Low Quality Images are Less Informative:

Measuring Quality via Information Content

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Low Quality images are less informative: Measuring quality via information content

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Abstract: We propose to measure a change in the biometric sample quality due to image degradation as the decrease in biometric information content. Here, the biometric information content is defined as the decrease in uncertainty about the identity of a person due to a set of biometric measurements, which may be calculated by the relative entropy D(p||q) between the population feature distribution q and the person's feature distribution p. To examine the behaviour of this approach, we simulate degradations of face images for a biometric face recognition system based on PCA and FLD features and calculate the resulting decrease in biometric information. Results show a quasi-linear decrease for small levels of blur with an asymptotic behavior at larger blur.

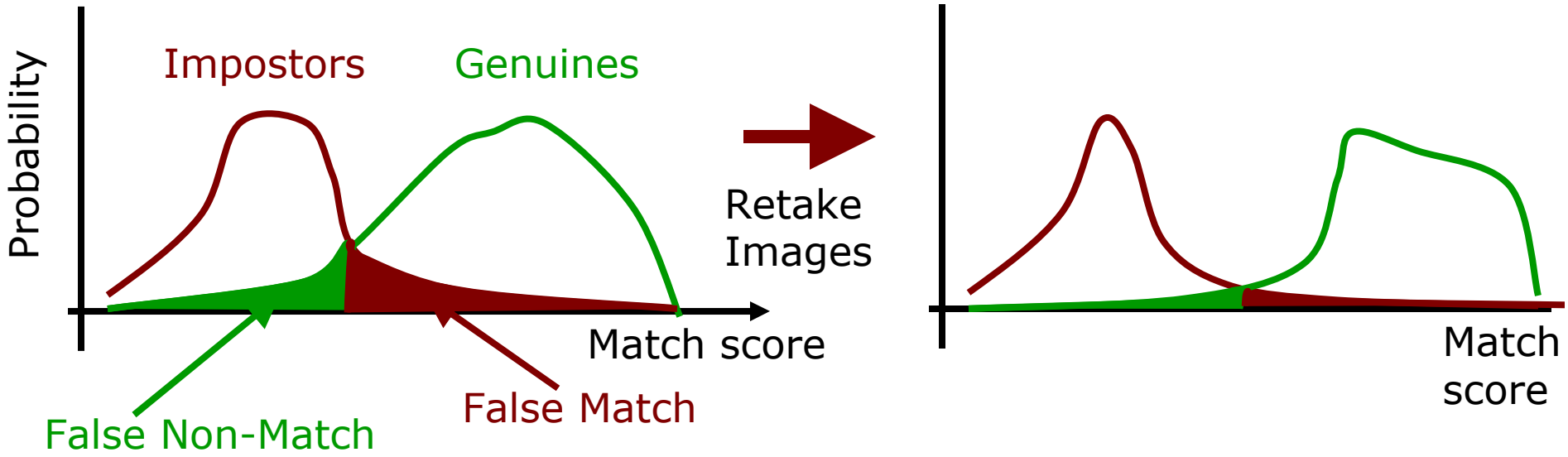
Biometric Sample Quality

Biometric Sample Quality measures:

- character
  - inherent features
- Fidelity
  - accuracy of features
- utility
  - predicted biometrics performance

INCITS, Biometric Sample Quality Standard Draft, M1/06-0003

Utility Quality



Since the algorithm errors were less, the retaken images had higher quality

But, could we have done better with the first images?

