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A forensic latent fingerprint image quality metric for preprocessing quality assurance

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Outline

- Latent fingerprint image preprocessing
  - What?
  - Why?
  - How?
- Latent fingerprint image preprocessing work flow
- Latent fingerprint image quality metric
- Discussion and future work

Forensic Latent Fingerprint Preprocessing: What

Scope:

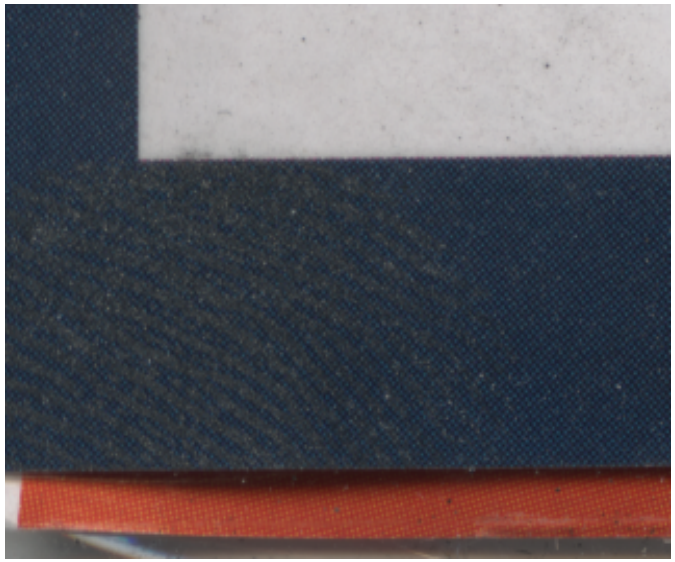
- Forensic latent fingerprint preprocessing covers all image transformation performed on fingerprint images obtained at crime scene prior to submission for identity analysis.

Before

After

Forensic Latent Fingerprint Preprocessing: What

- Before image samples (1)
  - Latent fingerprint from crime scene can be developed with a variety of processes: optical, physical, chemical, etc.



Bi-Chromatic Mag Powder Developed Print

Bi-Chromatic Powder Developed Print

Black ink pad on colored background

Forensic Latent Fingerprint Preprocessing: What

- Before image samples (2)

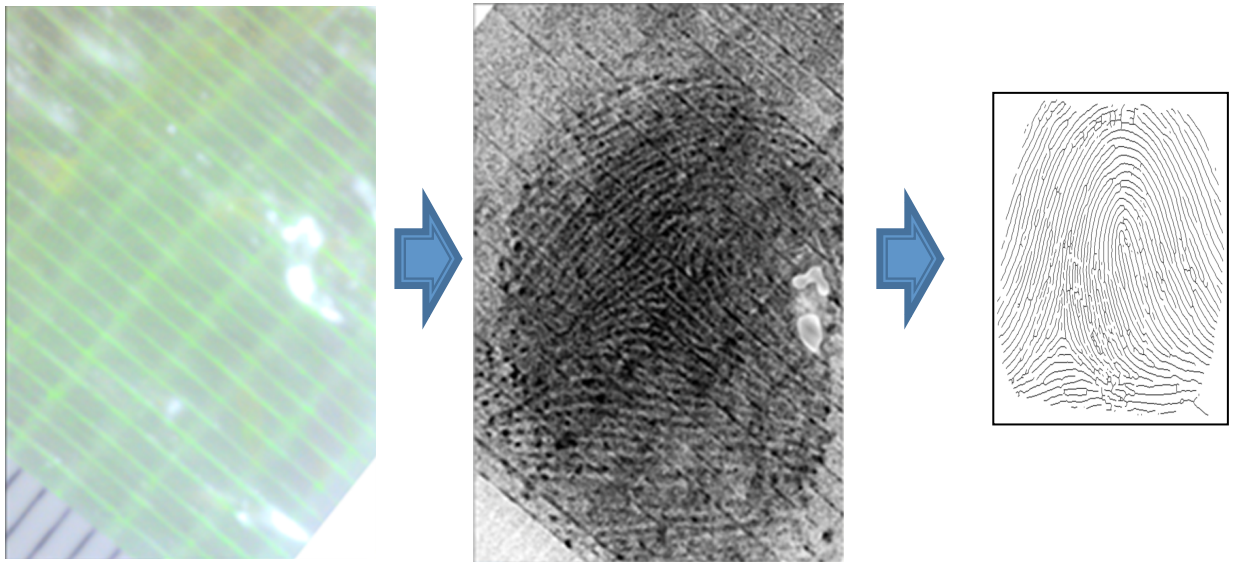
Ninhydrin developed prints

Silver mag powder developed prints

White powder developed prints

Forensic Latent Fingerprint Preprocessing: Why

- Directly affects the performance of fingerprint matching/recognition by both latent examiner and AFIS systems.
- Latent fingerprint image quality is generally much lower than scanned fingerprint. Preprocessing aims at improving image quality effectively.



Before

After

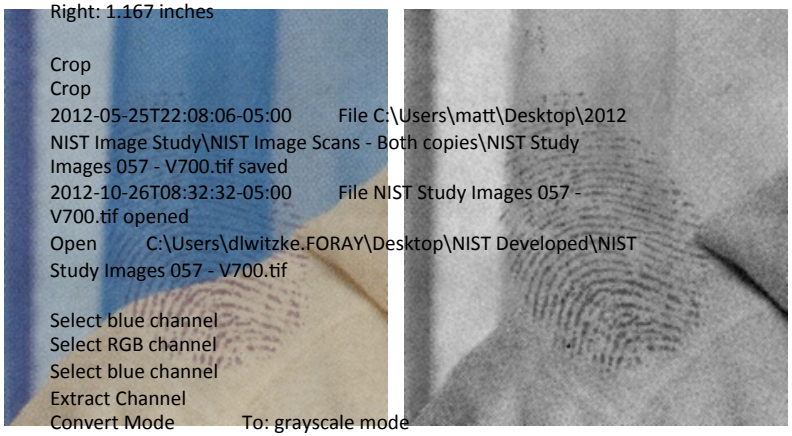
What AFIS sees

Forensic Latent Fingerprint Preprocessing: How

- Project Goal
  - To characterize the effects of image preprocessing that transforms the latent fingerprint image obtained from the crime scene ('before image') to the image used for identity analysis ('after image').
  - To study integrity problem.
  - To provide scientific, systematic tool and reproducible guidance.
- Approaches
  - Understand the preprocessing procedure and work flow;
  - Develop the latent fingerprint image quality metrics;
  - Compare before and after images, and study the effectiveness of preprocessing to both latent examiners and machine algorithms.

