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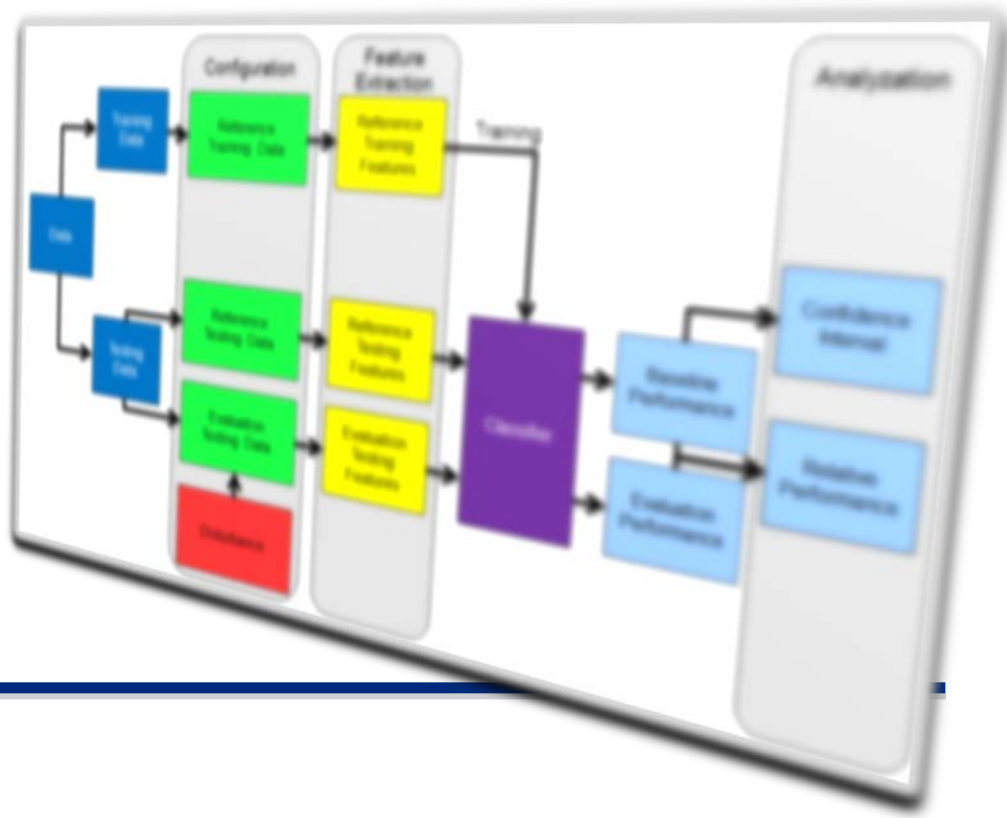
On Testing the Robustness of Liveness Detection Feature Extractors for Fingerprint Live Scanners



Patrick Schuch

Outline

- Why liveness detection?
- Typical Workflow
- Known challenges
- How to overcome
- An example
- Discussion & Conclusion

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Who is DERMALOG?

- HQ in Hamburg, Germany
- Outpost in Kuala Lumpur, Malaysia
- Modality: fingerprints
- Main Products:
  - AFIS
  - Live scanners

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Why Liveness Detection?

Spoofing

- Easy & cheap
- Manuals available
- Vulnerable systems

Risk

- False accepts
- Loss of trust
- Loss of acceptance

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Why Liveness Detection?

Detect spoofing

Increase security

Increase customer’s trust

Increase acceptance

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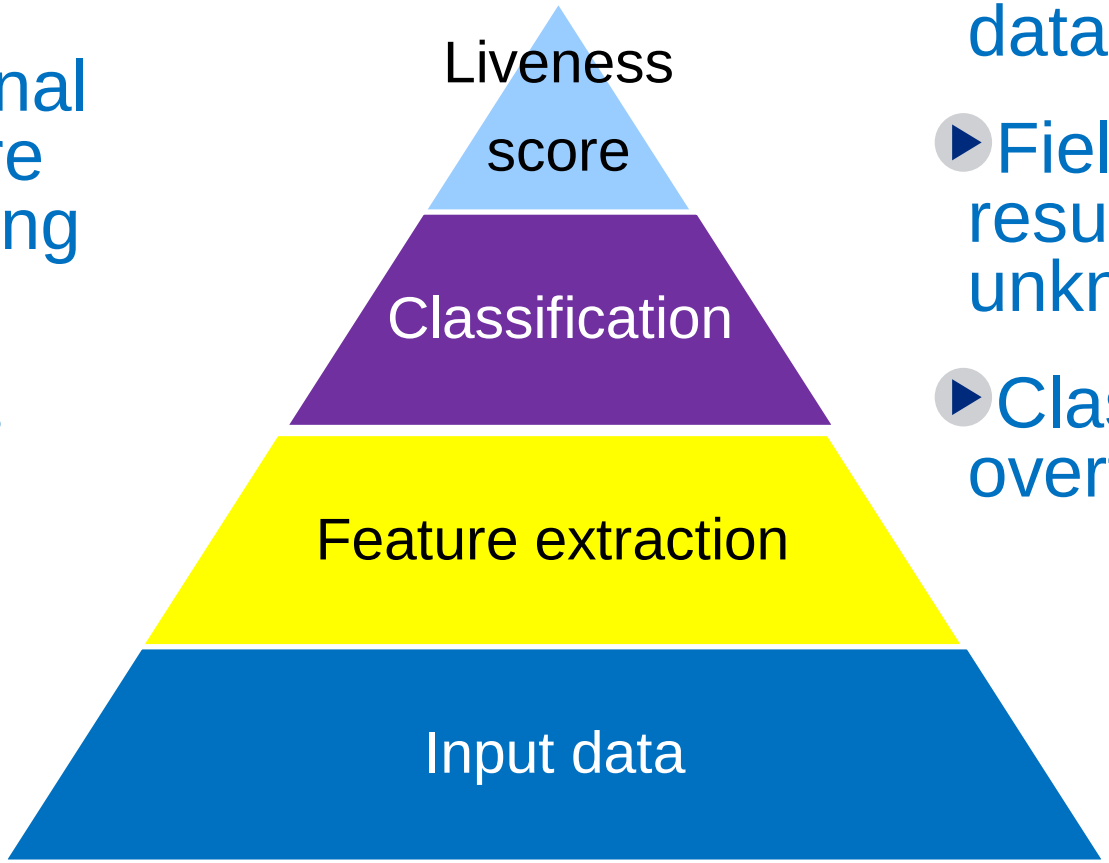
Typical Workflow

- Grayscale images
- Additional hardware measuring
- Result: liveness score



- Lab: good results on known data
- Field: bad results on unknown data
- Classifier overtrained?