Utility

- Fairly simple conceptually

- Dependent on matching algorithm
- Doesn’t allow quantification of “inherent” quality

Character / Fidelity

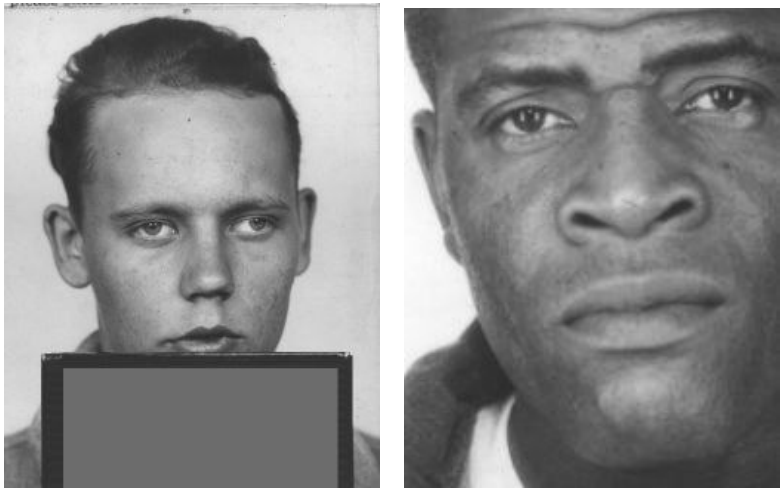
Descriptions of “inherent” quality of a biometric sample

- Character
  - Blur
  - Shadows
  - Poor lighting
- Fidelity
  - A good image of the wrong part

Example: *Character*

←Best Faces **Human Selections** Worst Faces →

Example: *Fidelity*



Low quality images are less informative

How can we measure character quality?

- Probing question*:*

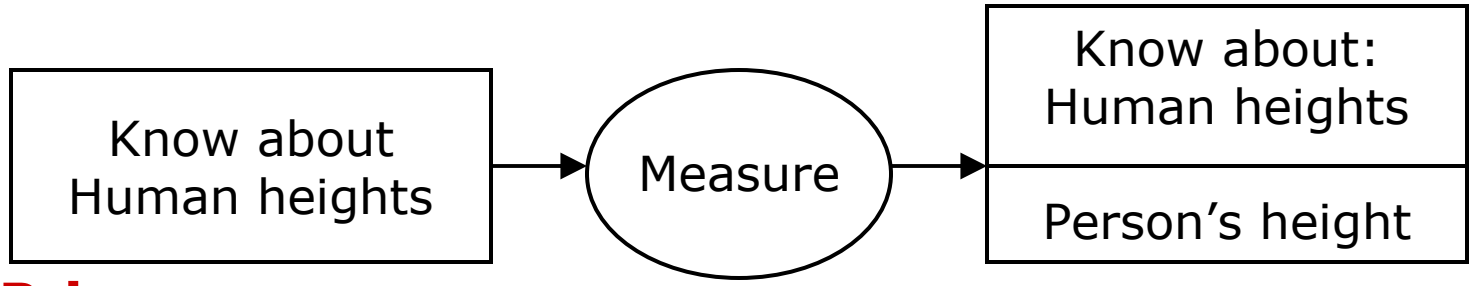
  Why do we worry about low quality images?

- Answer:

  They have less information about the person.

Definition:
Biometric Information (BI):

- the decrease in uncertainty about the identity of an individual based on a measurement of biometric features.