Forensic Latent Fingerprint Preprocessing: Work Flow (1)

2012-05-25T22:07:53-05:00 File NIST Study Images 057 - V700.tif opened
Open C:\Users\matt\Desktop\2012 NIST Image Study\NIST Image Scans - Both copies\NIST Study Images 057 - V700.tif
Rectangular Marquee
Set Selection To: rectangle
Top: 0.347 inches
Left: 0.124 inches
Bottom: 1.477 inches
Right: 1.167 inches



Crop
Crop
2012-05-25T22:08:06-05:00 File C:\Users\matt\Desktop\2012 NIST Image Study\NIST Image Scans - Both copies\NIST Study Images 057 - V700.tif saved
2012-10-26T08:32:32-05:00 File NIST Study Images 057 - V700.tif opened
Open C:\Users\dlwitzke.FORAY\Desktop\NIST Developed\NIST Study Images 057 - V700.tif

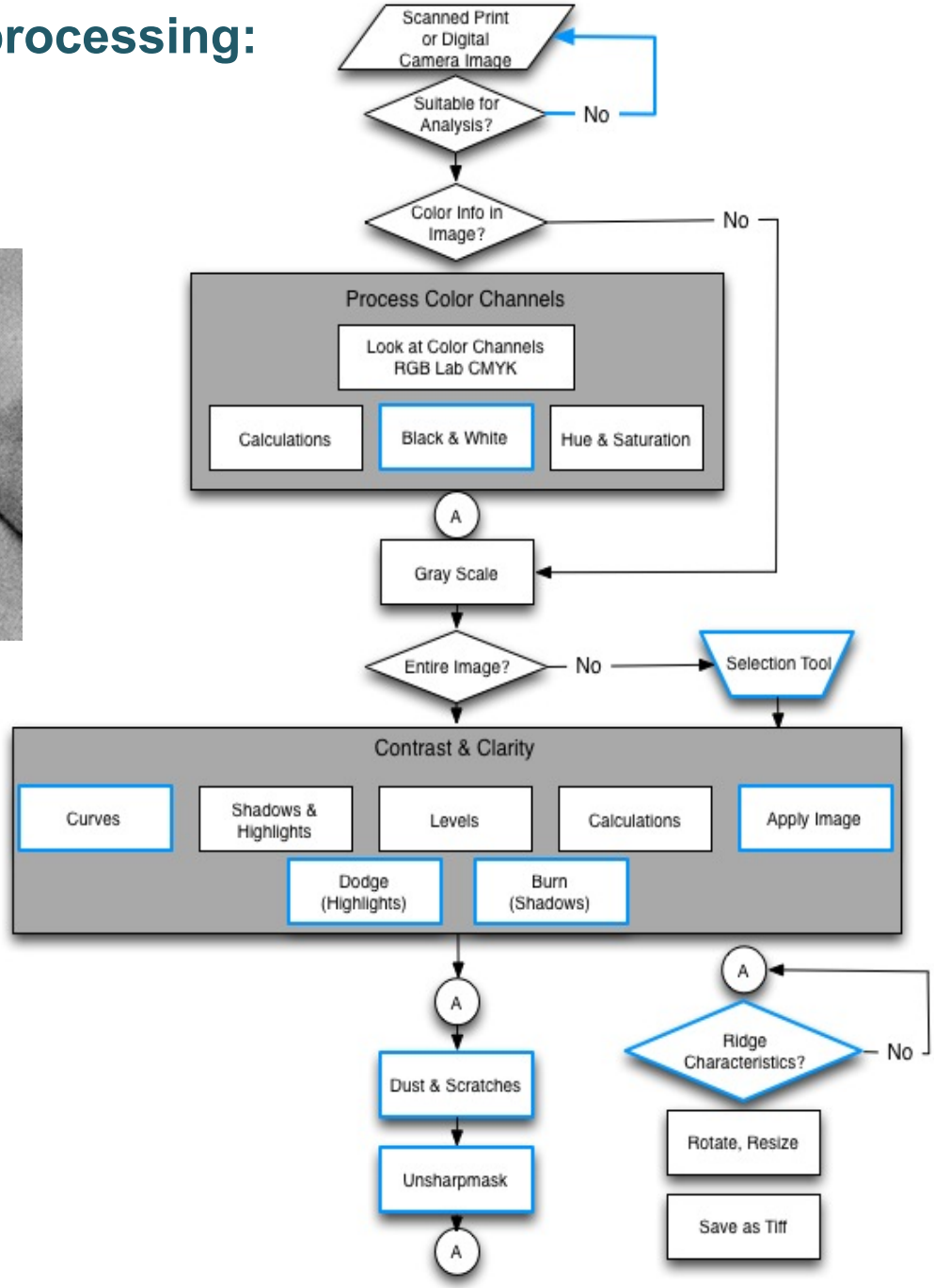
Select blue channel
Select RGB channel
Select blue channel
Extract Channel
Convert Mode To: grayscale mode

Chromatic FFT
Filter Using: "Chromatic FFT..."

Shadows/Highlights
Shadow/Highlight Shadow: Parameters
Amount: 35%
Tone Width: 50%
Radius: 30
Highlight: Parameters
Amount: 68%
Tone Width: 67%
Radius: 30
Black Clip: 0.01
White Clip: 0.01
Contrast: 36
Brightness: -24

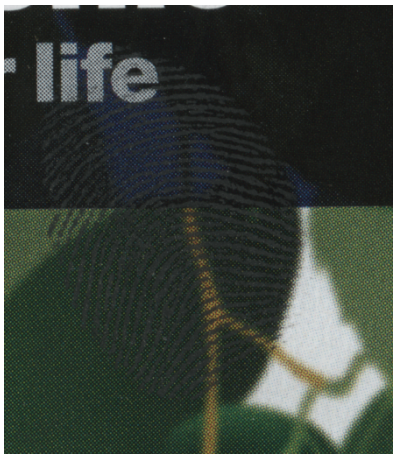
Apply Image
Apply Image With: calculation
Source: current channel
Calculation: overlay
With Preserve Transparency

Apply Image
Apply Image With: calculation
Source: current channel
Calculation: screen

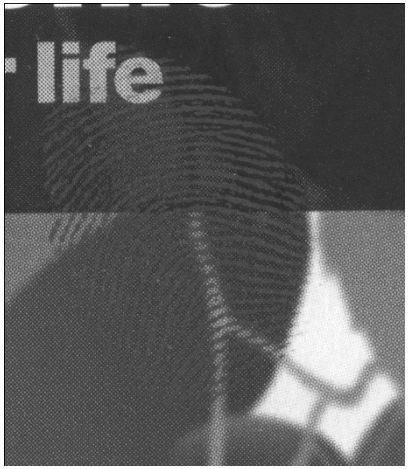


Work flow (2): A complex and creative procedure

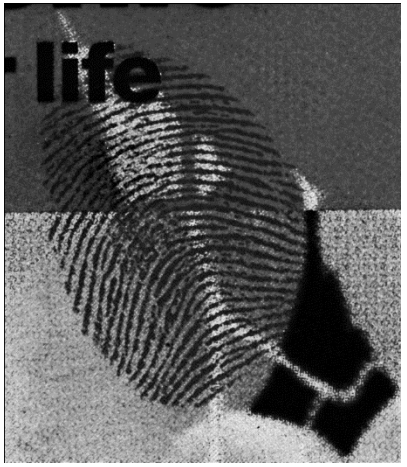
- A creative process
- Not a single activity
- Diverse implementation
  - color filtration
  - contrast adjustment
  - edge enhancement
  - background suppression
  - noise filtration
- Diverse endpoints