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Known Challenges

External	Internal
• Illumination • Temperature • Humidity • Dust/Dirt • Latents • Population (skin etc.) • …	• Noise • Defects • Sharpness • Fabrication tolerances • …

- ISO/IEC 29197: Evaluation Methodology for Environmental Influence in Biometric Systems Performance

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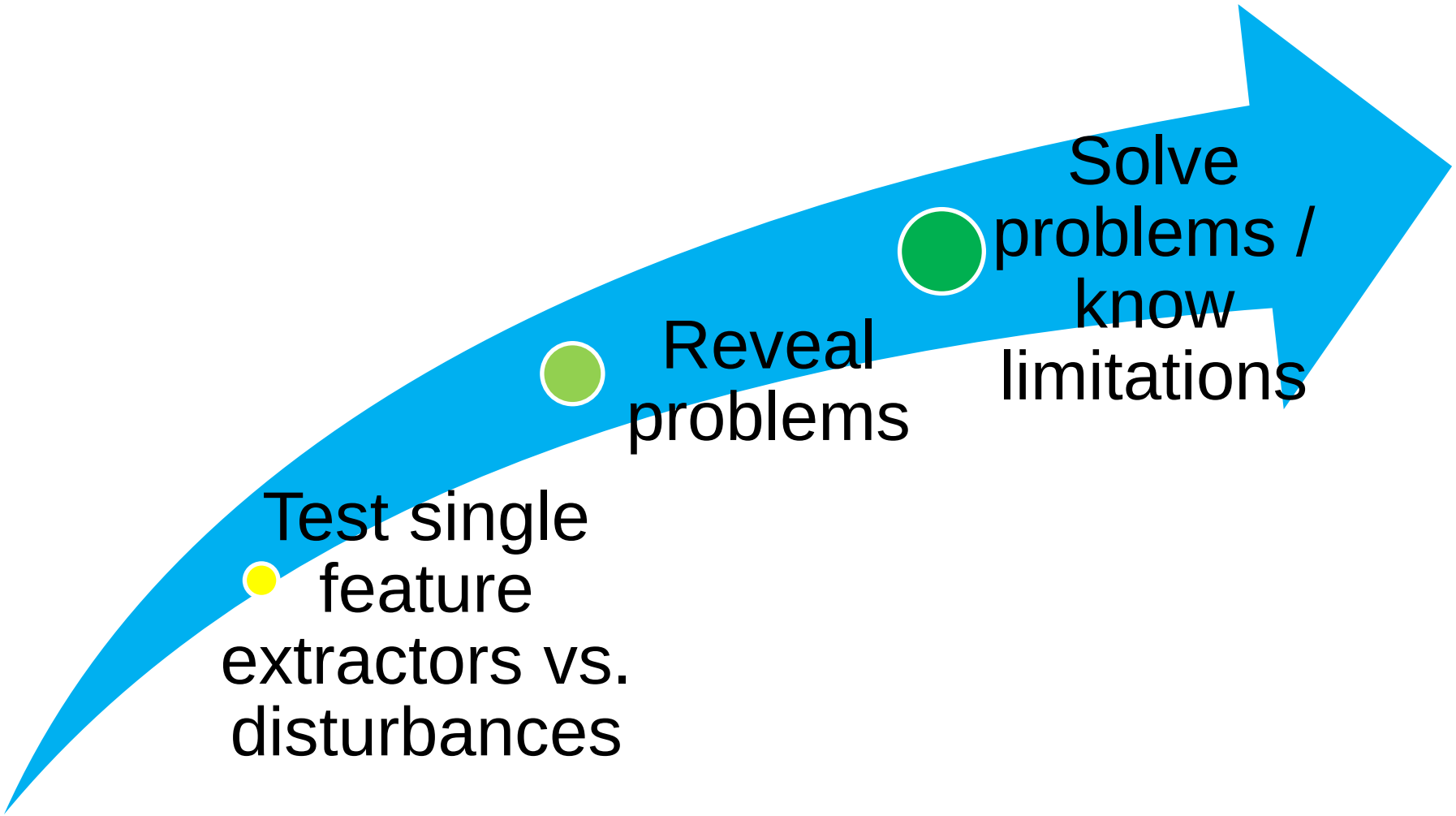
Known Challenges



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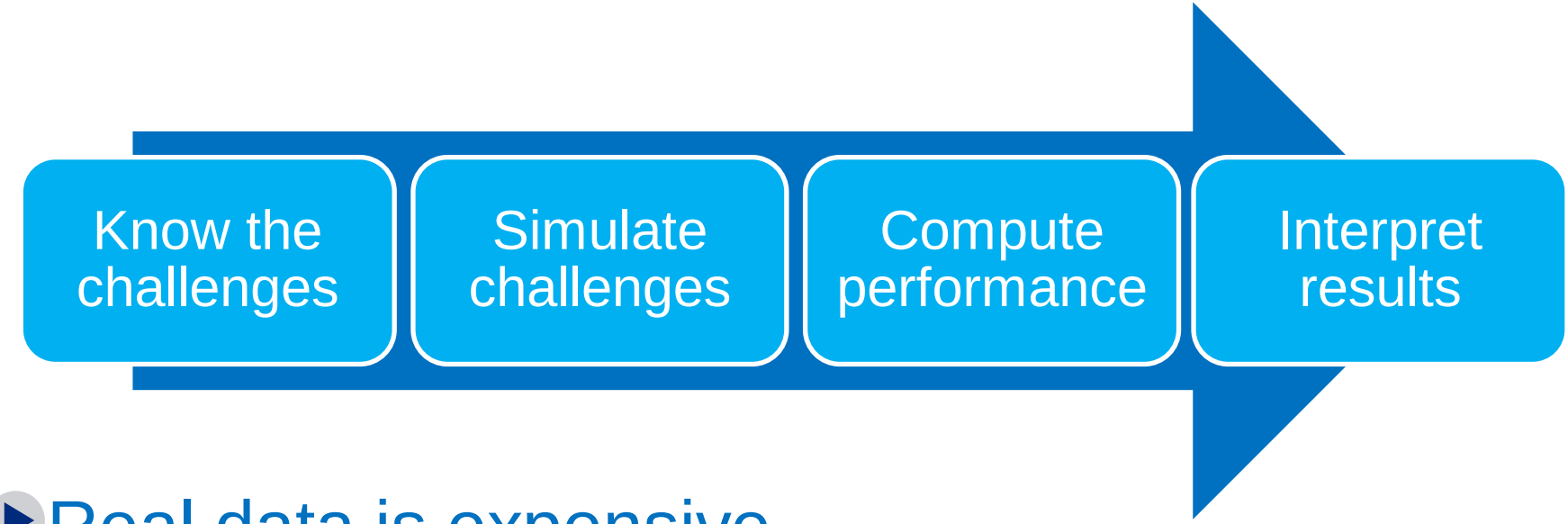
How to Test



- Real data is expensive
- Disturbances:
  - How to model them mathematically
  - What must be expected?

