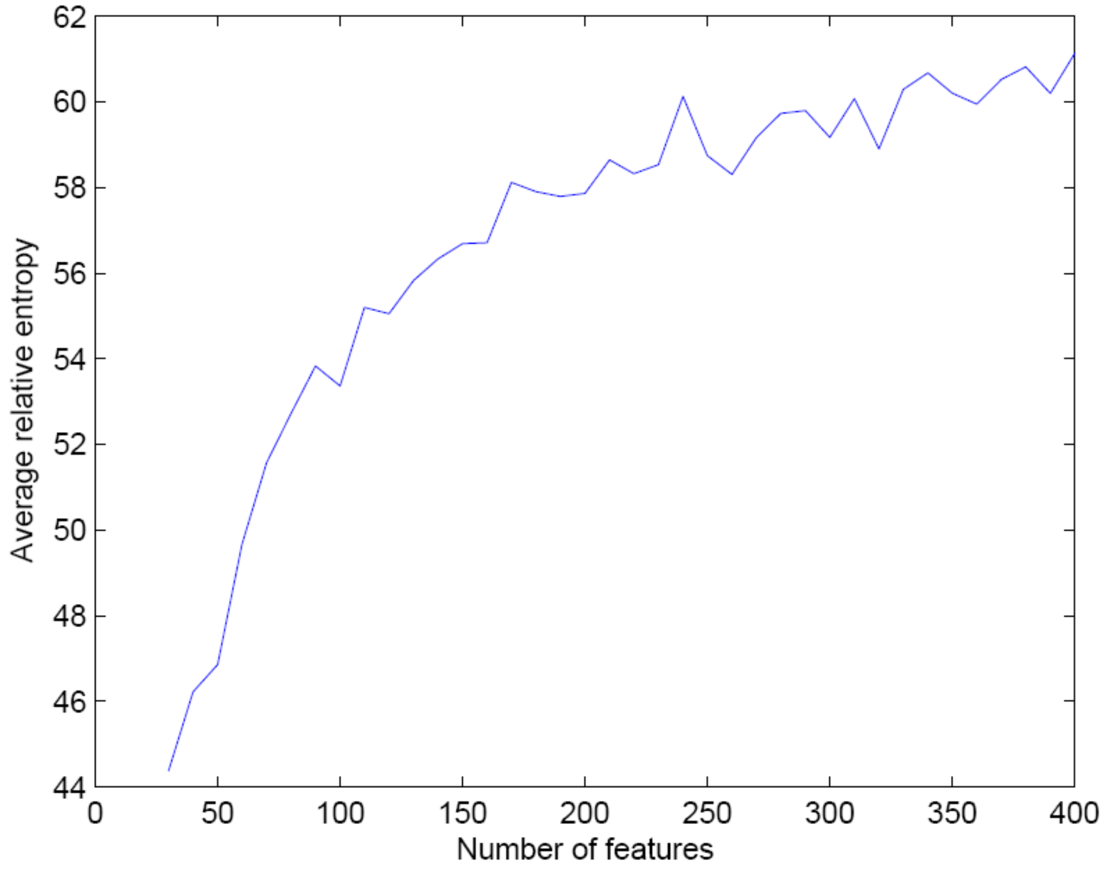
Lower information content



# Relative Entropy: Iris Region Entropy



# Relative Entropy: Iris Region Entropy (cont.)



# Conclusion

- Discrimination entropy:
  - too idealistic
  - does not measure identification information
- Relative entropy:
  - more appropriate measure of biometric information
  - the most informative: inner circles closer to the pupil
  - converges due to neighbor pixel dependencies

# Thank you!

Questions?