

# Validation of Image Processing Methods for Fingerprints

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# Outline

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- Introduction
- Literature study
- Experiments
- Conclusion

# Validation of image processing

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- Several publications in forensic journals and publications from 1988
- Actual work in fingerprints, documents, video image processing
- SPIE working group Investigative Image Processing
- US – Frye / Daubert

- “Often, the initial reaction is one of disapproval. The concern is that non-existent detail is added to the latent print. Image enhancement techniques are not designed to create detail but to improve images for human interpretation.

# continued

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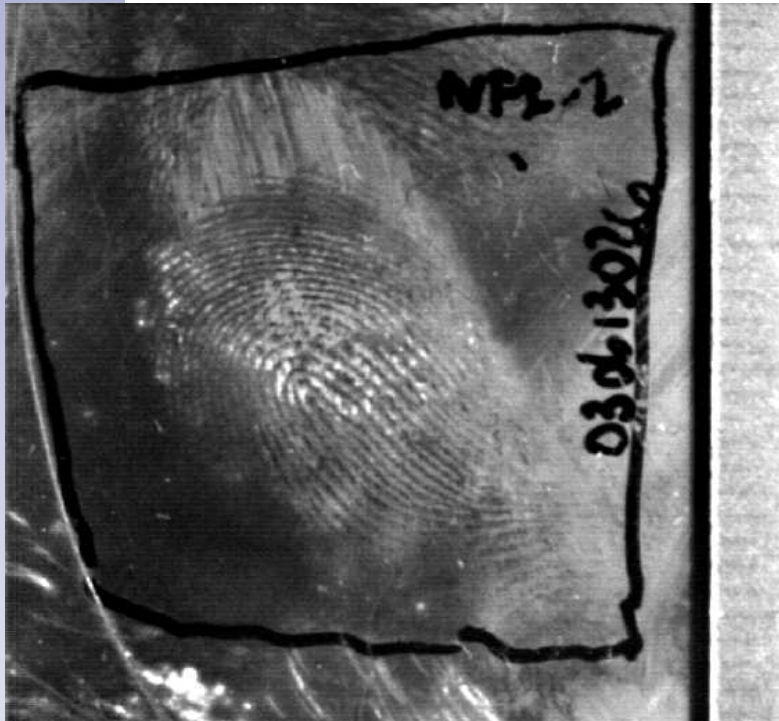
- Just as photographic techniques assist us in seeing various spectral ranges (such as infrared) and microscopes help us to see extremely small items, image enhancement techniques can help us to discern minute details within the image.”

# Methods


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- Contrast stretching / histogram equalization – low risk
- use of kernels - depending on kernel risk
- FFT – higher risk
- Dilation / erosion – high risk
- Wavelet – unknown risk
- Subtraction with registration (Improofs project EU) – depending on method used

# Use of a kernel



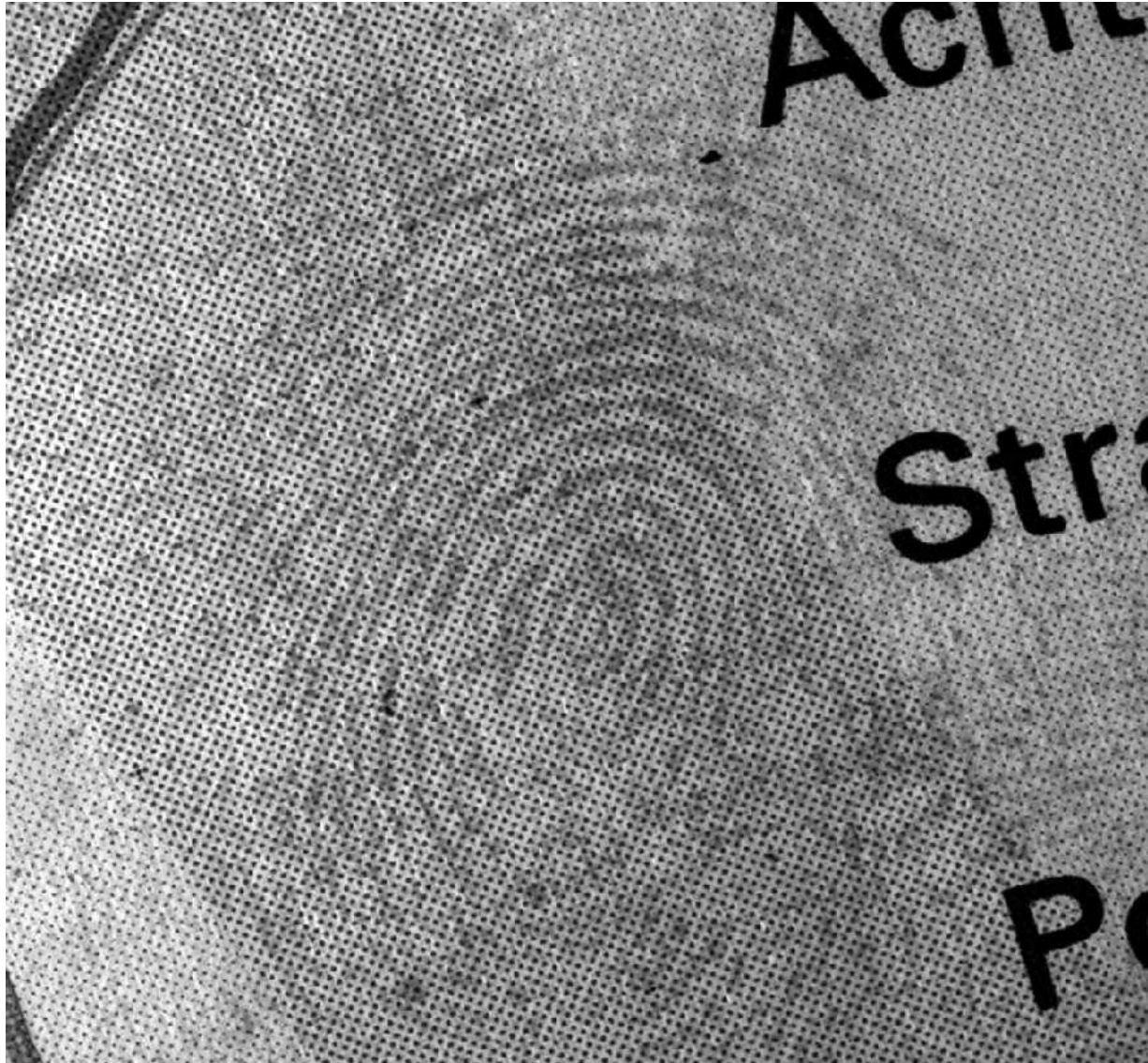
Eigen

	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	OK
	<input type="text"/>	<input type="text"/>	<input type="text"/>	7	<input type="text"/>	<input type="text"/>	<input type="text"/>	Annuleren
	-1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	Laden...
	-1	-1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	Opslaan...
	-1	-1	-1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input checked="" type="checkbox"/> Voorbeeld