Prior:
Uncertainty is 1:6 billion

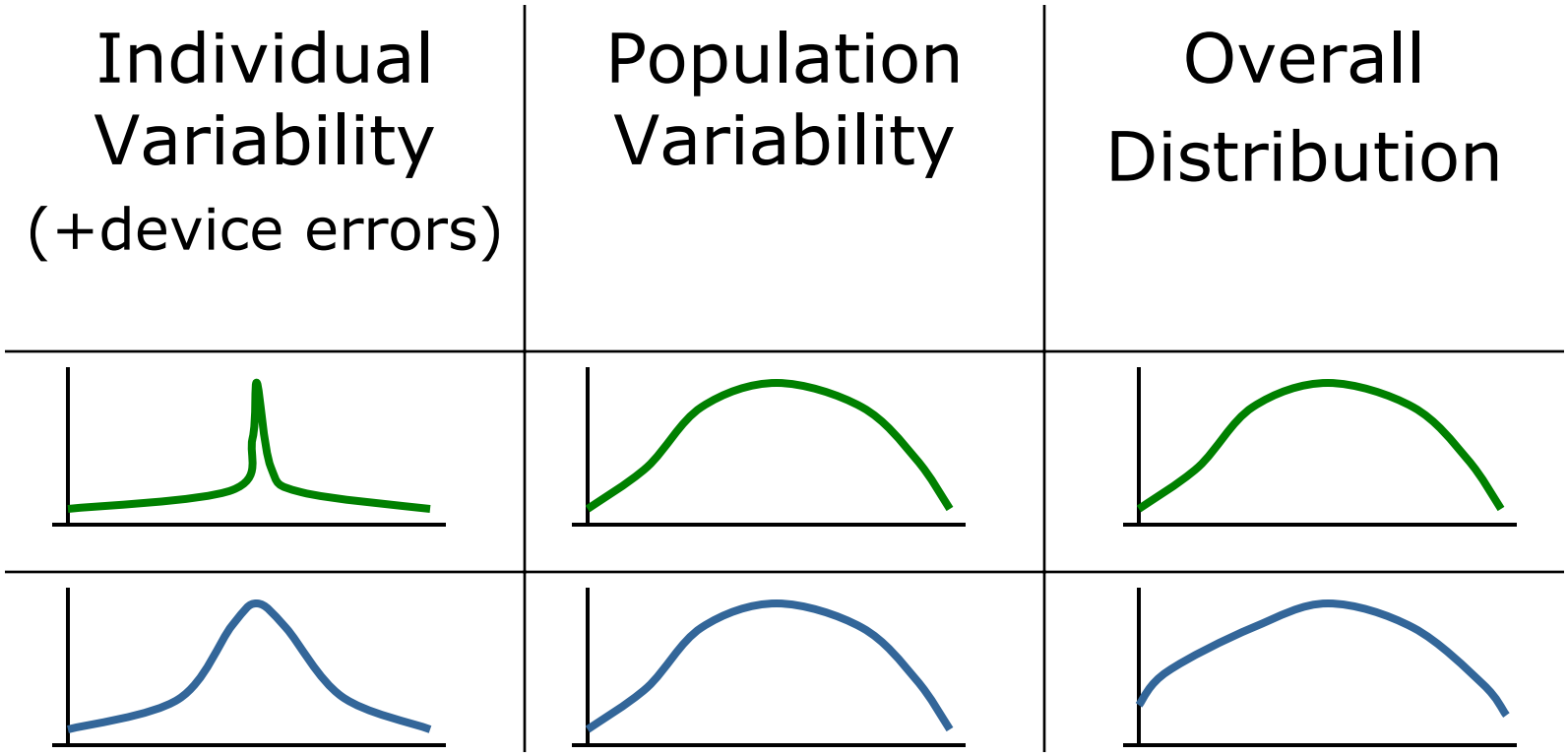
$$q(y) \Longrightarrow p(y)$$

Posterior:
Uncertainty is less

- Measure **KLD (**Kullback-Leibler divergence) the "extra bits" of information needed to represent *p(y)* wrt *q(y)*

Example #1: measure *Height*