1 Address Color

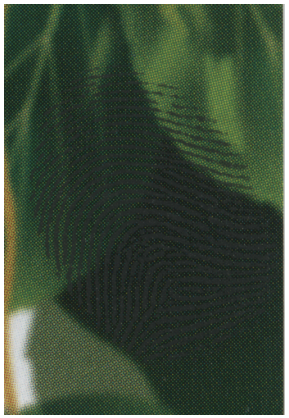


2 Address Contrast



3 Fine Tune Image

Before



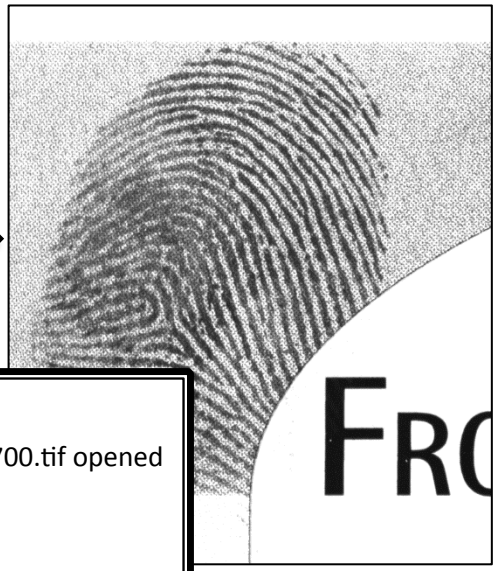
After 2

Forensic Latent Fingerprint Preprocessing Samples (1)

Bi-Chromatic Mag Powder

Before

After



Metadata

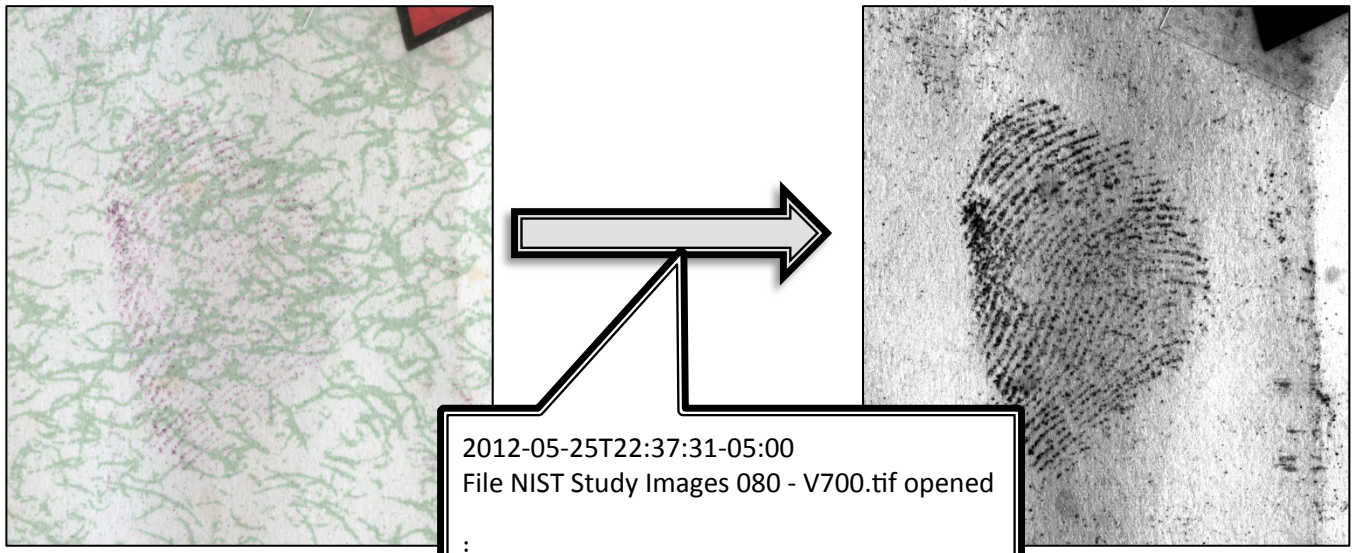
2012-05-26T16:13:11-05:00
File NIST Study Images 158 - V700.tif opened

Black & White
red: -12
yellow: -68
green: 300
⋮
Invert
⋮
Burn
⋮

Forensic Latent Fingerprint Preprocessing Samples (2)

Before **After**

Ninhydrin



Metadata

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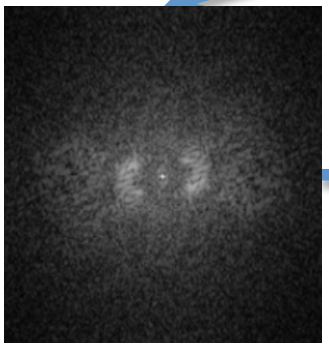
⋮
Calculations
MakeNew: channel
Using: calculation
Source: current channel
Calculation: multiply
Opacity: 50%
Source2: current channel
Calculations
Extract Channel
⋮

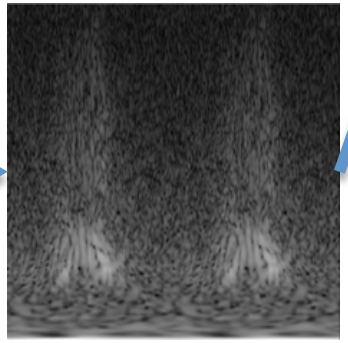
Spectral Image Validation and Verification (SIVV) [1]