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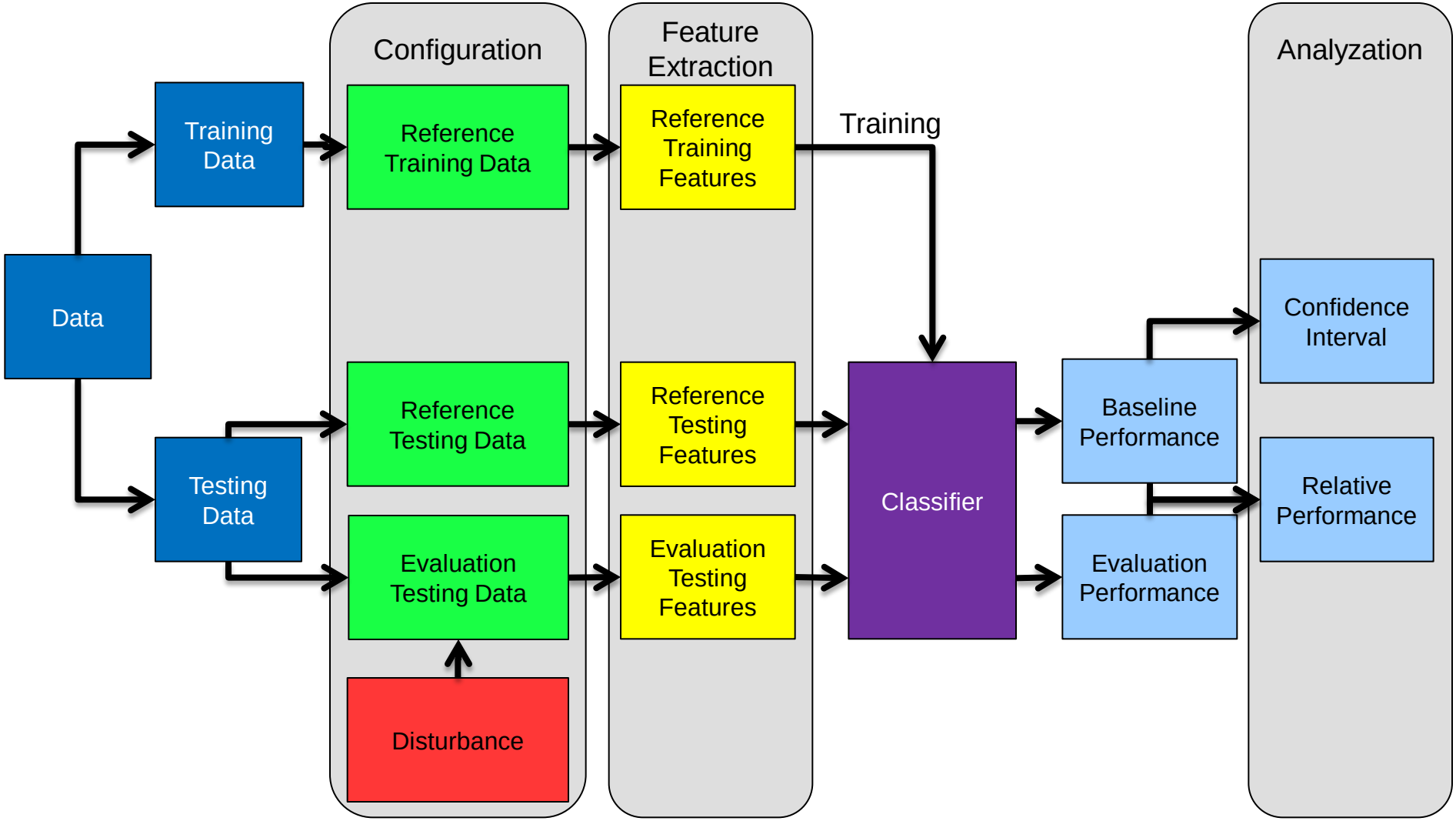
How to Test



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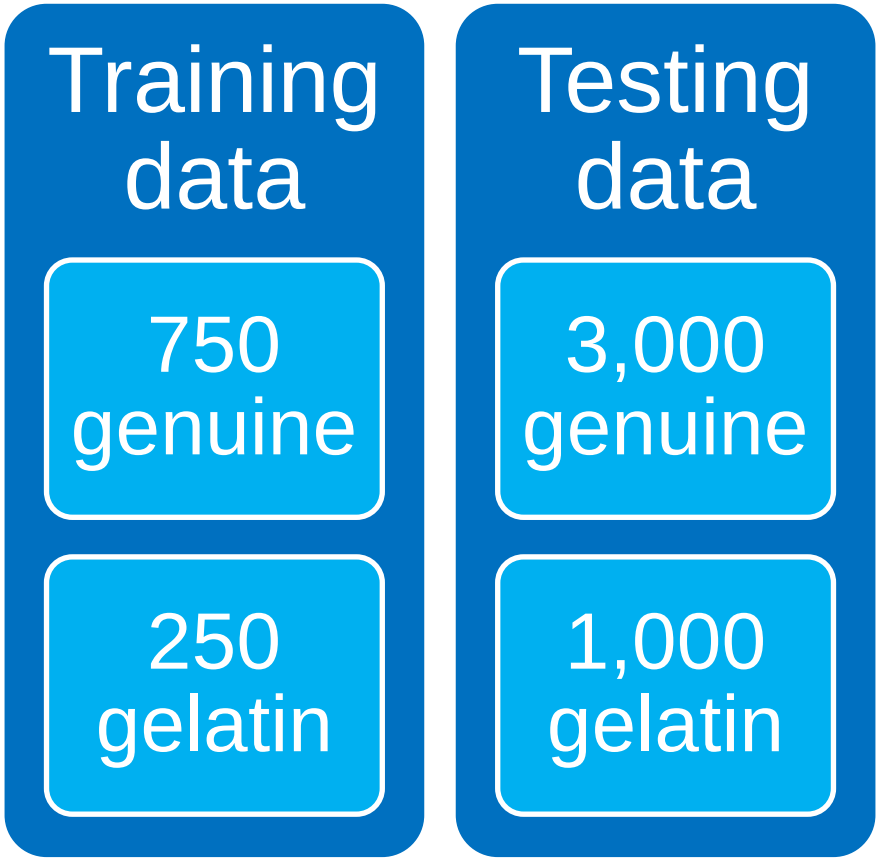
Example - Data

- LivDet2009 data set
  - Subset only
  - Identix DFR2100
  - 686 dpi, 720x720 pixels
  - Cropped ROI



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Example - Tested Feature Extractors

γ_2

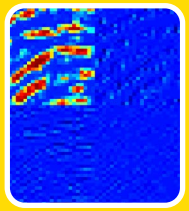
Kurtosis

- Proposed by Abhyankar et al. [2006]
- Baseline performance: EER ~ 21%

μ/σ

Coefficient of variation

- Proposed by Abhyankar et al. [2006]
- Baseline performance: EER ~ 8.9%



Surface coarseness

- Proposed by Moon et al. [2008]
- Baseline performance: EER ~ 25%

Combined

- Combination of the previous three
- Baseline performance: EER ~ 8.4%

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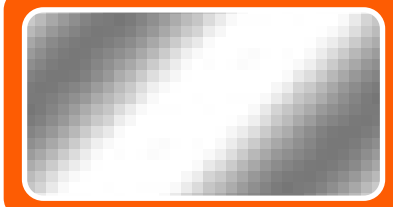
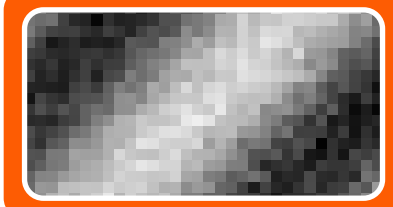
Example - Disturbances to be Tested



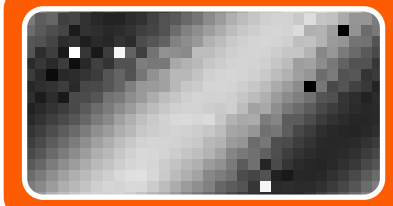
Illumination offset

- Internal/External illumination variation
- Homogenous offset



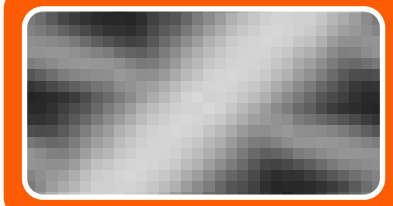
White Gaussian Noise

- Noise in components



Shot Noise

- A.k.a. “Salt and Pepper Noise”
- Defect pixels



Latents

- “Dirt” from previous acquisitions
- Simulated latents

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Example – Confidence Intervals