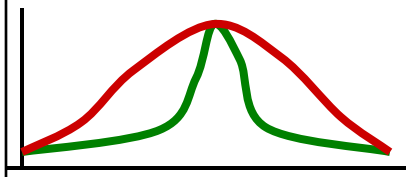
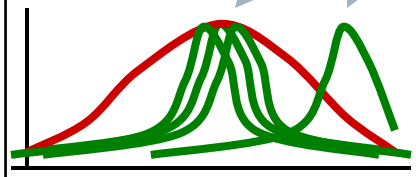
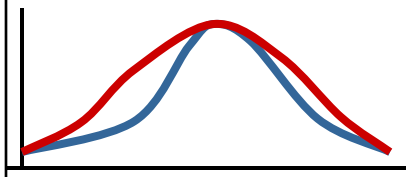
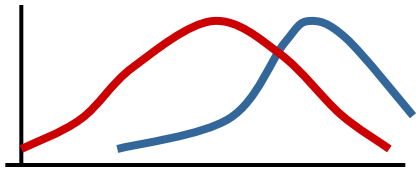
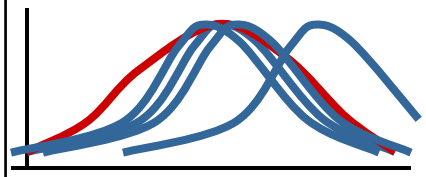
- Measure #1 (at doctor's office, ie. accurate)
- Measure #2 (via telescope, ie. inaccuate)