Input image

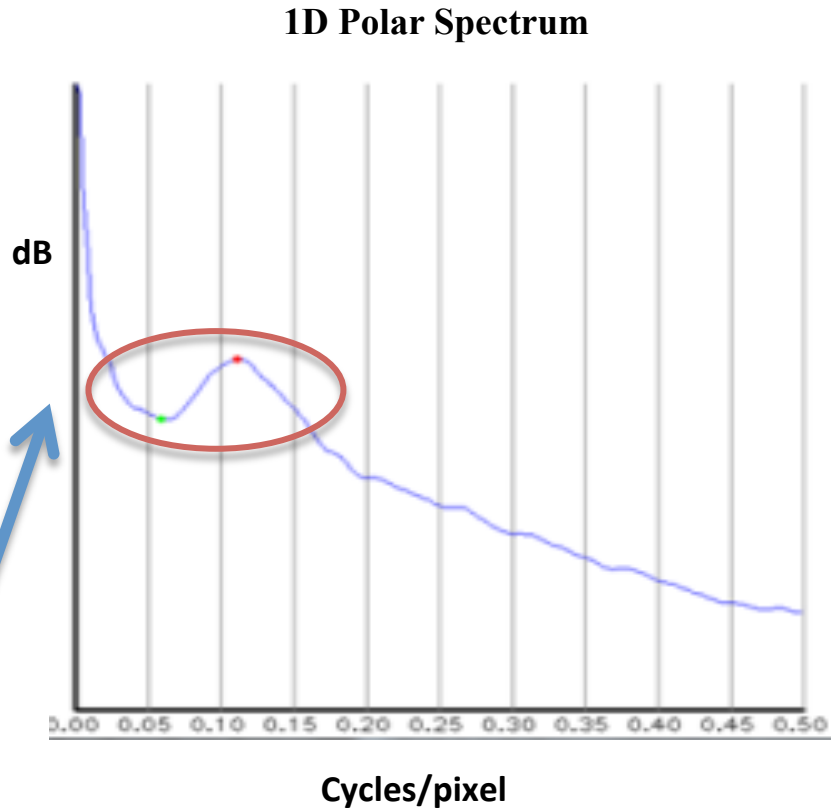
Windowed image



2D Log Power Spectrum

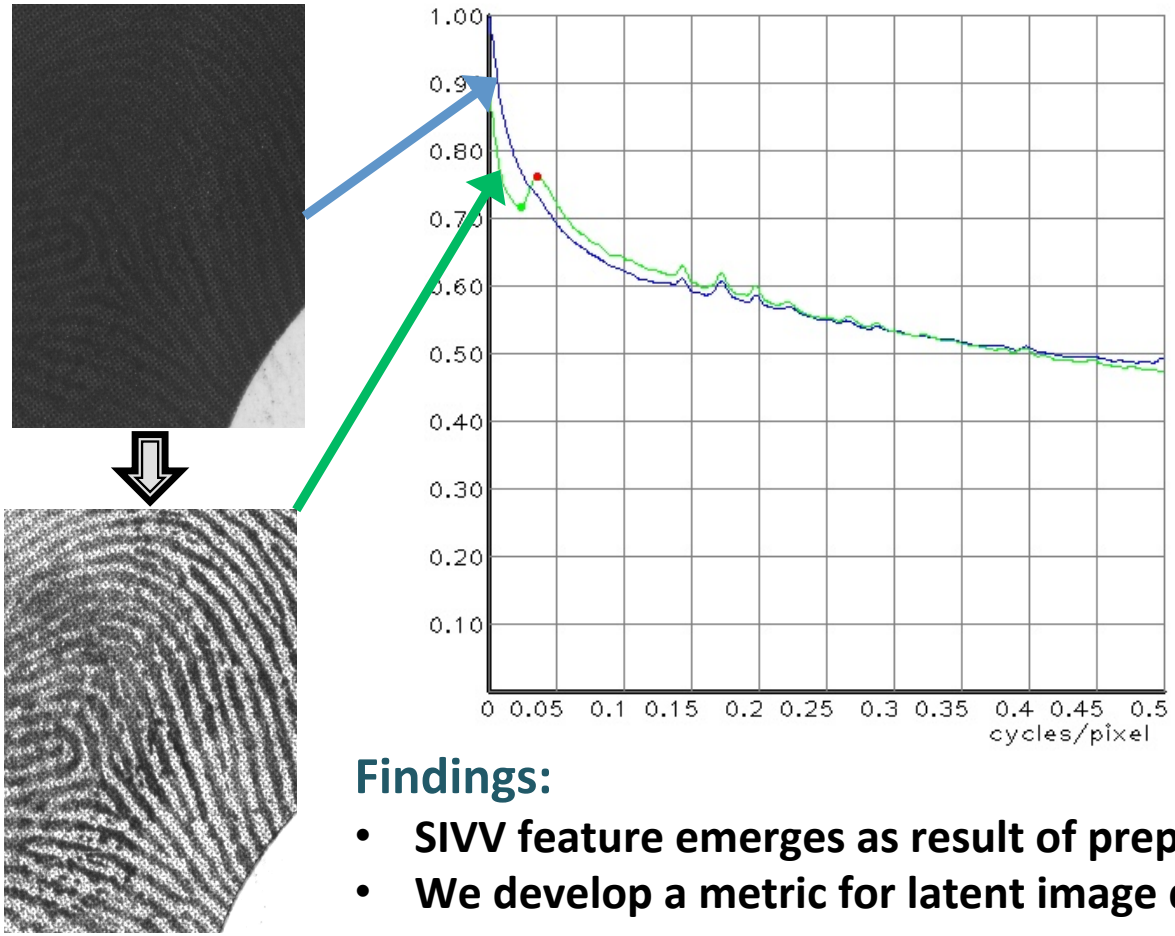


2D Polar Spectrum



[1]Libert, John M., et.al, A *1D spectral image validation/verification metric for fingerprints*, NISTIR 7599 (2009)

Can SIVV Measure the Preprocessing Quality?

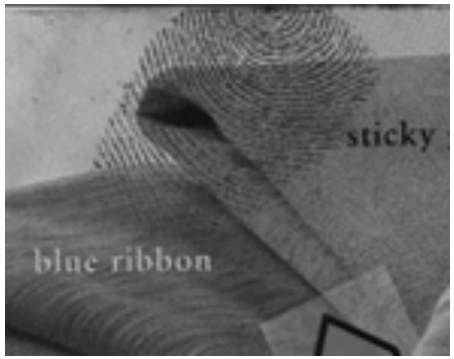


Findings:

- **SIVV feature emerges as result of preprocessing**
- **We develop a metric for latent image quality measurement.**

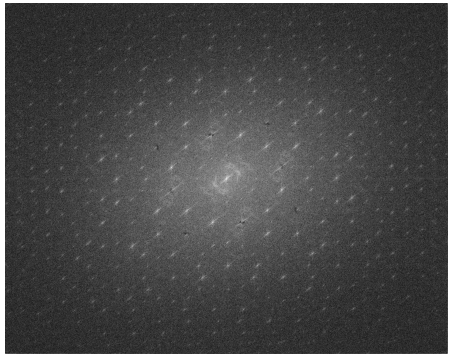
SIVV on latent fingerprint image [2]