Schalen:  Verschuiven:



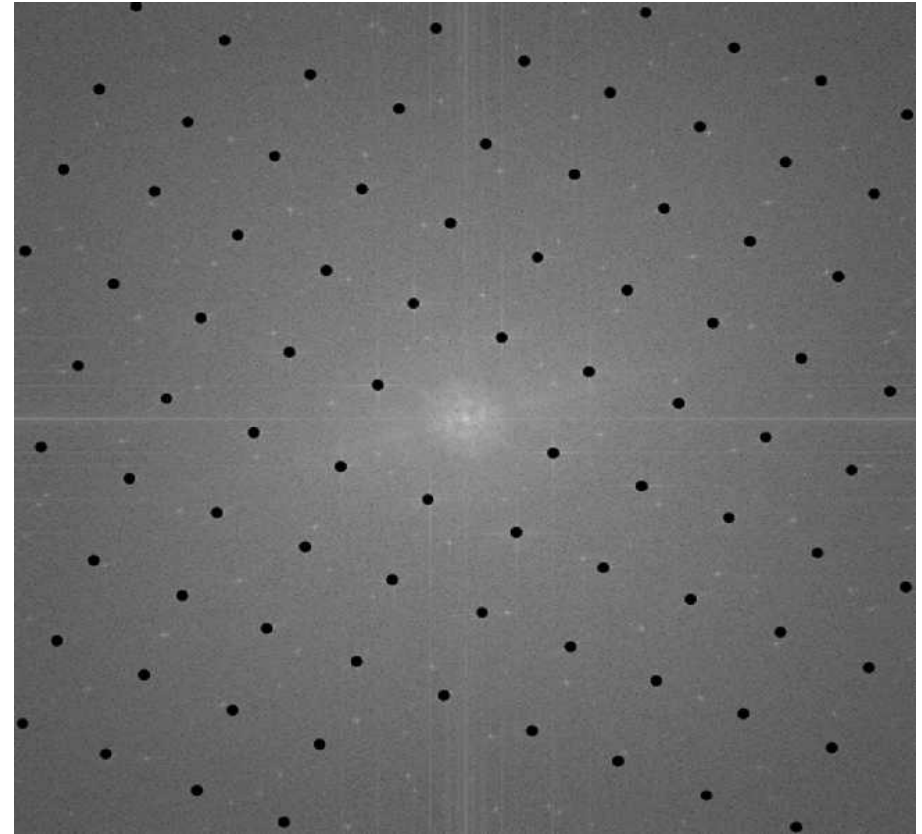
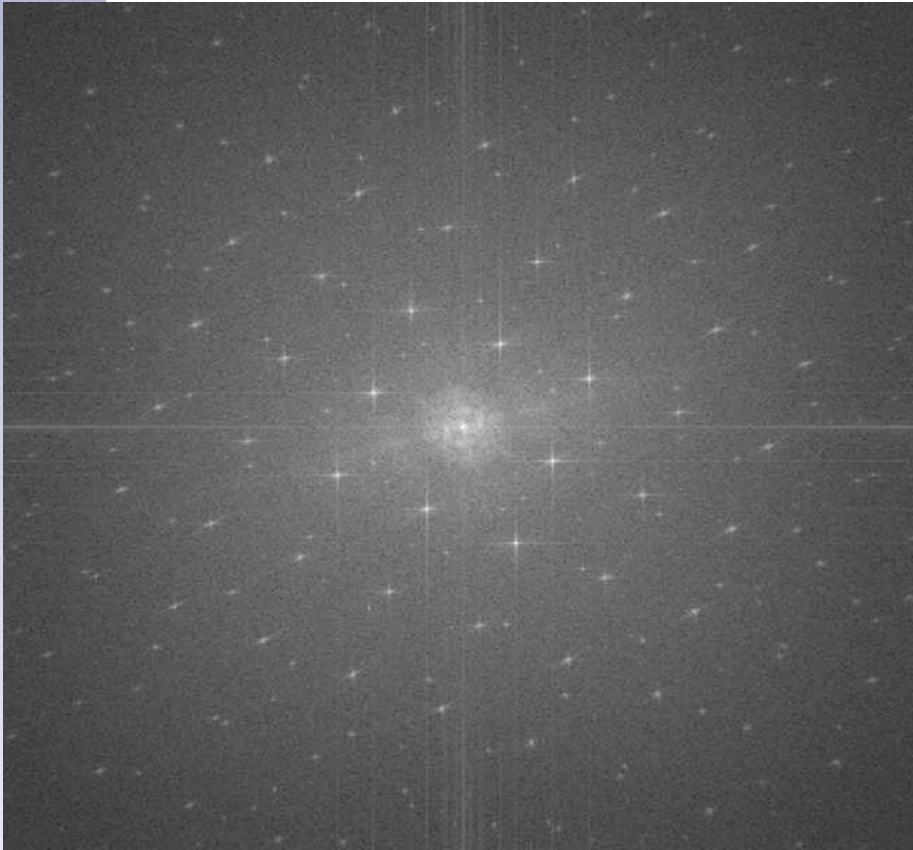
# FFT Example 1