BI for height

The biometric system quality is reflected by the mean BI: System BI (SBI)

Most People Are average

	Average (5½′ tall)	Tall (6½′ tall)	Mean BI
Measure #1: accurate			
	BI = 0.23b	*BI* = 2.7b	*BI* = 0.3b
Measure #2: inaccurate			
	BI = 0.05b	*BI* = 1.1b	*BI* = 0.07b

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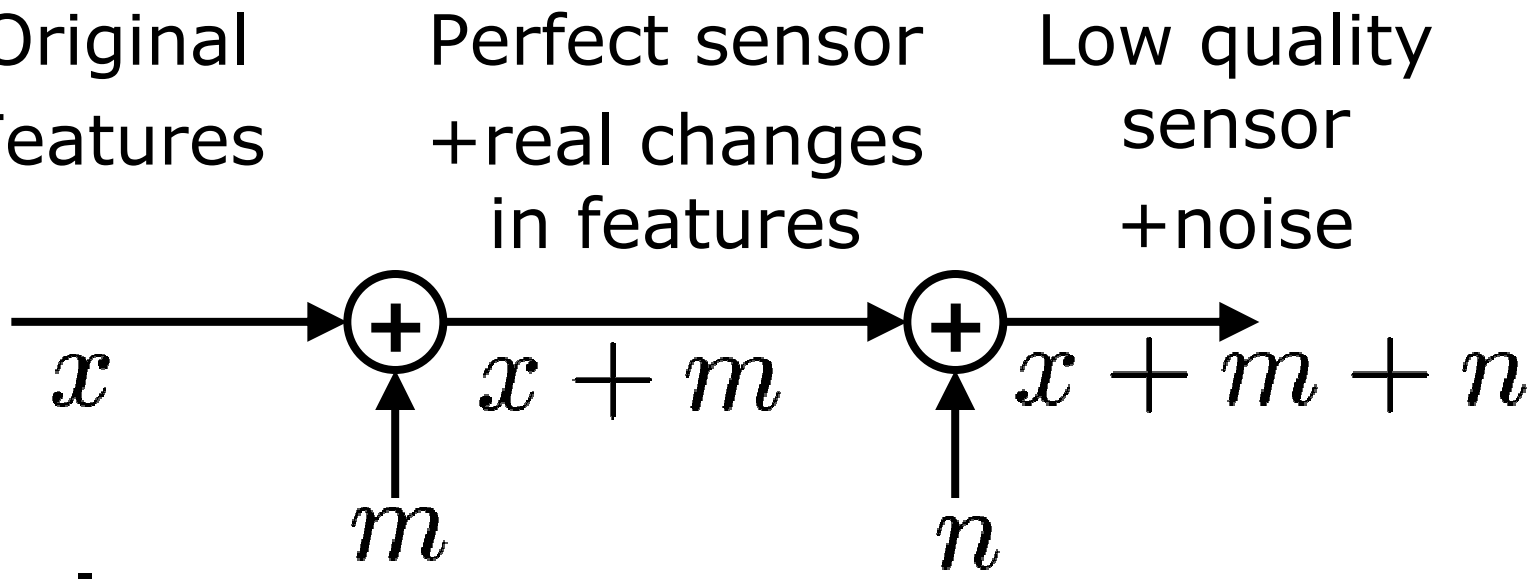
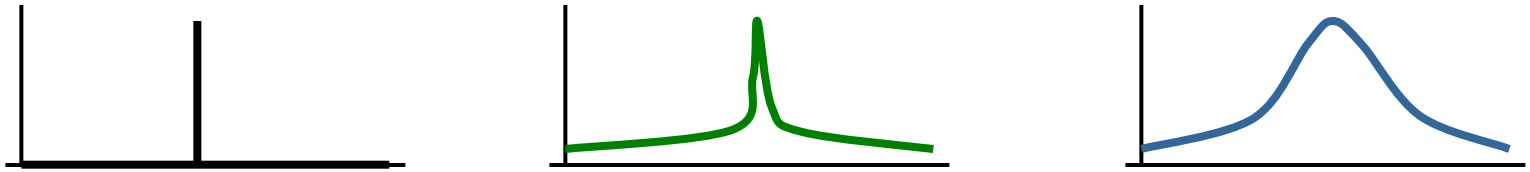
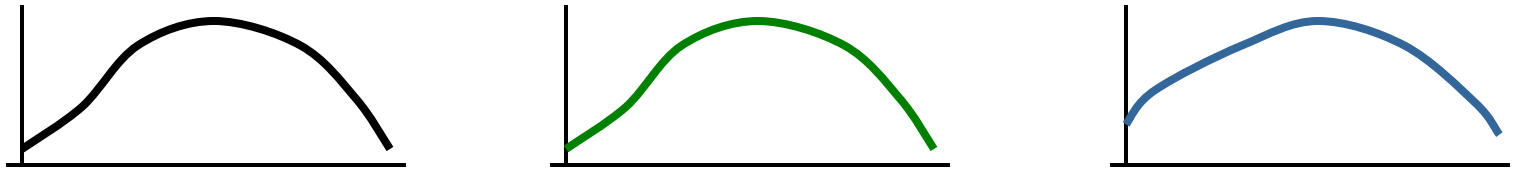
Quality Loss Model