- Naive Bayes Classifier
- False suspicious presentation detection rate (false SP-DR aka FRR)
- False suspicious presentation non-detection rate (false SP-NDR aka FAR)
- Use upper bounds of Confidence Intervals (significance level $\alpha = 0.05$)
- Only relative error rates will be used

Feature Extractor	EER on Testing Set	Upper Bound for Relative FRR	Upper Bound for Relative FAR
Kurtosis	21.3%	1.07	1.12
Coefficient of variation	8.9%	1.12	1.22
Surface coarseness	25.0%	1.06	1.11
Combined	8.4%	1.13	1.23

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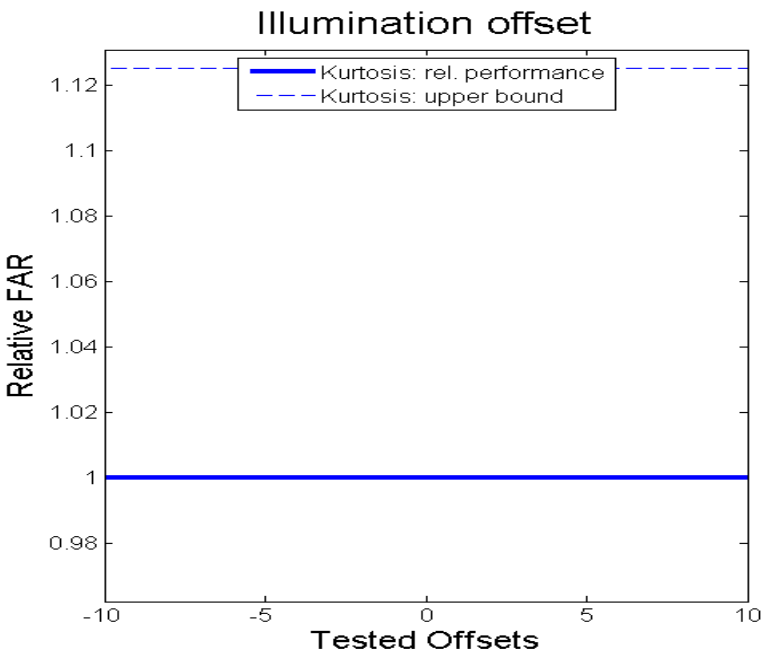
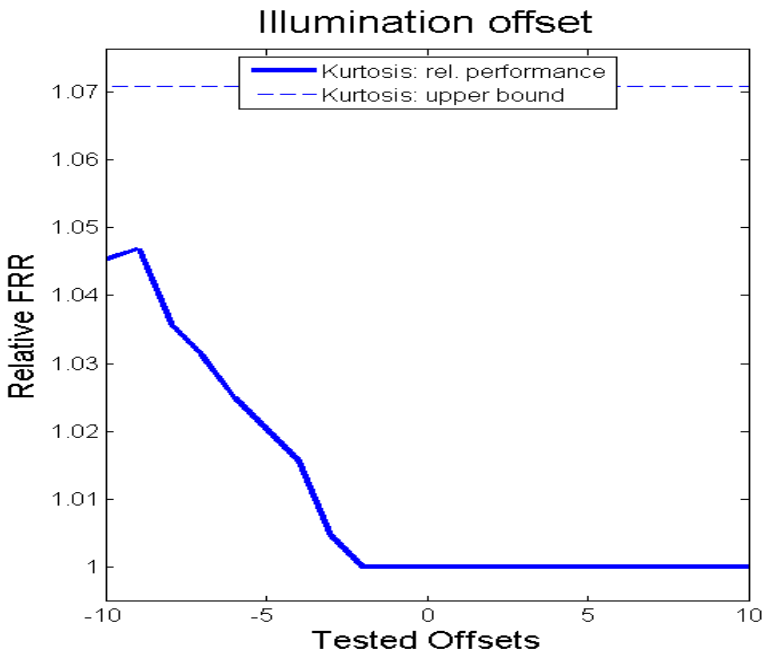
Example – Some Results





- Baseline performance for offset 0
- Tendencies revealed in relative error rates
- Apply confidence intervals
- Crop to relative performance 1.0

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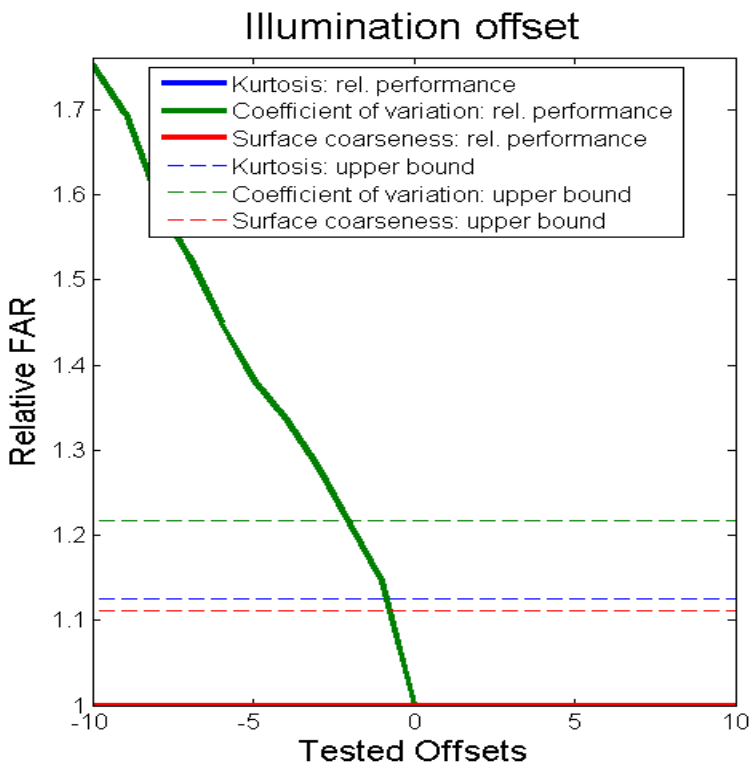
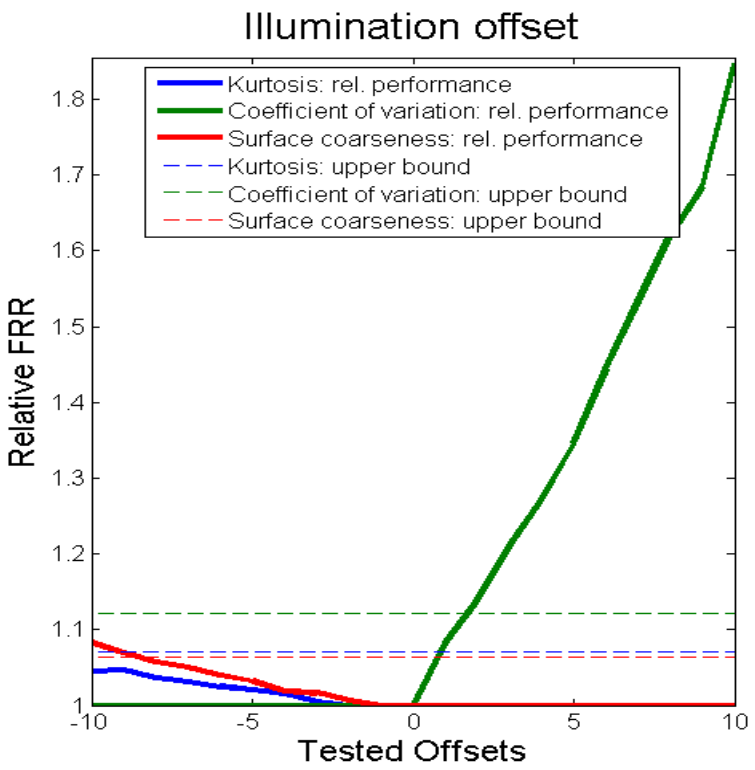
Example – Some Results