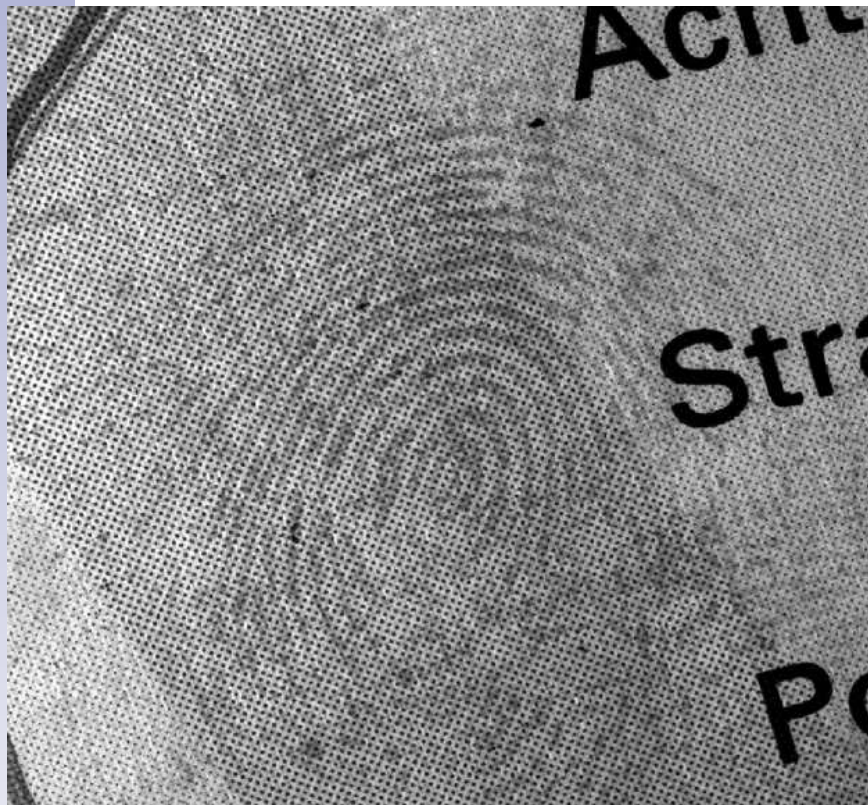
# Frequency Spectrum

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# Result

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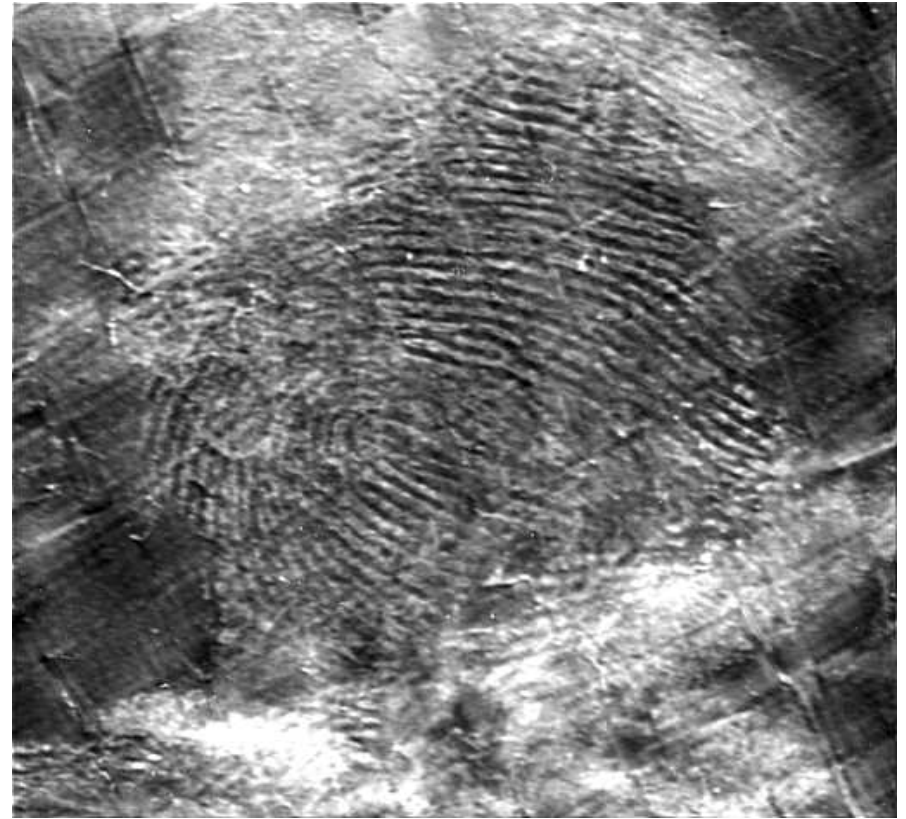
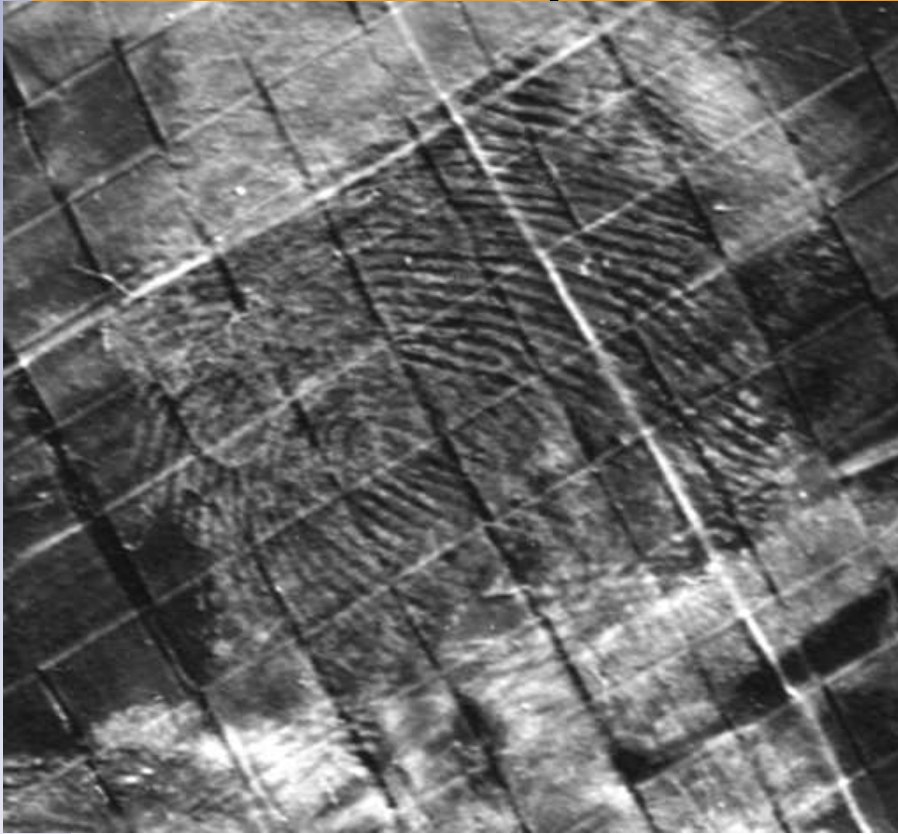