Individuals



Population



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Formula page …

- BI (KLD): $D(p\|q) = \int p(\mathbf{y}) log_2 \frac{p(\mathbf{y})}{q(\mathbf{y})} d\mathbf{y}$
- SBI: $\mathrm{SBI} = \underset{q}{E}\left[D(p\|q)\right]$
- Gaussian Models:

$$\mathrm{SBI} = \frac{1}{2} log_2 |\boldsymbol{\Sigma}_q \boldsymbol{\Sigma}_p^{-1}| + tr\left(\boldsymbol{\Sigma}_p \boldsymbol{\Sigma}_q^{-1}\right)$$

When signal>noise

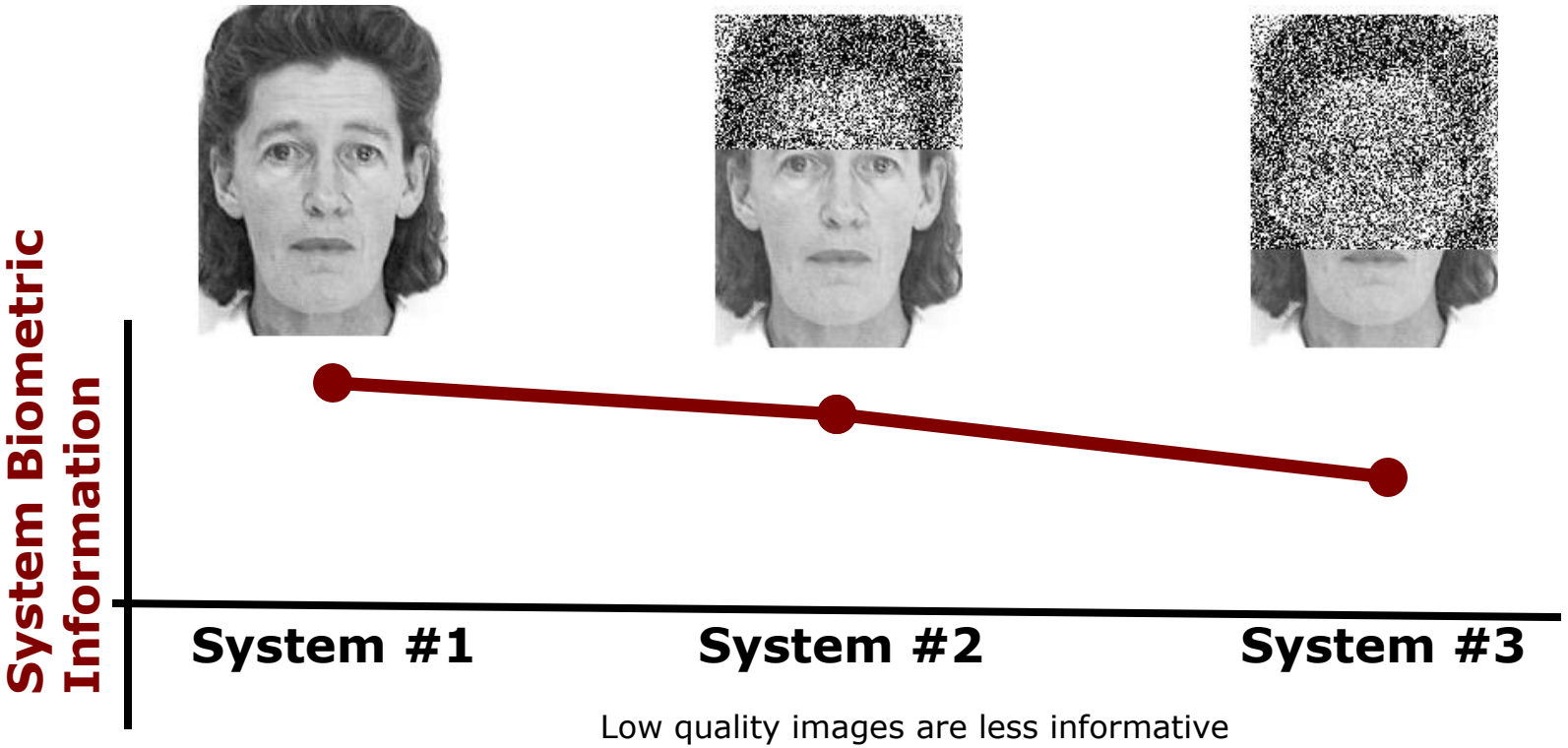
When noise>signal, *ignore*

- With noise model:

$$\mathrm{SBI} = \frac{1}{2} log_2 |\boldsymbol{\Sigma}_x (\boldsymbol{\Sigma}_m + \boldsymbol{\Sigma}_n)^{-1} + \mathbf{I}|$$

Example #2: Face Recognition

- Aberdeen Face database
  - 18 frontal images of 16 persons
  - Variability in lighting and expression
- Noise added to images (face covering)