- Parameter range [-10 10]
- Strong decay for coefficient of variation

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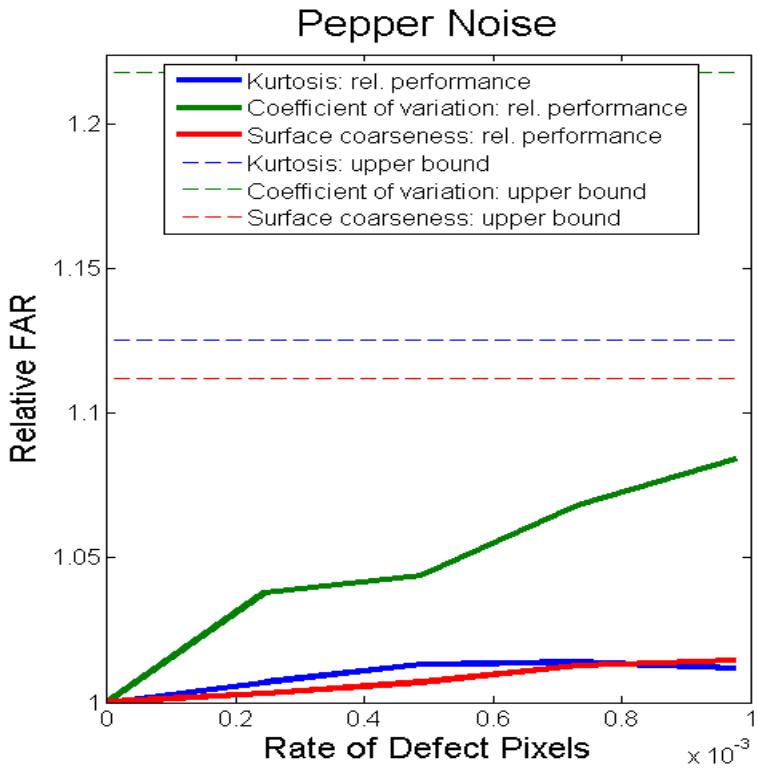
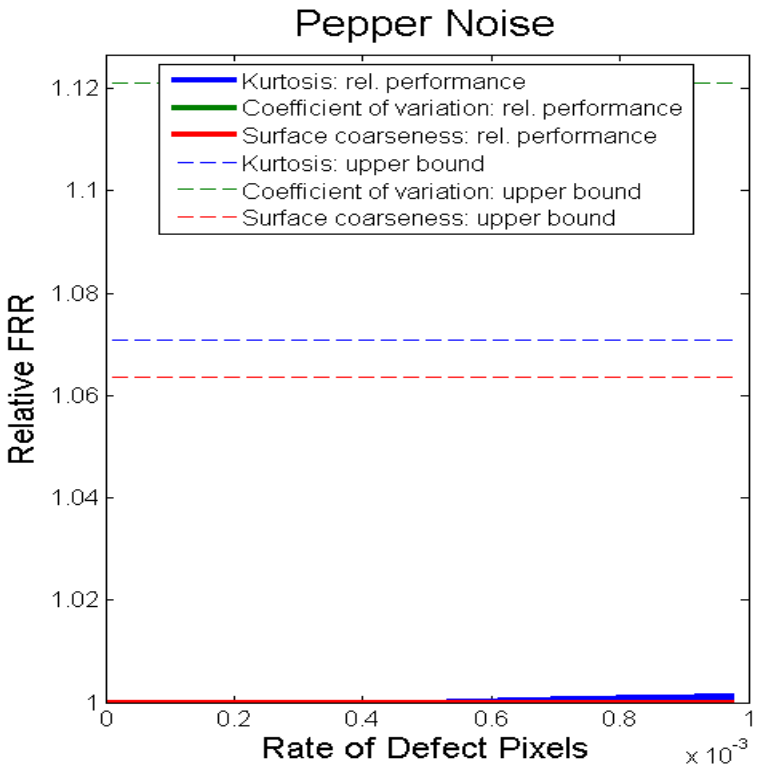
Example – Some Results





- Parameter: Rate of defect pixels
- "Pepper Noise": All seem to be robust.

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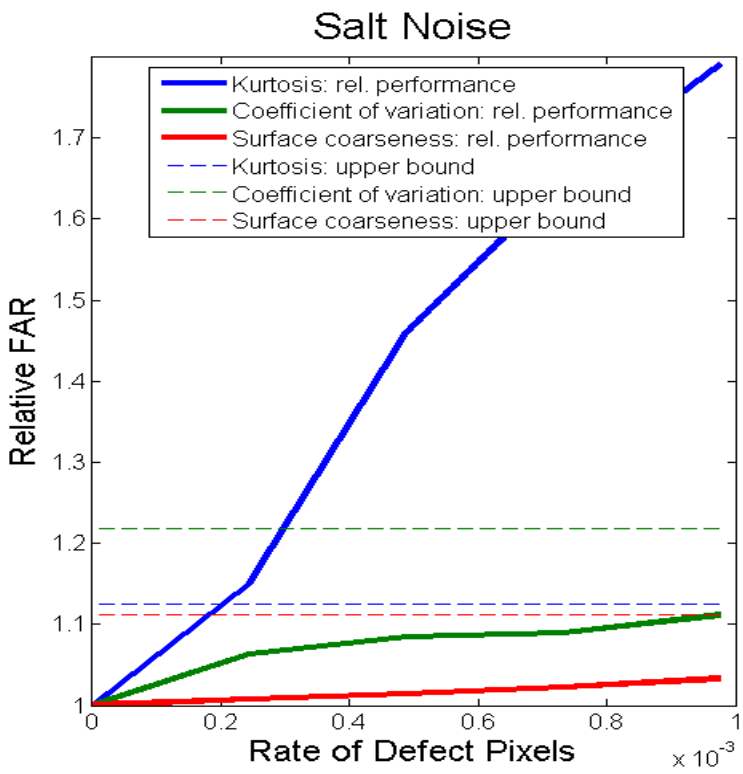
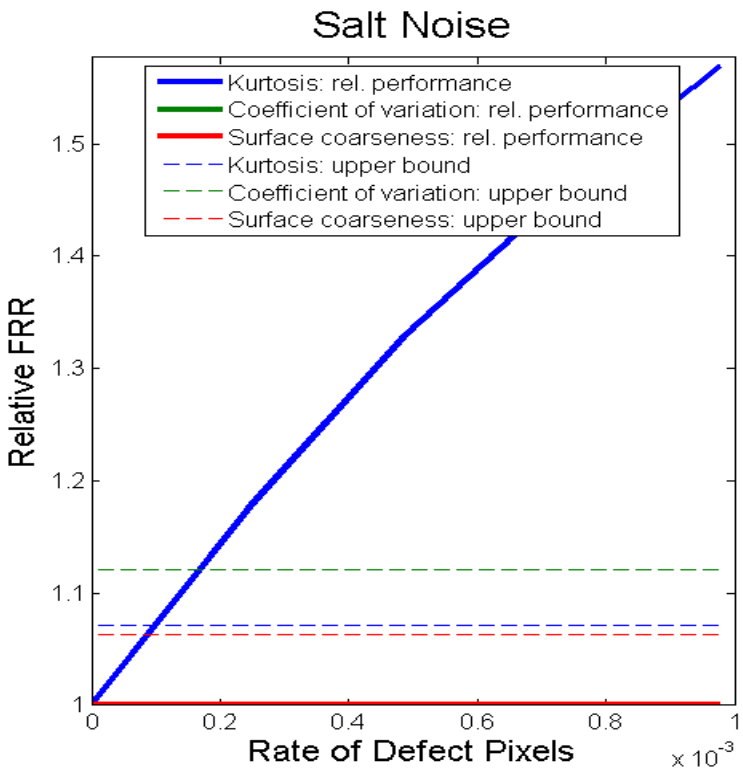
Example – Some Results