# FFT example

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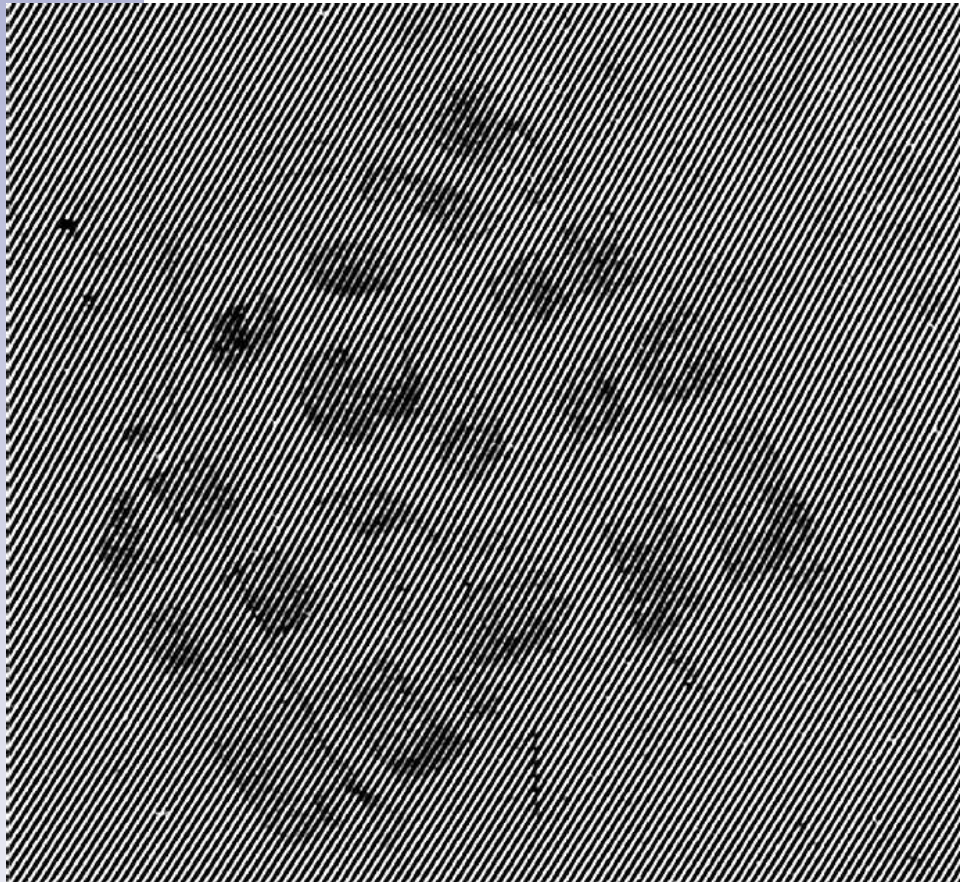
# FFT example 2





# FFT shoeprint

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# FFT crossed fingerprints

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# Warnings

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- 1994 S. Bramble : “We found that excessive cutting of the data can seriously degrade the image”. And in
- 1993 E. Berg / 1999 W. Watling : “However, one must be extremely careful when using the FFT spike boost so as not to cross the line between enhancement and restoration”.

## *Feb. 1998 STATE v. HAYDEN 109 90*

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- “The evidence in the record supports the trial court's unchallenged findings that the technique utilised by Berg has a reliability factor of 100 percent and a zero percent margin of error and that the results are visually verifiable and could be easily duplicated by another expert using his or her own digital camera and appropriate computer software.”

# Subtraction - Improofs

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<http://www.esat.kuleuven.ac.be/~konijn/improofs.html>

# New techniques

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- Che-en Wen ; Journal of Forensic Science  
September 2003 pp. 1-12.
- Tests on synthetic fingerprints
- AM-FM method - similar to wavelet filtering

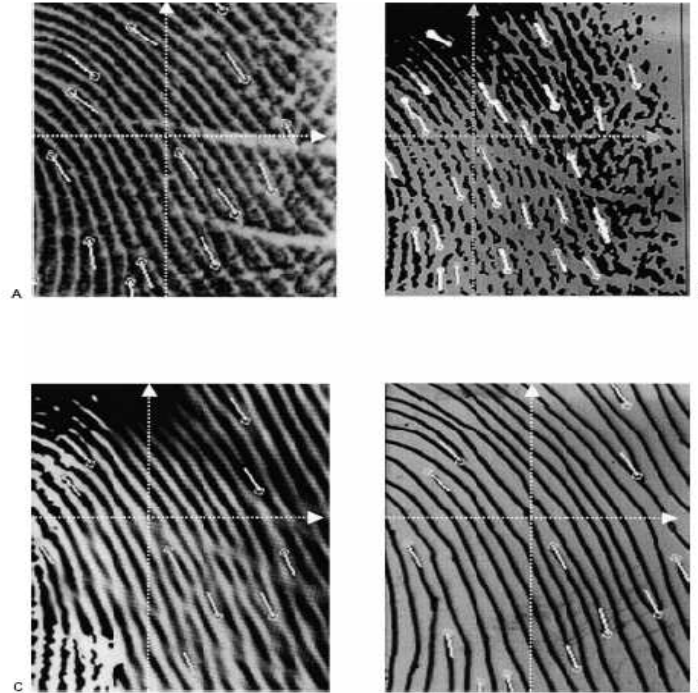


FIG. 15—(a), An original perfect fingerprint image; (b) the same image with the bad impressing process; (c) and (d) are the restored images by our method and fingerprint examiners, respectively. From the experimental results, we can see the feature extraction results are similar to each other.

# research questions

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- do we assign more correct points in the extreme enhanced version => intended effect
- do we assign more false points in the extreme enhanced version => side effect
- classification / limits



# consequential effects

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- effect on database search:
  - scores / ranking / hitlist occurrence
- effect on systems imprecision:
  - less variation => benefit
- effect on time:
  - time needed to assign points
  - number of needed database-searches