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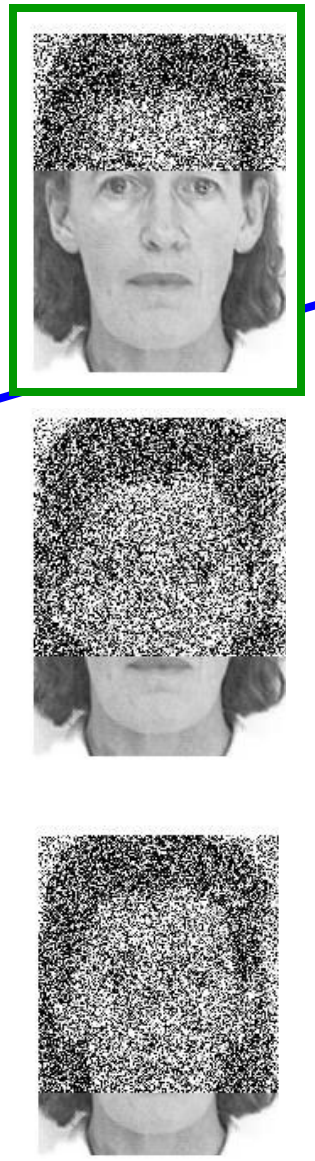
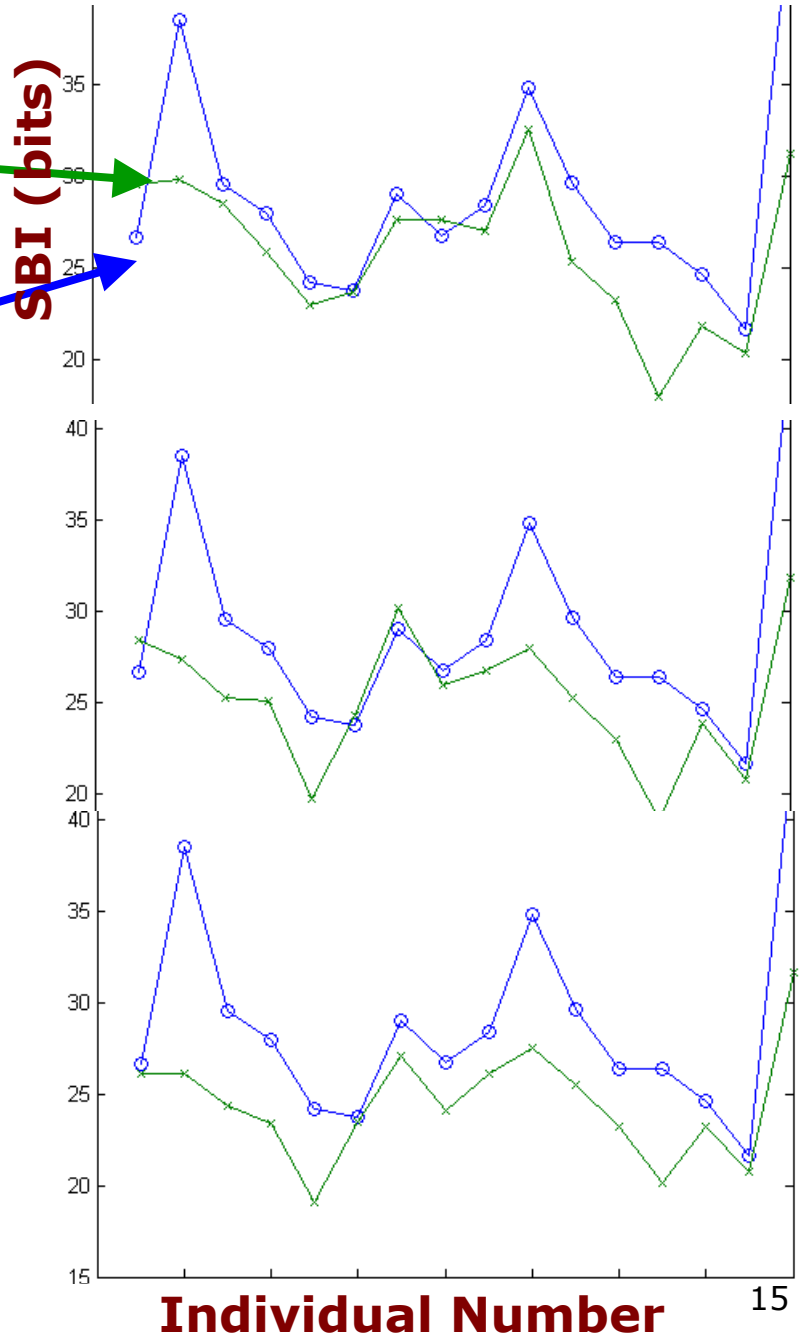
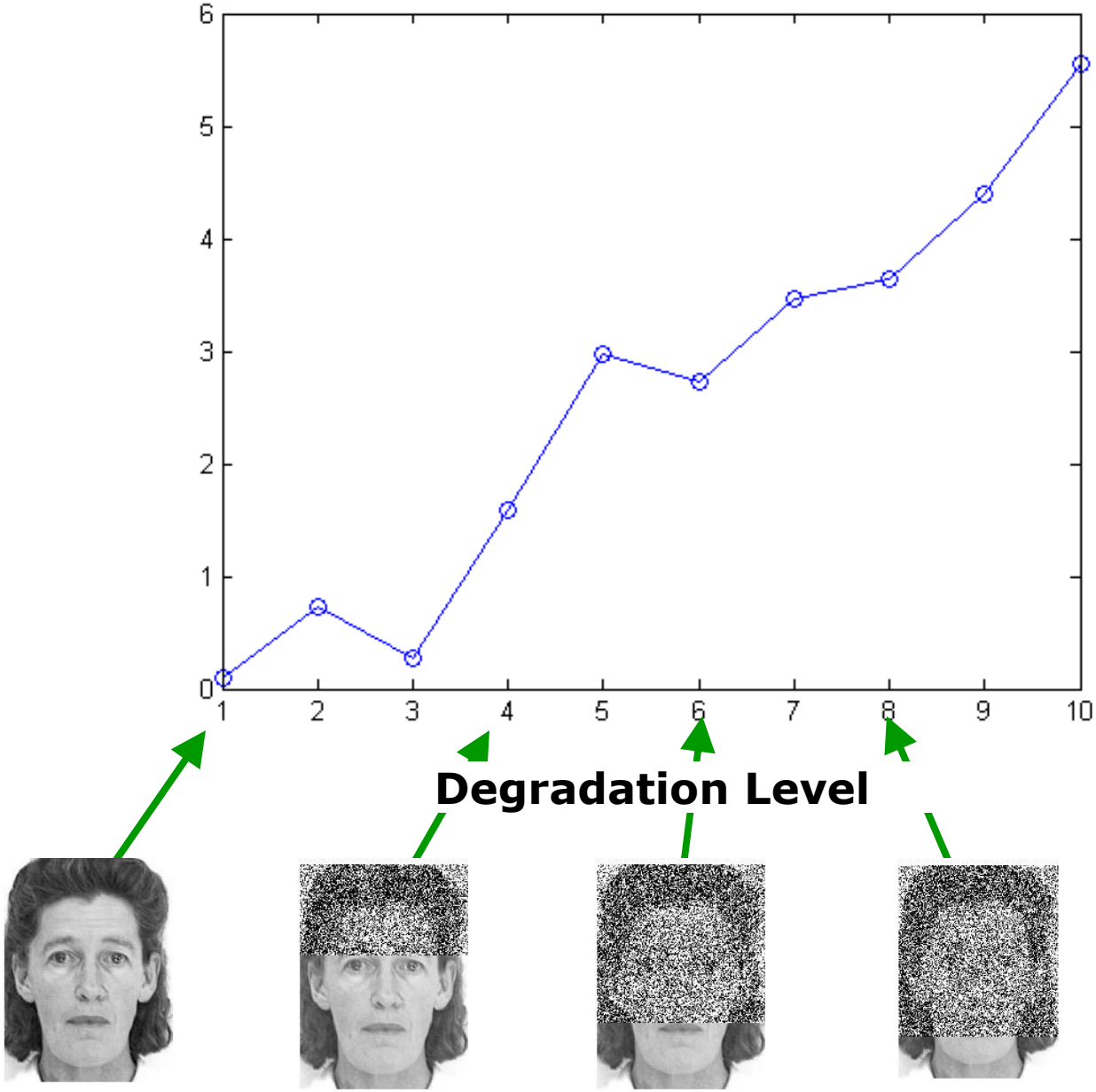
Results


Original




SBI (bits)
35
25
20
40
35
30
25
20
40
35
30
25
20
15
Individual Number

Results: average



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Summary

- Start with intuitive idea that
  - Low quality images are less informative
- A method to measure the quality loss due to an image degradation

- *Limitation:*
  - We measure the quality of a system
  - Can’t measure quality of a single image

Applications

- Clarify implications of biometric quality measures
- Help quantify limits of impact of quality on matcher performance
- Help quantify effects of biometric fusion with low quality data
- Privacy impact of approaches to de-identify face data

Comment: *Quality*

- *Quality* is a value laden term
- Can we tell users this?

- We need to be careful with the terminology