- A good case from our latent fingerprint image dataset

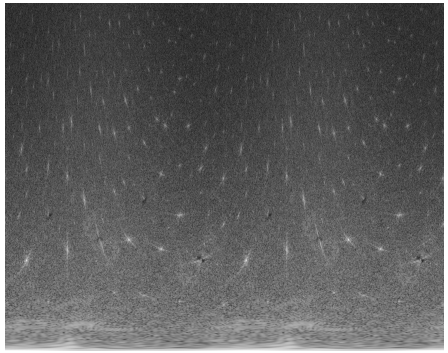


Input image

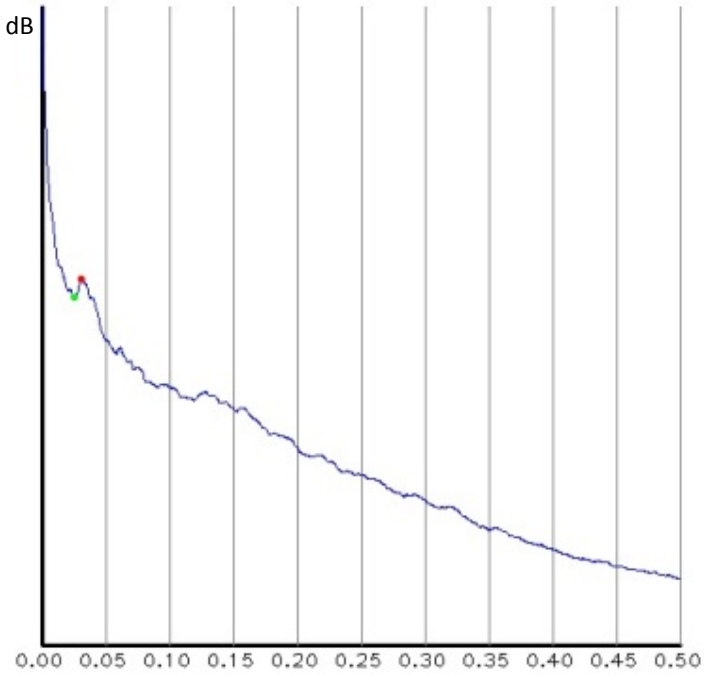
Windowed image



2D log power spectrum



2D polar spectrum

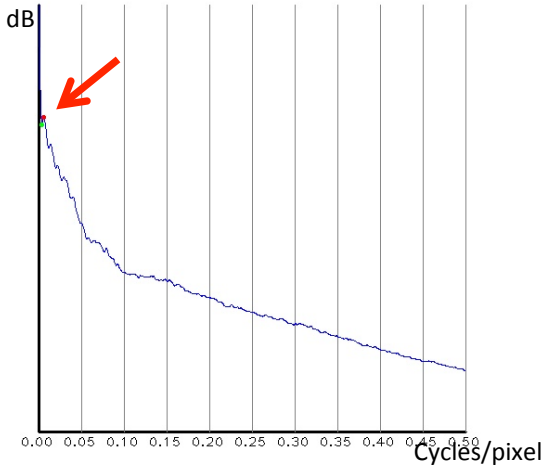


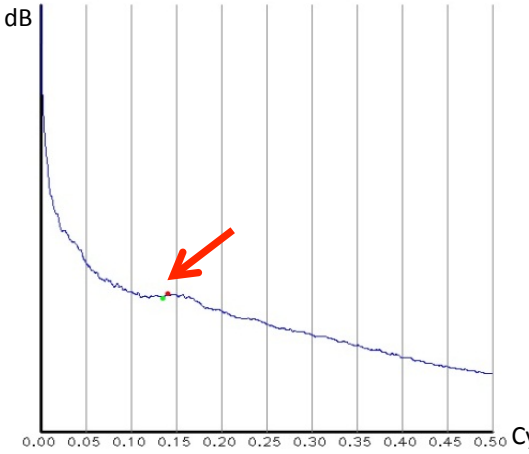
1D polar spectrum

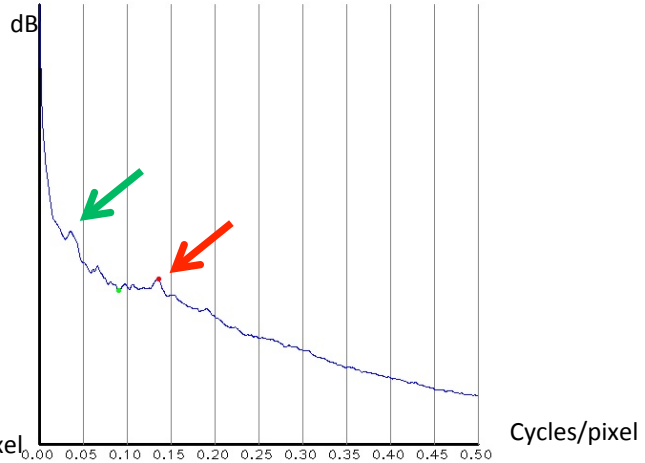
[2]SIVV software package in NBIS, courtesy of NIST Biometric Image Software, http://www.nist.gov/itl/iad/ig/nbis.cfm, NIST USA.

SIVV on latent fingerprint image

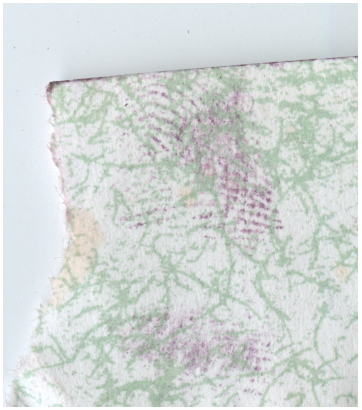
- Difficult cases from latent forensic fingerprint image dataset



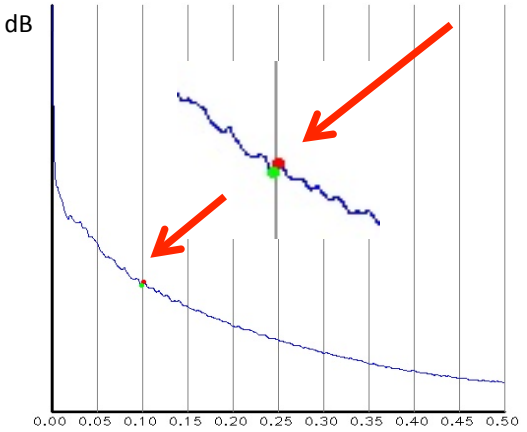


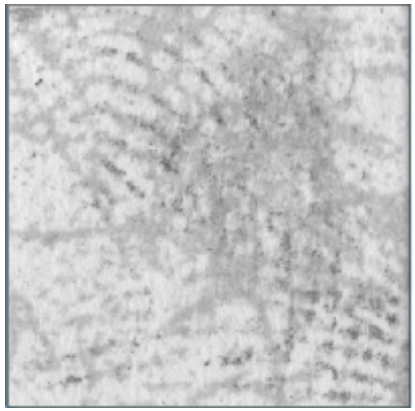


Refinement 1: Region of interest

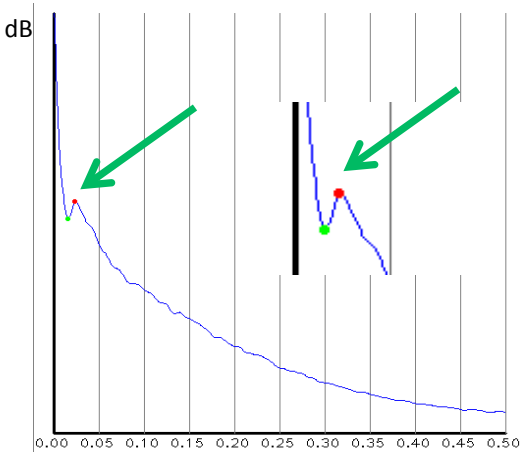


Full Image





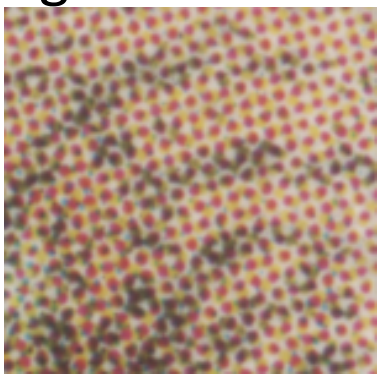
Region of Interest



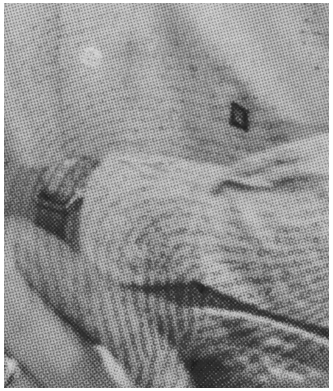
Refinement 2: Peak Location Constraint

- Frequency peak is directly related with the image pixel distance between the ridges.