# Experimental design

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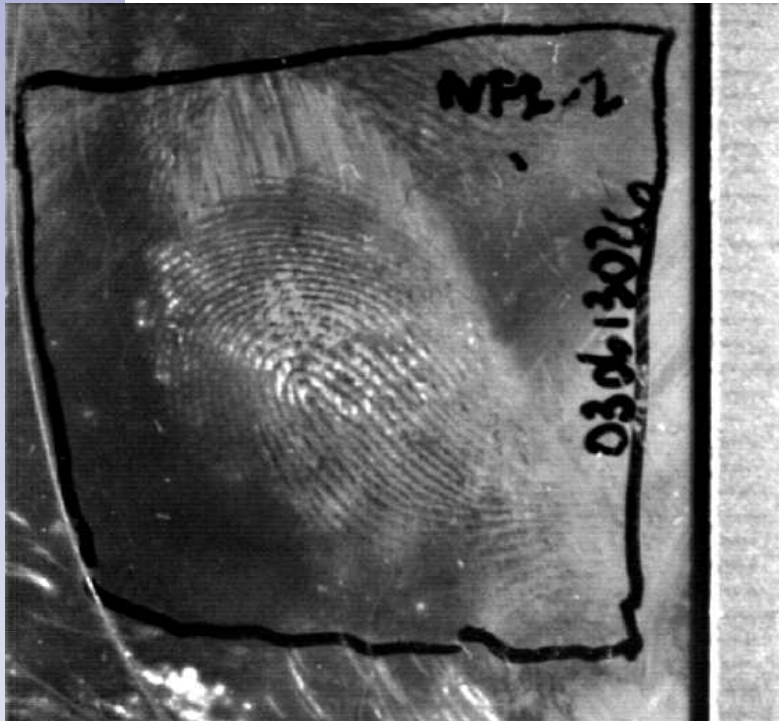
- 100 fingers: 4 versions => 400 images
- assign all points in all images (random order)
- compare number of correct and false points in all versions
- compare scores and hitlist appearances
- determine if possible found differences are indeed differences and don't fall within range of systems imprecision

# processing methods

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- Contrast stretching – low risk
- Histogram equalization – low risk
- kernels – risks depending on kernel
- FFT- amplify – higher risk
- FFT- reject – high risk
- Dilation / erosion – high risk
- Brush tools – low risk

# Use of a kernel

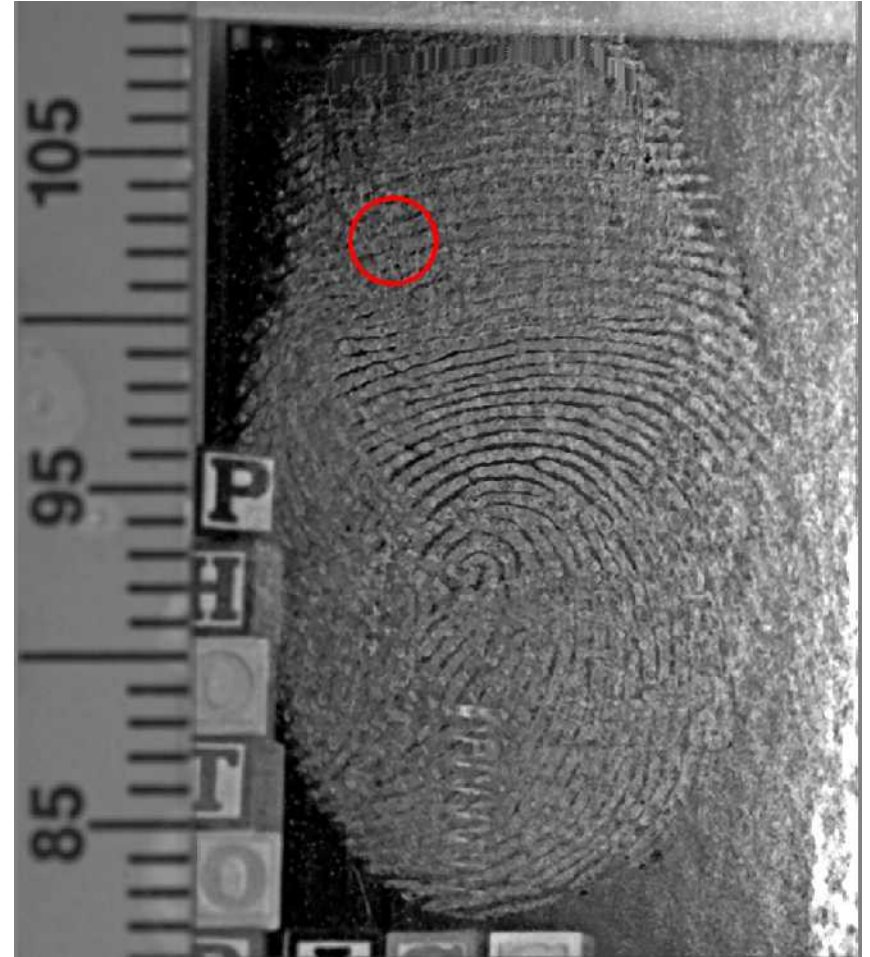
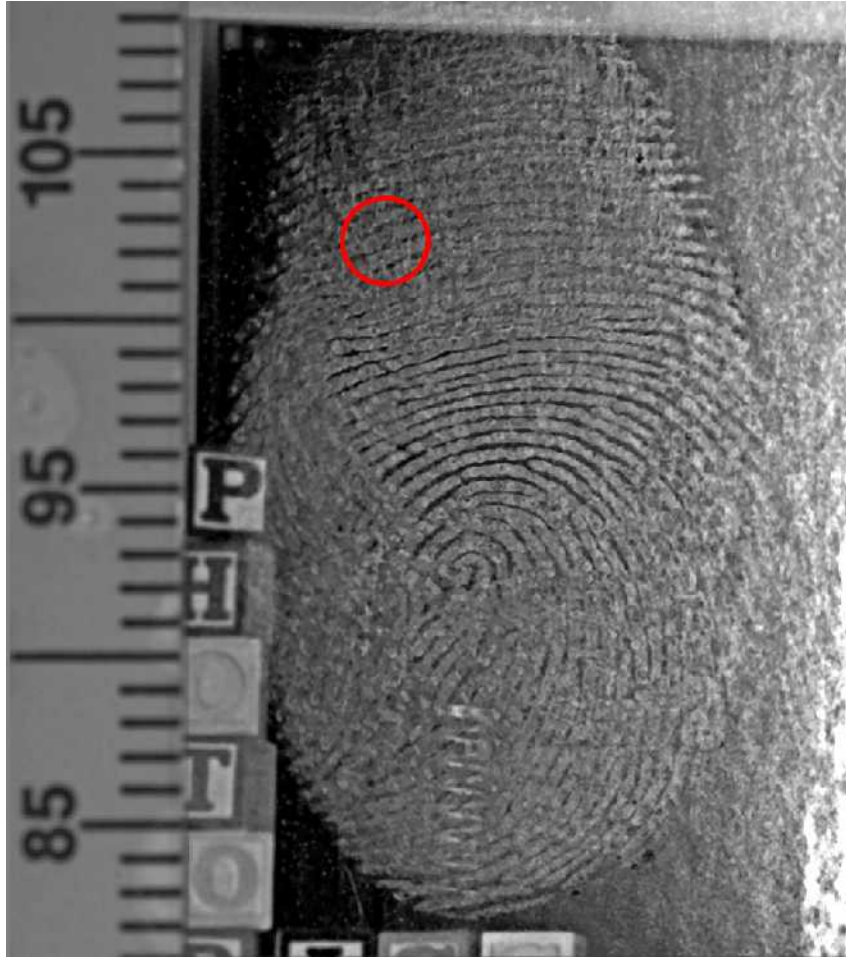