- Parameter: Rate of defect pixels
- "Salt Noise": Kurtosis is not robust.

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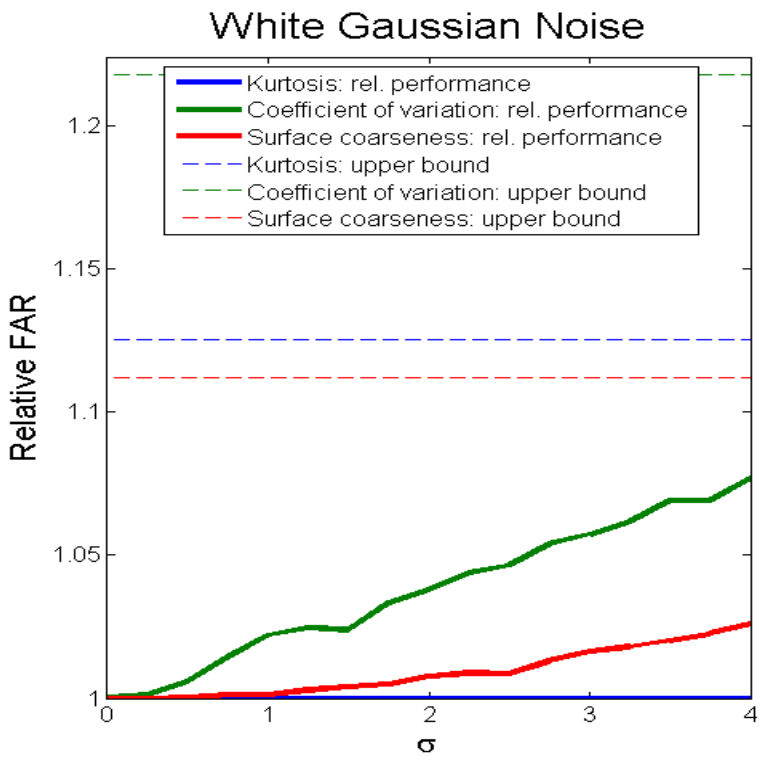
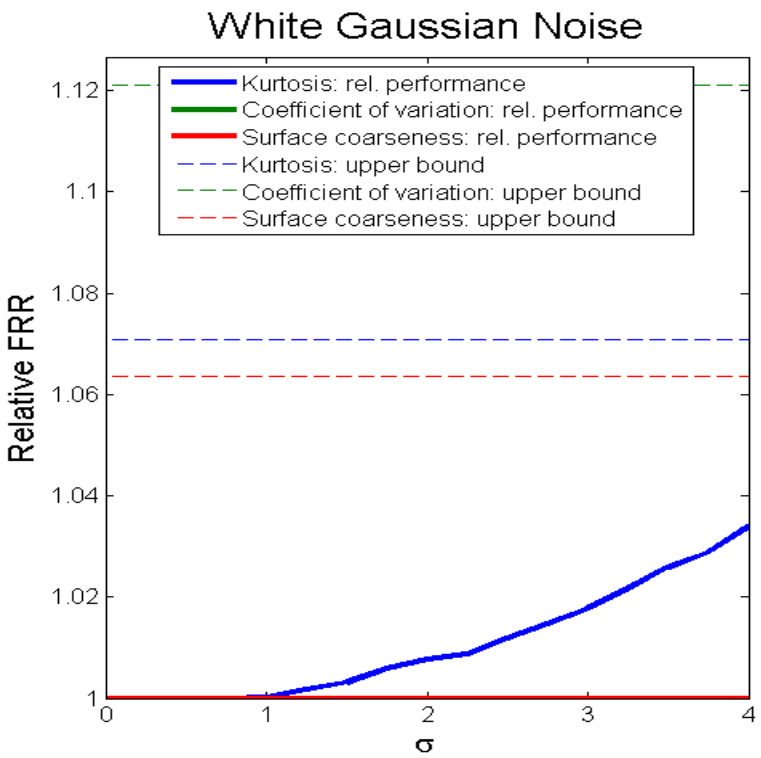
Example – Some Results





- Parameter range [0 4]
- All extractors seem to be robust.

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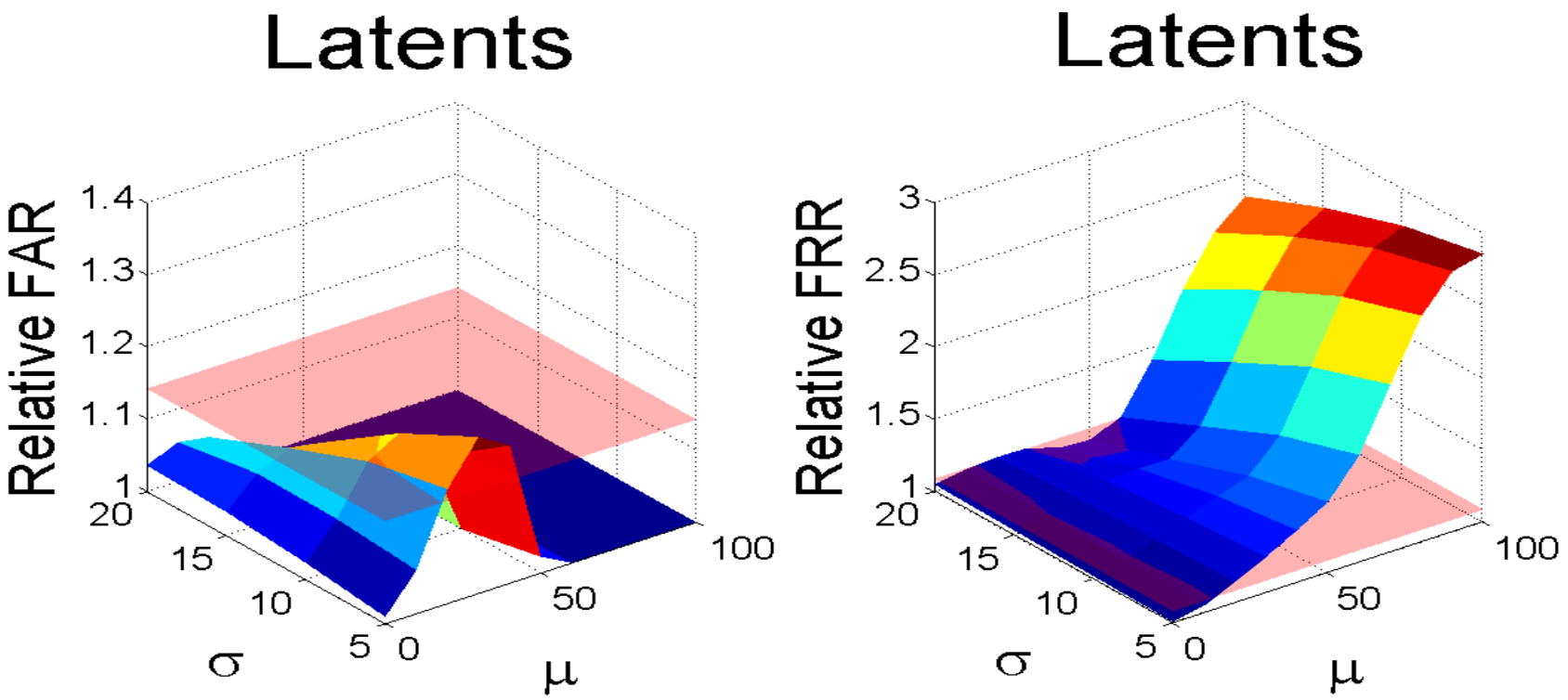
Example – Some Results