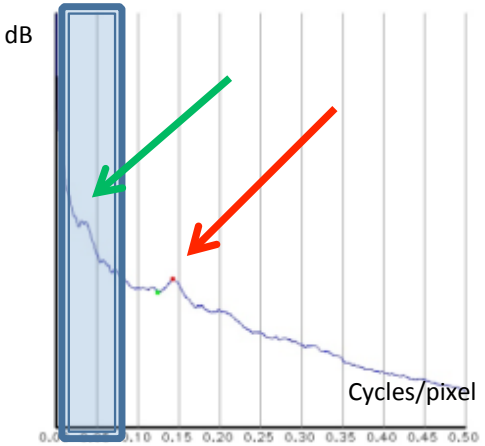
1. Original (153)



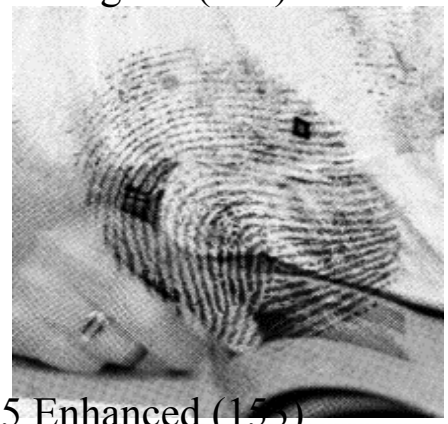
2. Zoom in



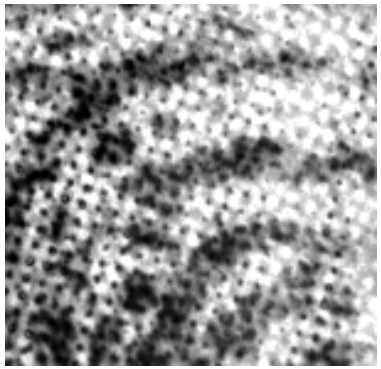
3. ROI



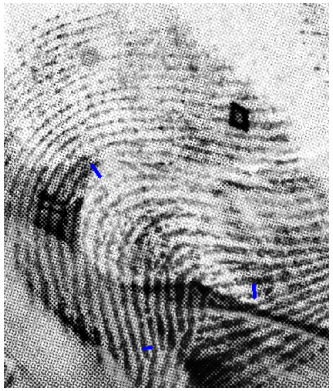
4. SIVV of original



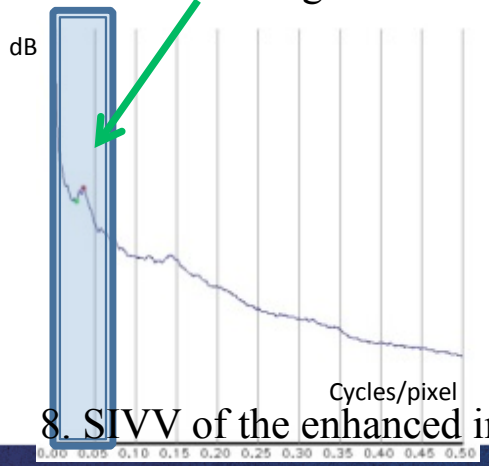
5.Enhanced (153)



6. Zoom in on enhanced



7. ROI



8. SIVV of the enhanced image

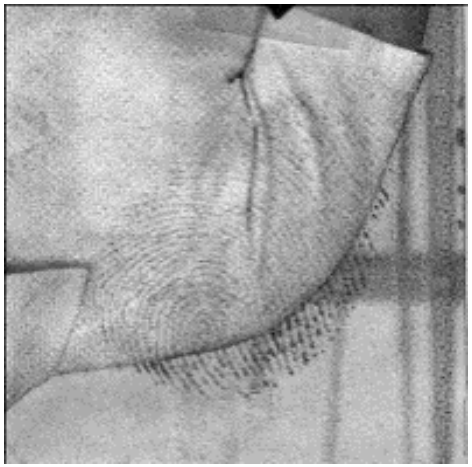
Experiment results (1)

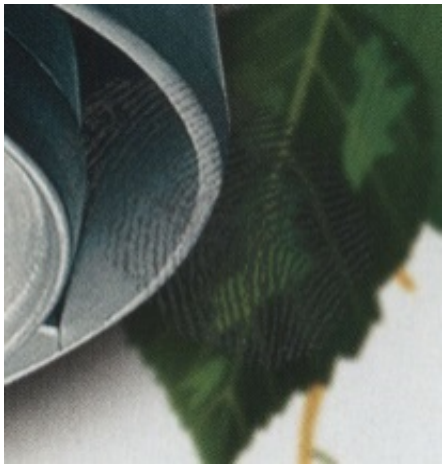
- True Positive Rate (TPR, sensitivity)

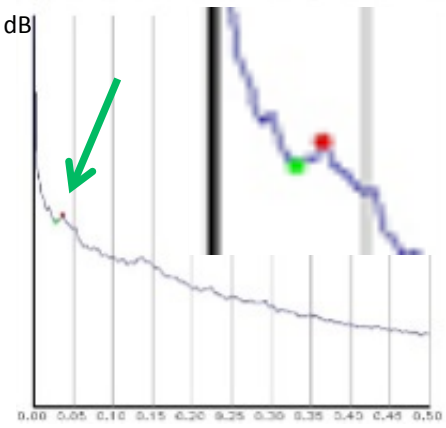
Table 1: The comparison of different implementations

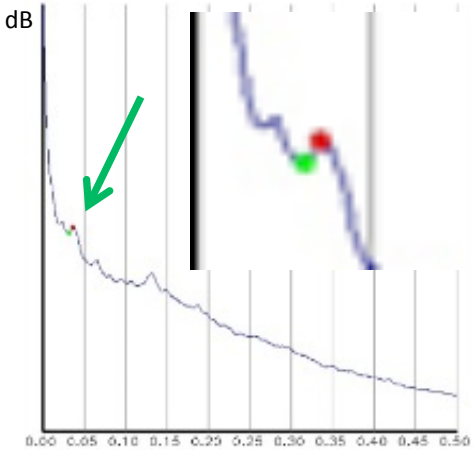
TPR = TP/(TP+FN)	Original image Whole option	Original image ROI	ROI Peak loc. Constraint
Before	33%	79%	85%
After	72%	87%	92%

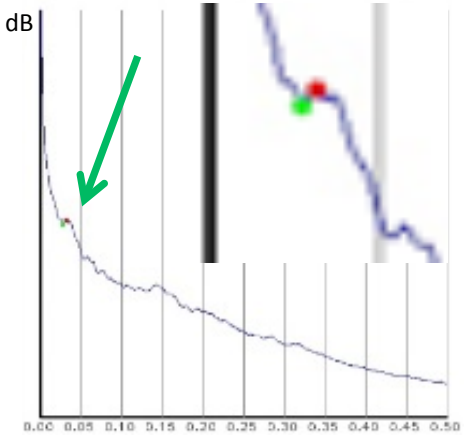
Experiment results (2)