Eigen

	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	OK
	<input type="text"/>	<input type="text"/>	<input type="text"/>	7	<input type="text"/>	<input type="text"/>	<input type="text"/>	Annuleren
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	-1	-1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	Opslaan...
	-1	-1	-1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input checked="" type="checkbox"/> Voorbeeld

Schalen:  Verschuiven:

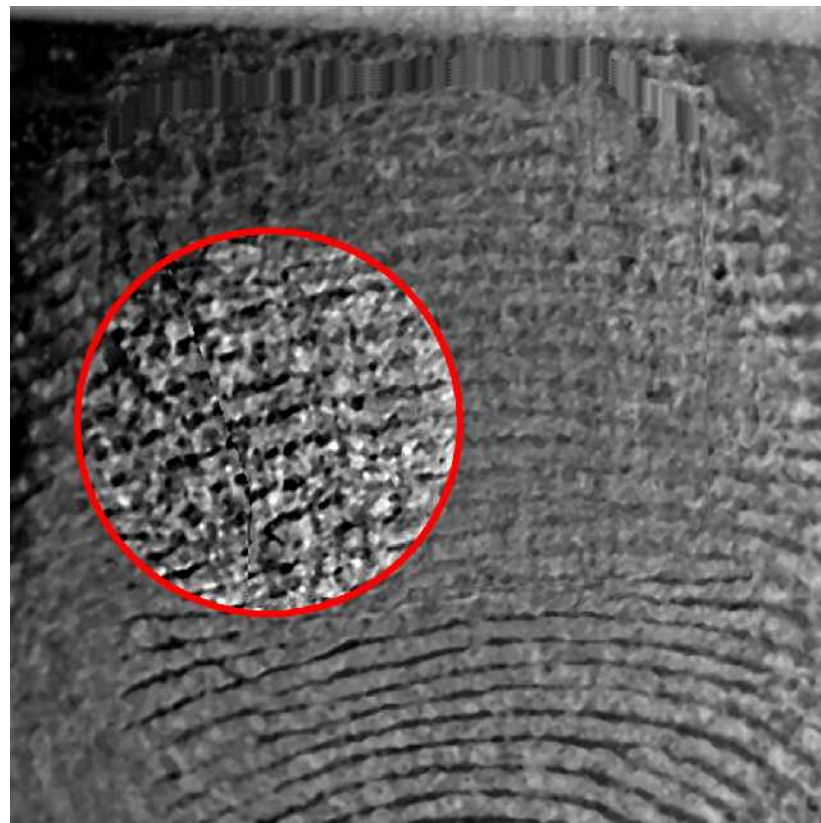
# shift down kernel





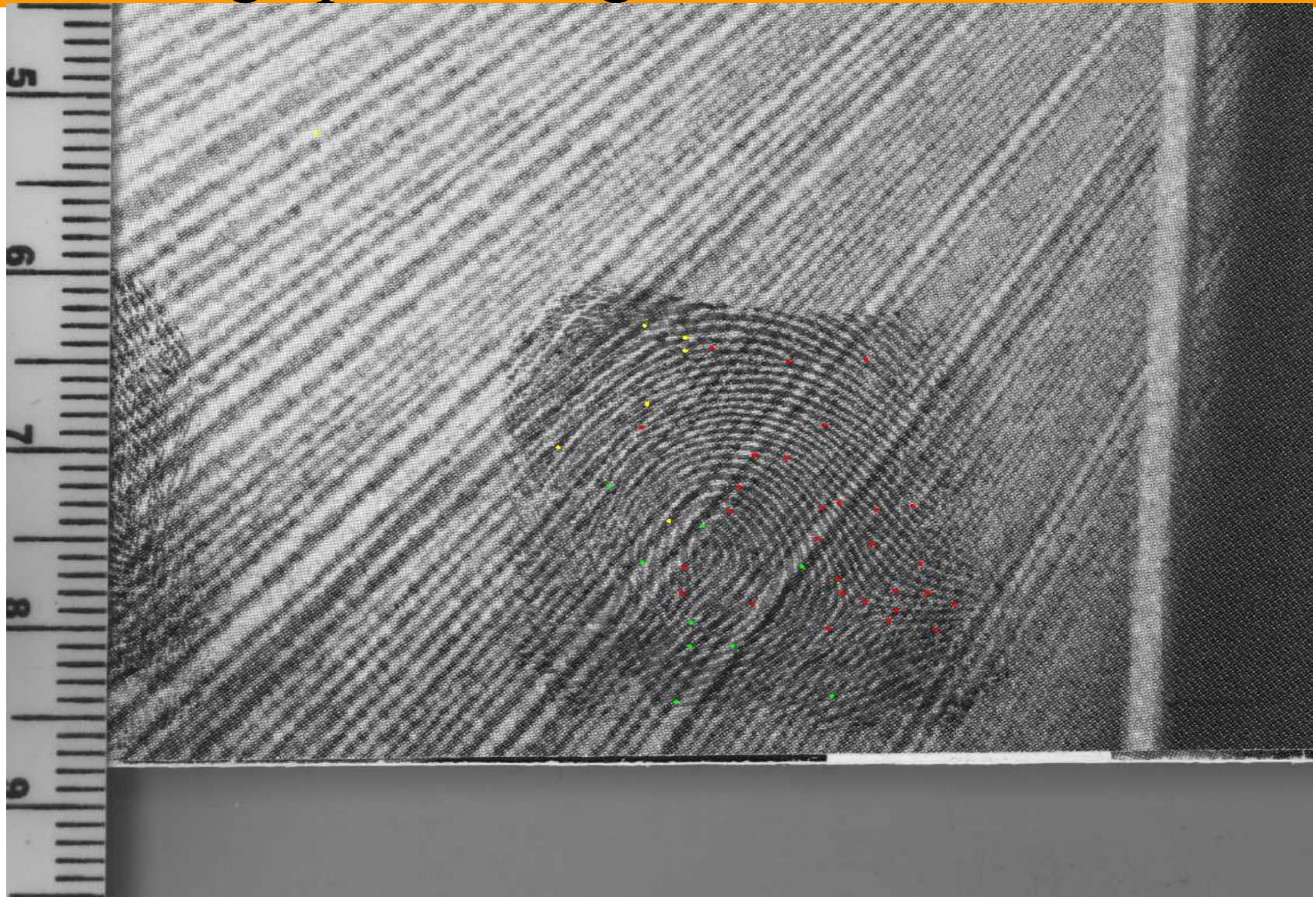
# shift down kernel

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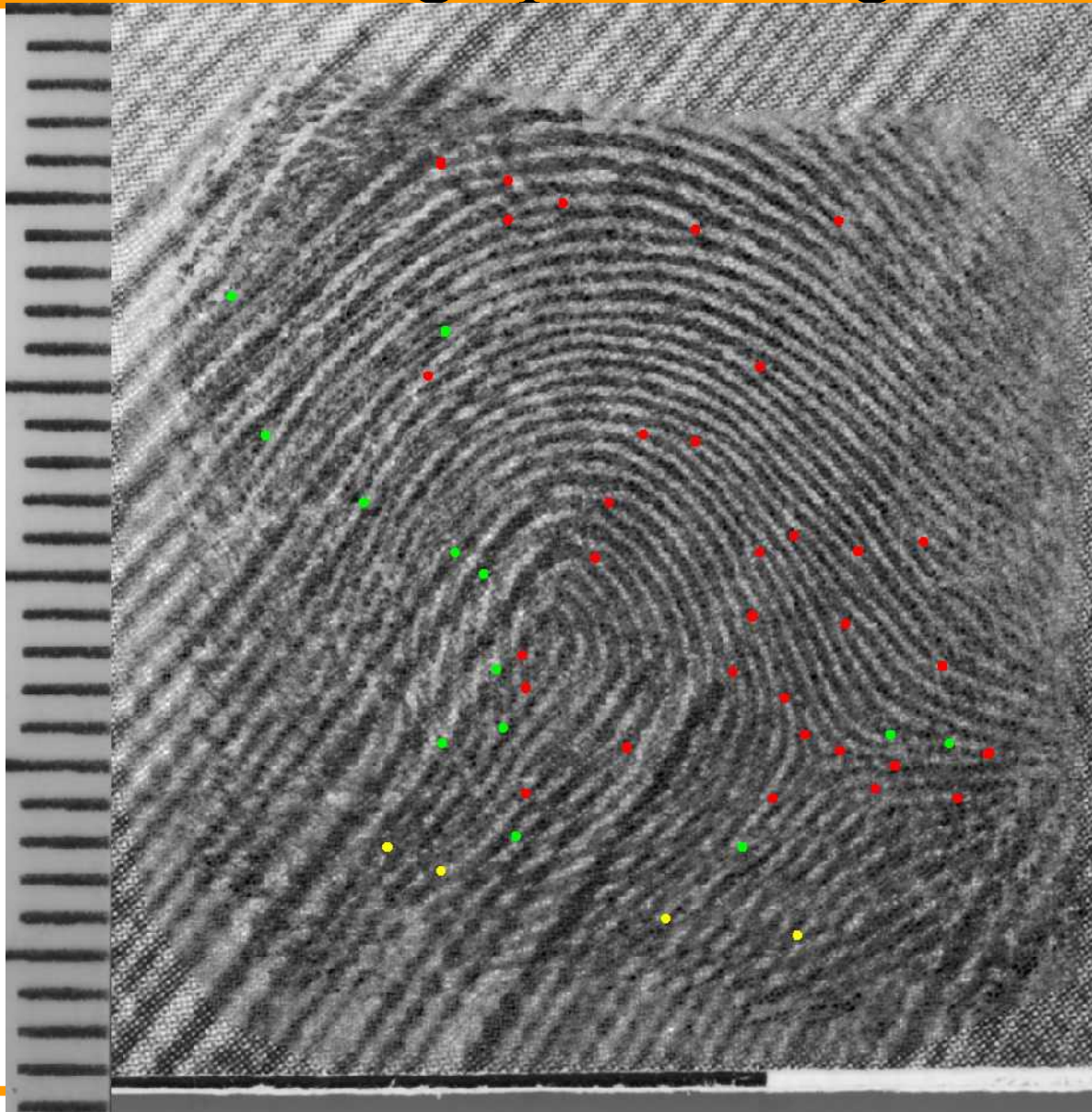
# No image processing





