Transcending PSNR: SIVV as an Image Fidelity Metric

John M. Libert
Shahram Orandi
John Grantham

November 30, 2012

Problem:

- Measure change in an image due to some process or compare effects of different processes on an image
  - Spatial(pixel) domain
  - Frequency domain

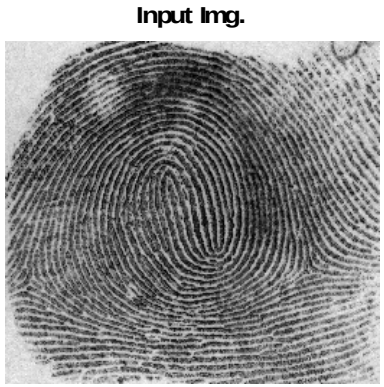
Solution (spatial domain):

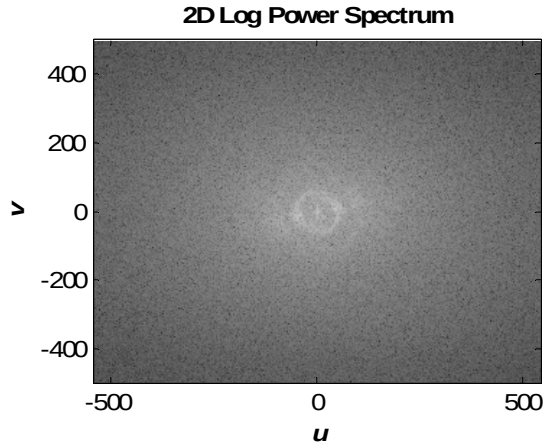
- Peak Signal-to-Noise Ratio (PSNR)
- Root Mean Squared Error (RMSE)
- Structural Similarity Index (SSIM)

Solution (frequency domain):

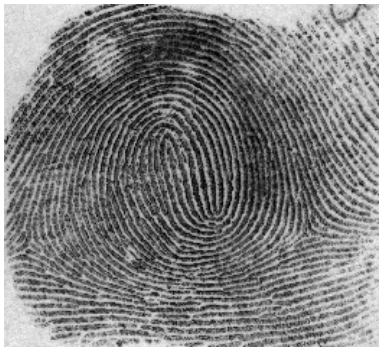
- NIST Spectral Image Validation Verification (SIVV) Metric

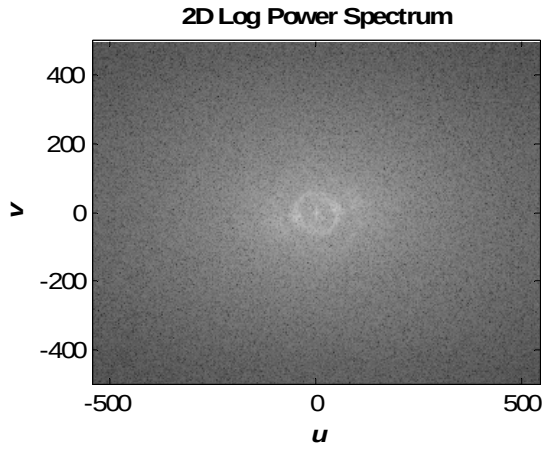
SIVV Procedure:

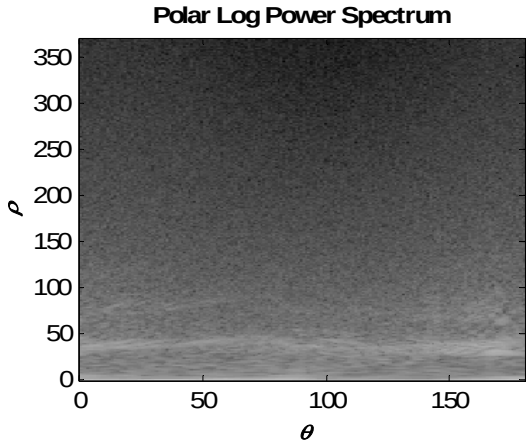




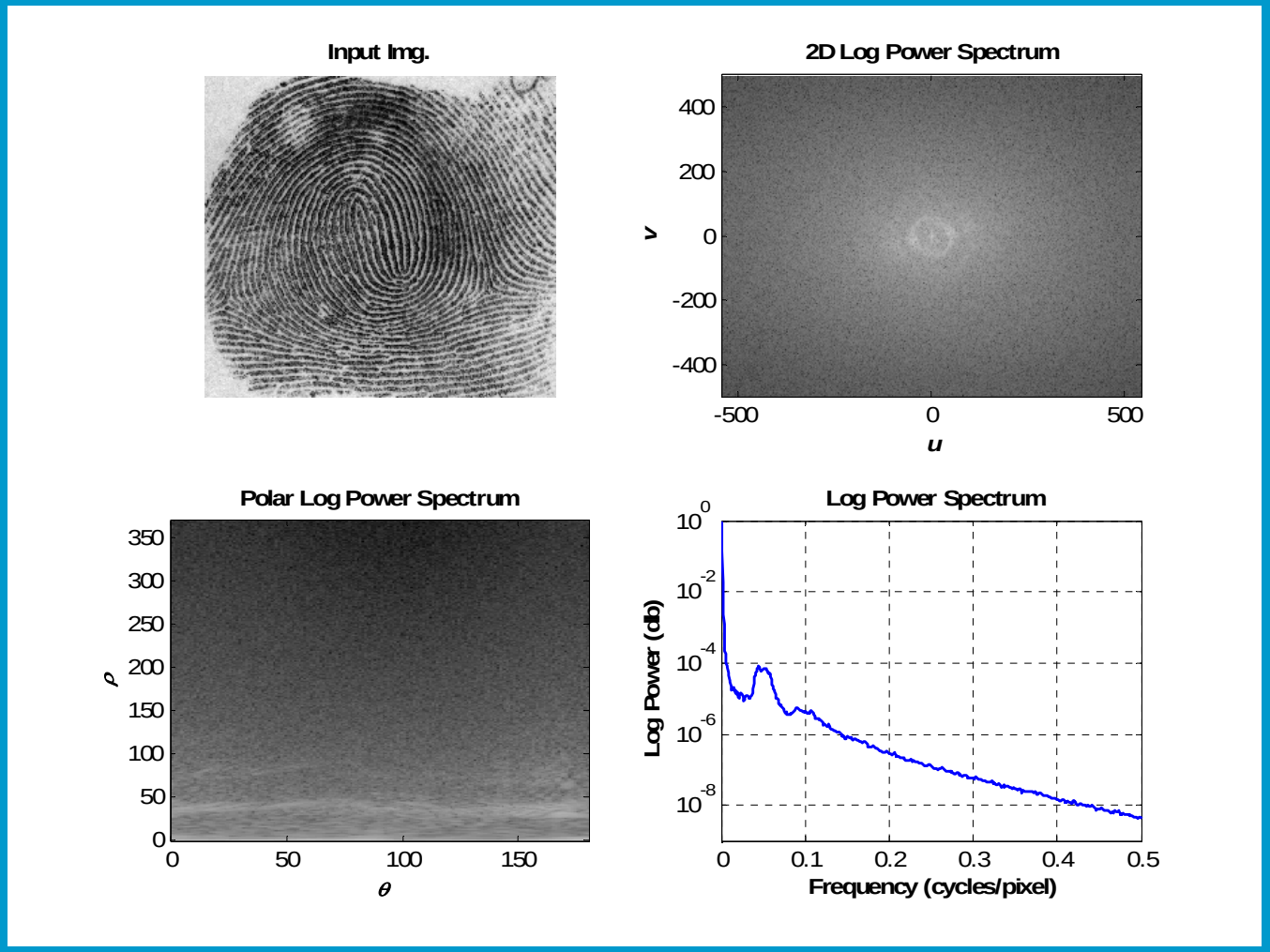
Step 1 : 2D normalized power spectrum of image encodes frequency structure in all directions