- Extractor: Kurtosis
- Parameter range: mean [0 100], deviation [0 15]
- Decay when mean gets close to common ridge mean.

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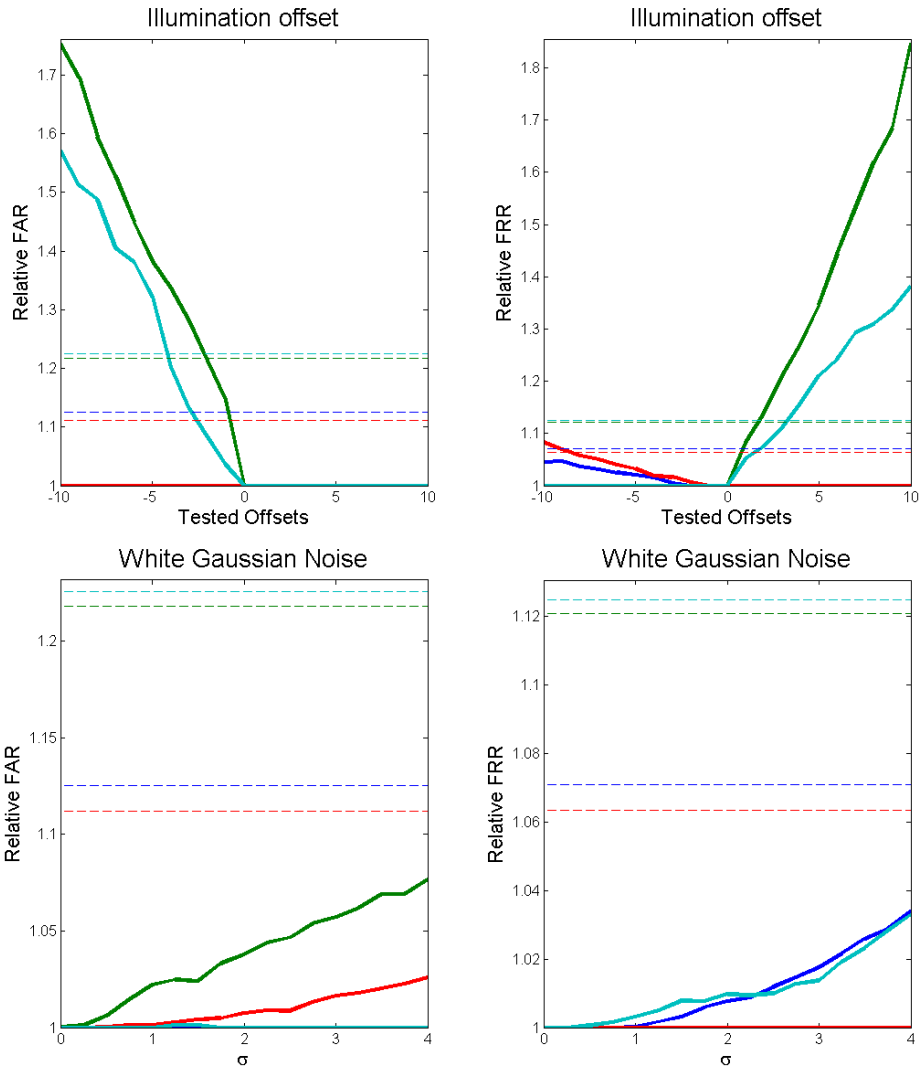
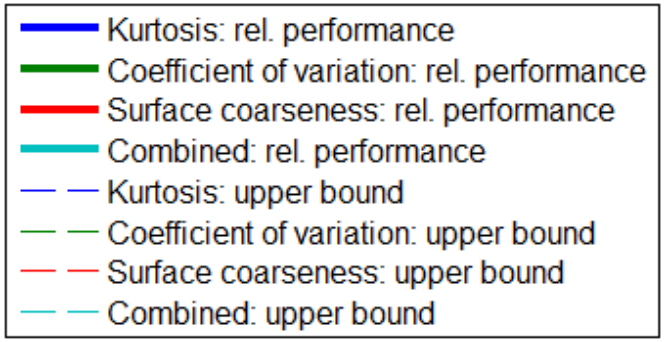
Example – Some Results





- Combination tested
- Single extractor may have impact on combined performance.