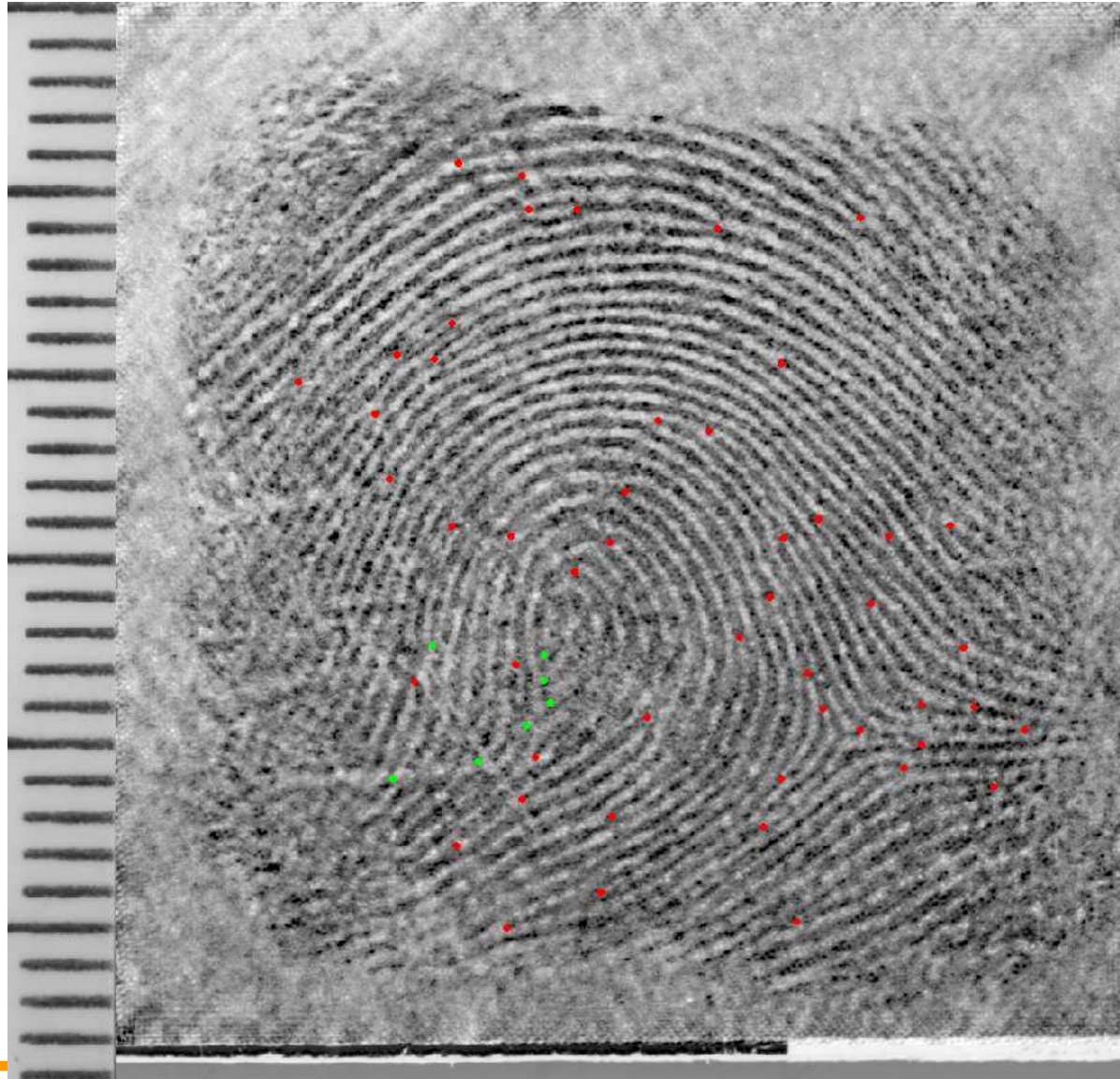
# Results with image processing

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# Results with extreme image processing

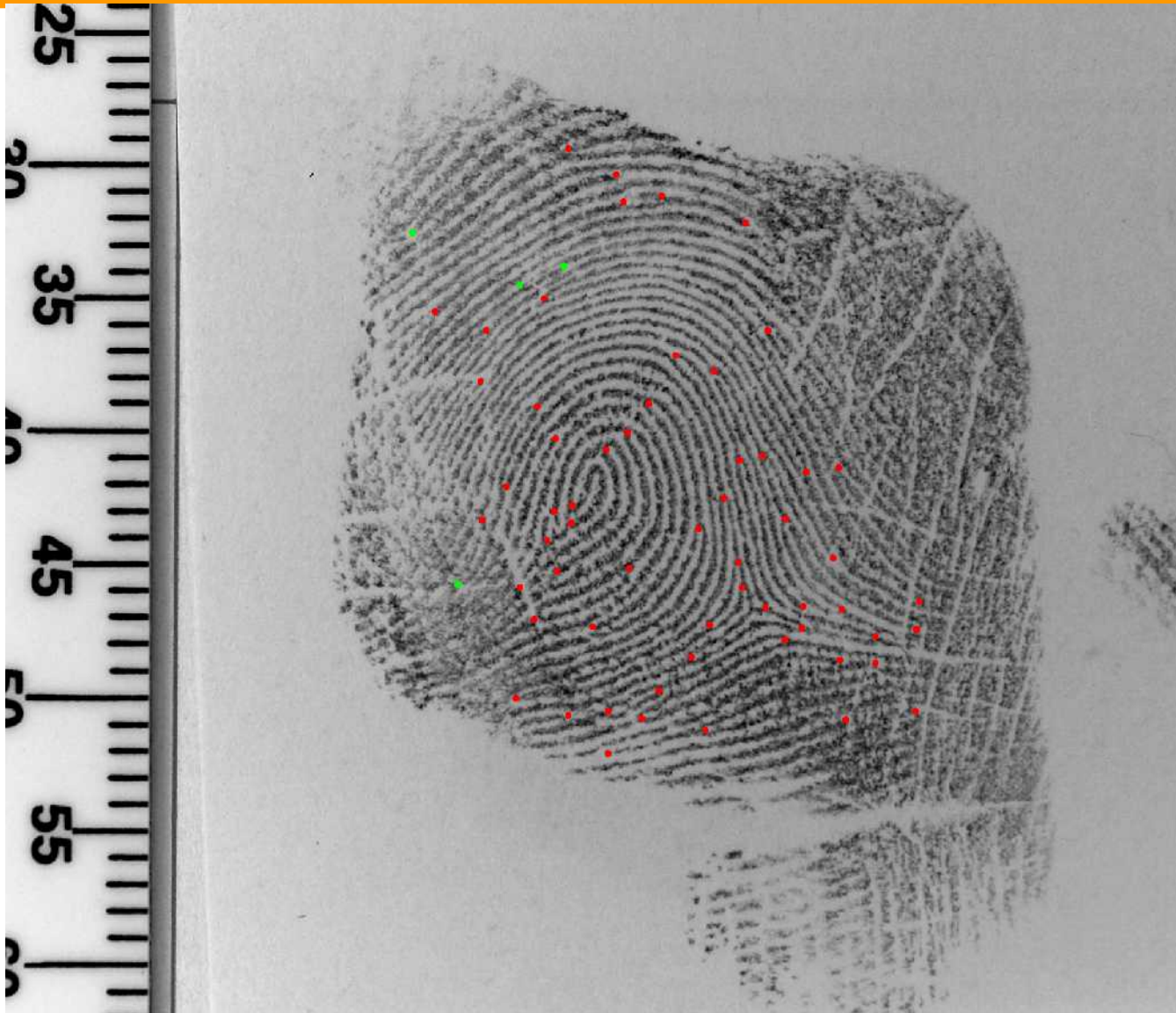
- 





# Print

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# Results

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- Red = sure, green = doubt, yellow = false
- Not processed (r,g,y) (35, 4, 0)
- Processed (r,g,y) (44, 11, 0)
- Extremely Processed (r.g.y) (51, 6, 0)

# observations so far

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- risks highly depend on use of tools
- extreme use not likely to be accidental => hard to be that “unknowing”..
- difficult to make good “bad” marks
- register used tools determine afterwards which cause problems



# Discussion

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- Which new techniques are admissible
- If critically reviewed, can the current techniques also lead to discussion in court ?
- Know what the limits are of image processing
- Validation with same method as is used for the WSQ-compression ? - test with different examiners (proficiency testing)
- Depending on the number of features that are visible

# Conclusion

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- The errors with different examiners clicking different points should be looked at closer
- With extreme image processing it seems that fingerprint experts are becoming more aware of possible errors
- Always inform the examiner what kind of image processing has been used