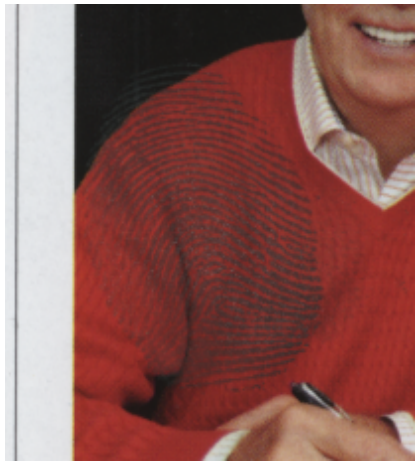




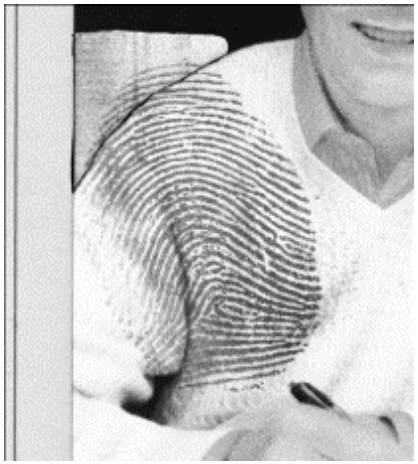


A metric to characterize the effect of image preprocessing

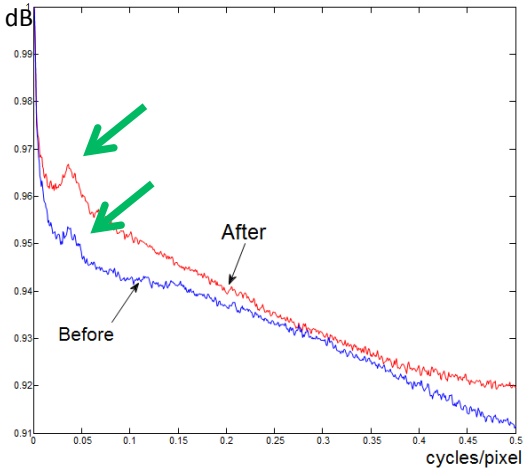
- ‘Before Image’ and ‘After Image’ pair.



1. Before Image

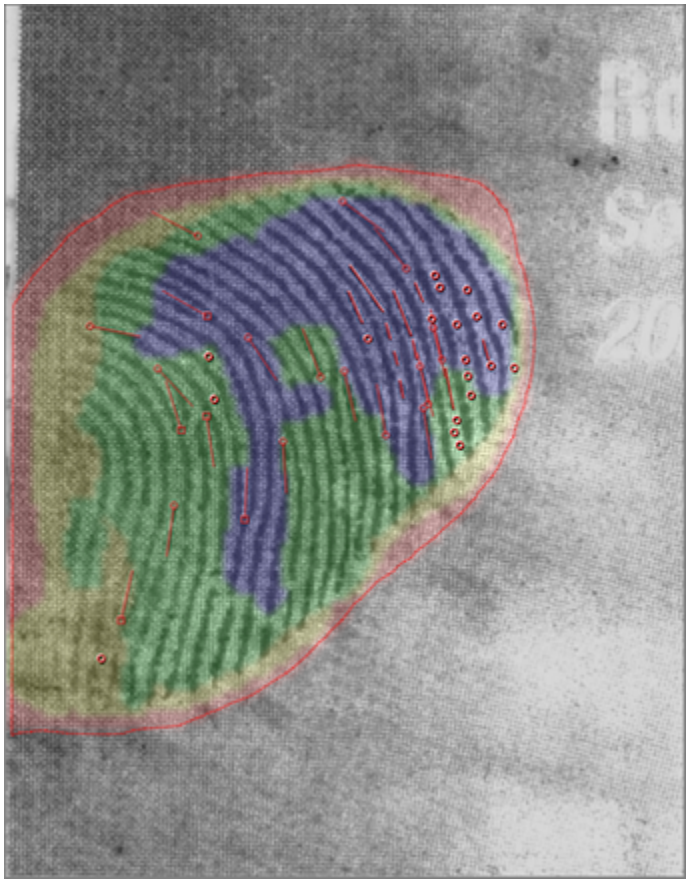


2. After Image



3. SIVV of before and after Images

Ongoing Work: Minutiae Mark Up by Latent Examiners



Discussions

- Variability and errors
  - Currently, preprocessing is subjectively based on latent examiners own experiences and even personal favors (software /procedure), which results great variability and inclines to large and unpredictable errors.
  - Most of the software packages (for example, Adobe Photoshop) are not particularly designed for latent fingerprint preprocessing, and they are also powerful enough to easily introduce artifacts which can lead to non-existing minutia, or modify critical local region that results in removing minutia.
- Quality metric for error management
  - Detect the ineffective enhancement operation;
  - Provide the latent examiner a feedback of an editing operation;
  - Help on endpoint selection;

Acknowledgements

- The authors thank John M. Libert, John Grantham, and Shahram Orandi of NIST for their valuable contributions on this work.
- The authors thank Mathew Schwarz of Schwarz Forensics and David Witzke of Foray Technologies for valuable consultation on this work[3].
- This research was supported by the 2012 NIST Forensic Measurement Challenges grant, “Metrics for Manipulation and Enhancement of Forensic Images”.

[3]Disclaimer: Any mention of commercial products or reference to commercial organizations is for information only; it does not imply recommendation or endorsement by NIST nor does it imply that the products mentioned are necessarily the best available for the purpose.

THANKS!