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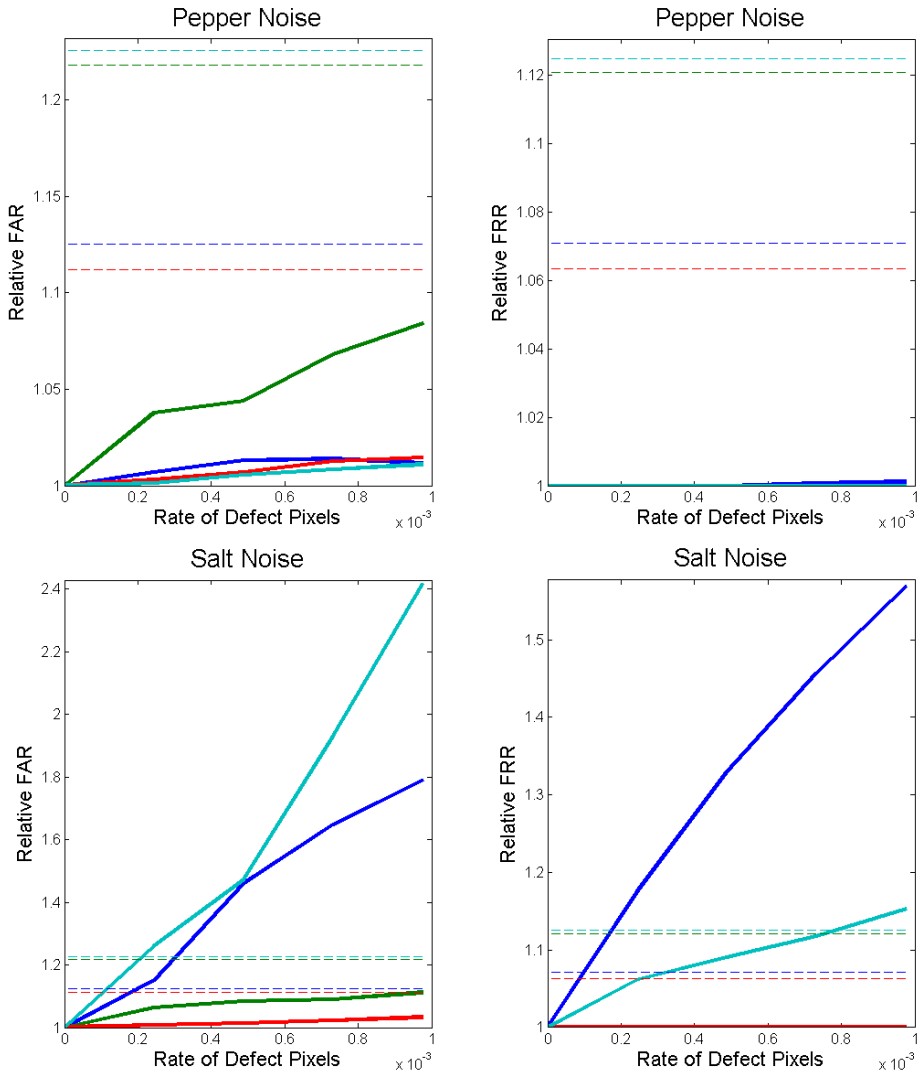
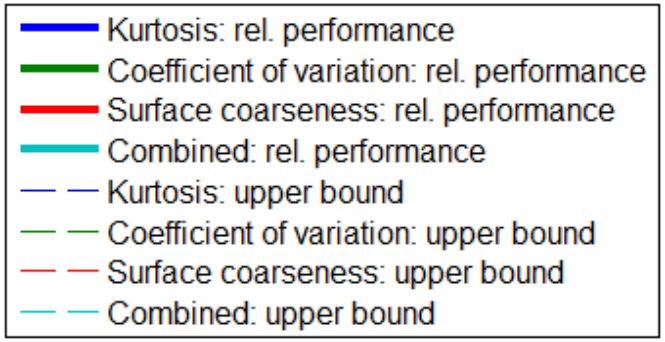
Example – Some Results





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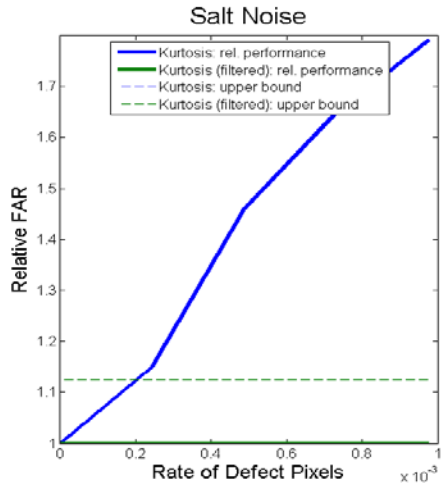

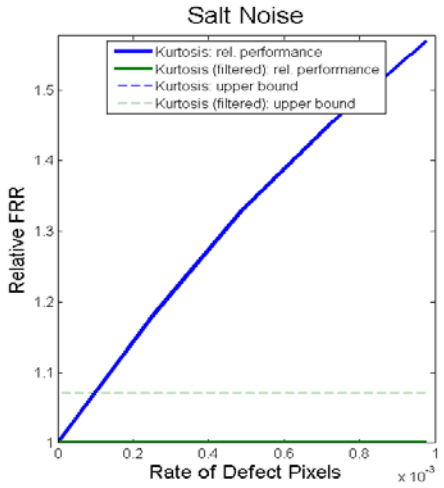

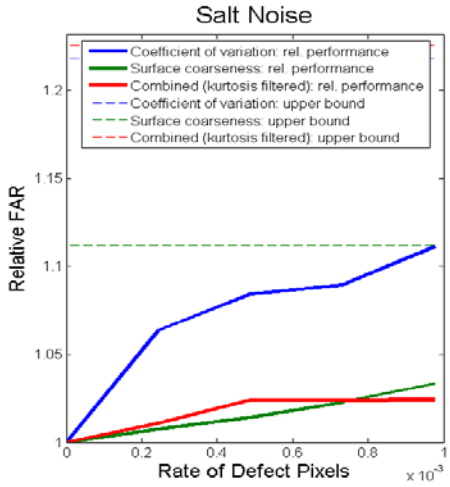

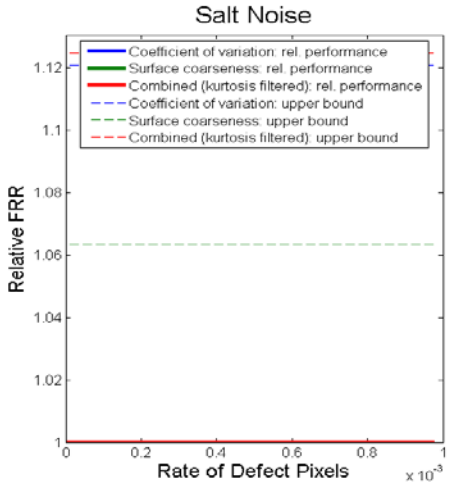

- Revealed problem: Kurtosis vs. “Salt Noise”
- Solution: apply special filter
- Robustness gained
- Iterative process

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Discussion

- Testing simulations…
  - shall not replace real data.
  - is cheaper.
  - is better than no testing.
- Curse of dimensionality: testing all combinations
- Classifiers influence needs inspection.

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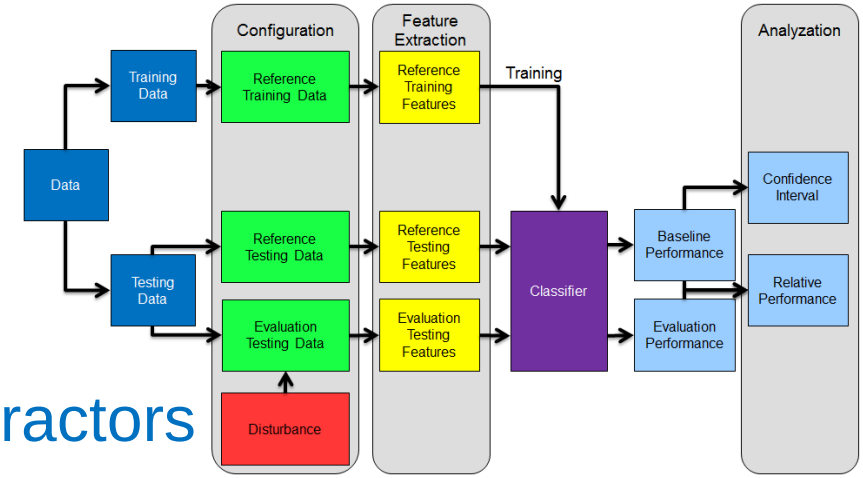
Summary

- Proposed method:
  - Easy workflow
  - Concentration on feature extractors
  - Know and model the environment
  - Tendencies observable in relative error rates.
  - Not limited to fingerprint
- Weakest link may have serious impact



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Outlook

- Revealed weaknesses in our own extractors
  - Robustness gained
  - Performance stabilized in the field
- Robustness over performance
- More disturbances to be modeled
  - More sophisticated models

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Do you have any questions?

Thank you.

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