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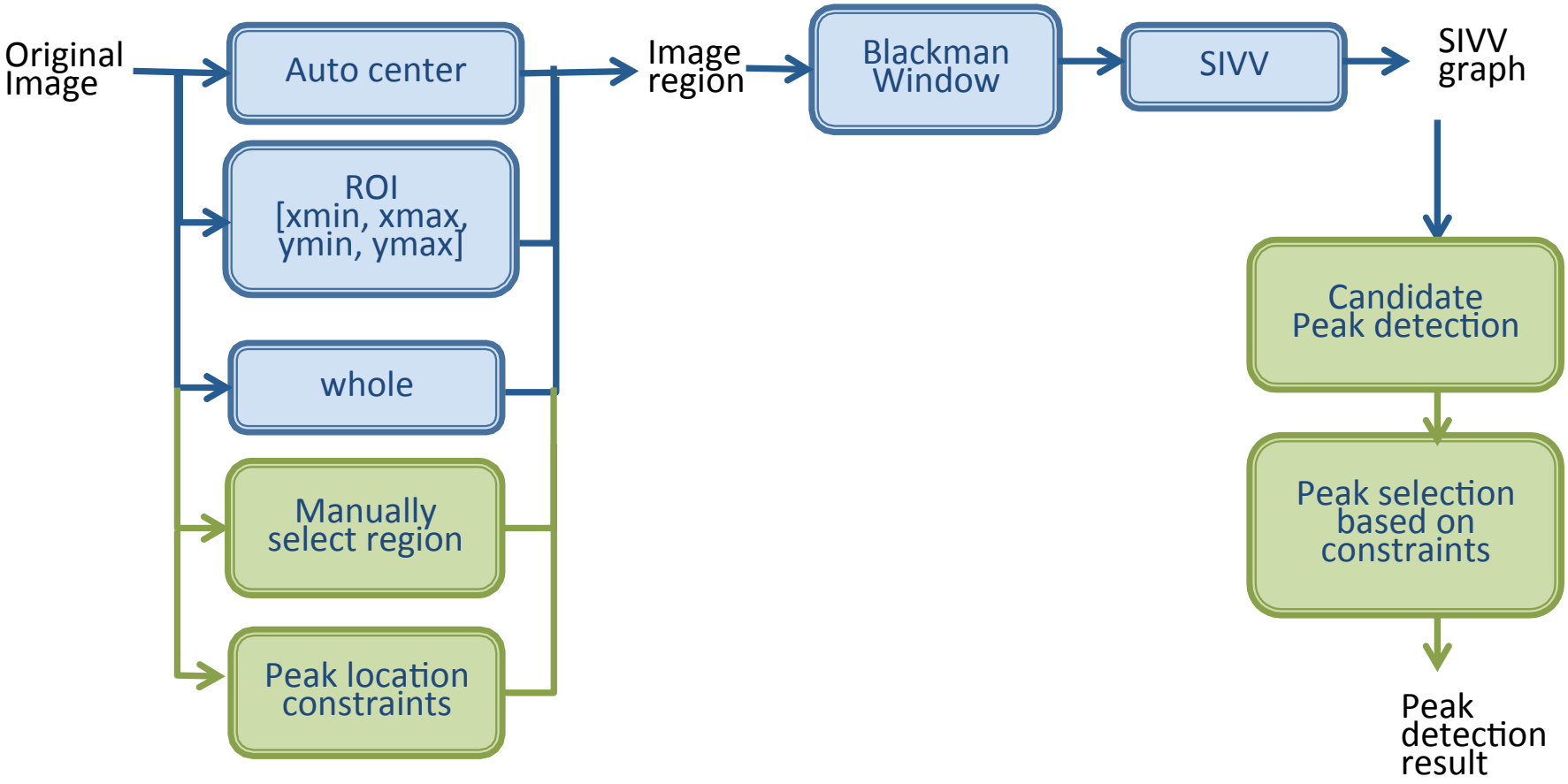
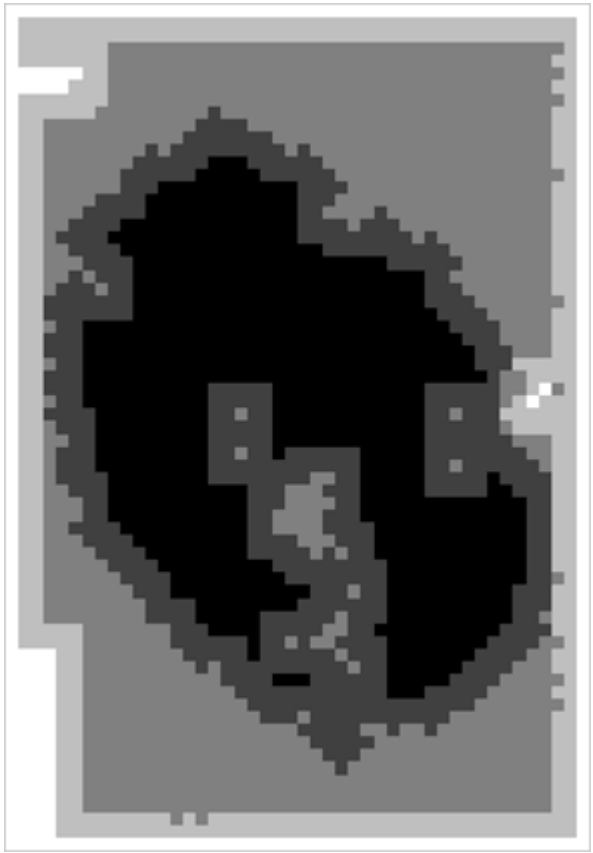
- Andrew Dienstfrey: andrew.dienstfrey@nist.gov
- Brian Stanton: brian.stanton@nist.gov

Revised SIVV Implementation

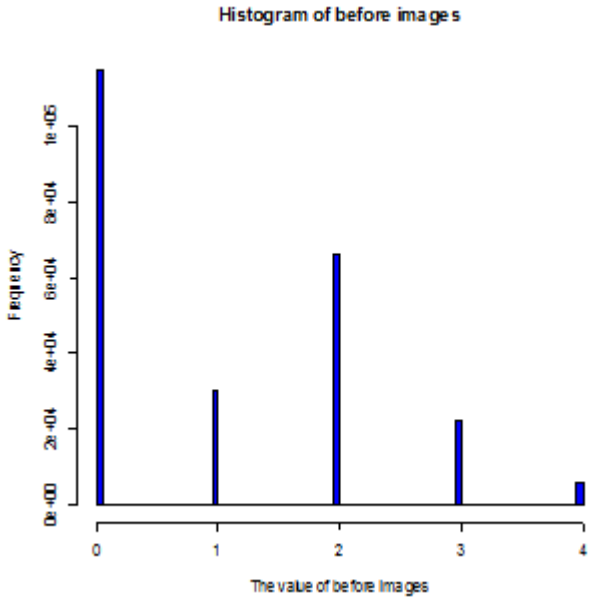


Ongoing Work (2): quality map

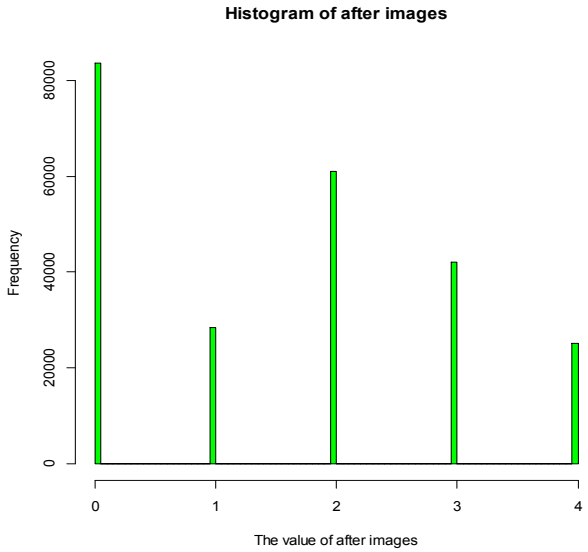


Statistical comparisons of before and after quality map

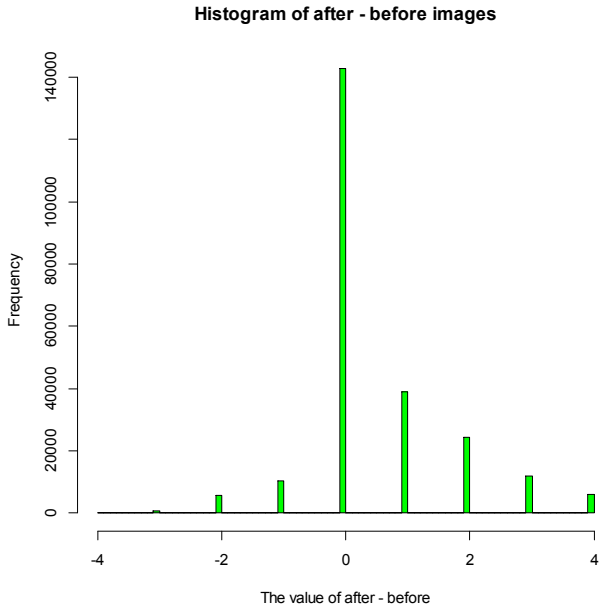
- Paired t-test:
  - 240,384 pairs.
  - t.test(before, after, mu=0, alt="less", paired=T, conf.level=0.99)
  - p-value < 2.2e-16



Histogram of Before



Histogram of After



Histogram of After-Before