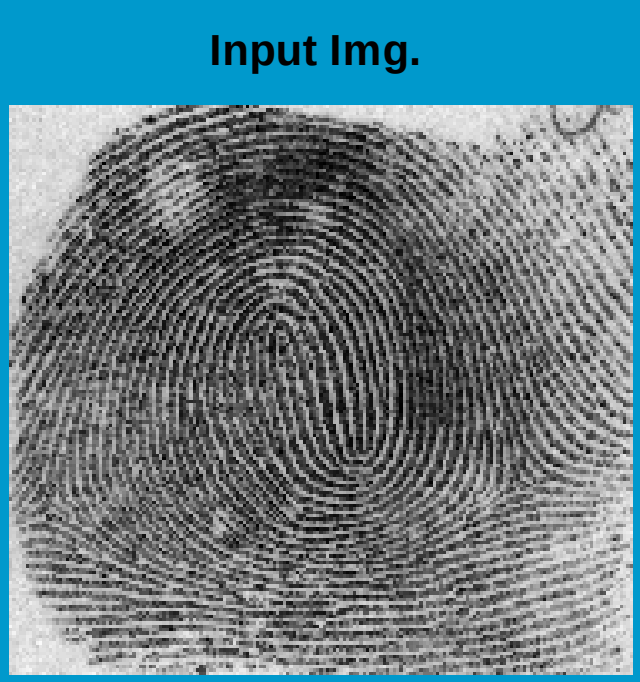


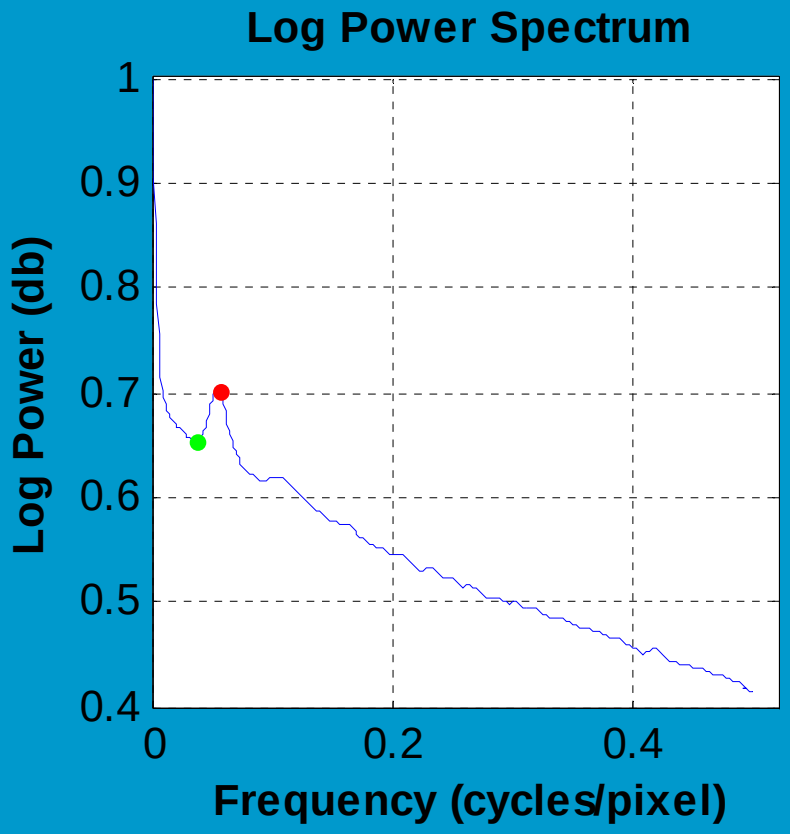
Step 2: Polar transform of 2D spectrum simplifies



Step 3: Sum over angle and rescale pixels to frequency to get 1D spectral summary signal for SIVV

- Peak structure is diagnostic feature
  - Relative amplitude
  - Frequency location





Problem Images

- Rotation
- Translation
- Dimension change - loss of row(s), column(s)
- SIVV is largely invariant to these artifacts

Experiments:

- Examine response of metrics over a range of
  - Rotations
  - Translations

Rotation

Rotation 0.20 Deg.

Image 1

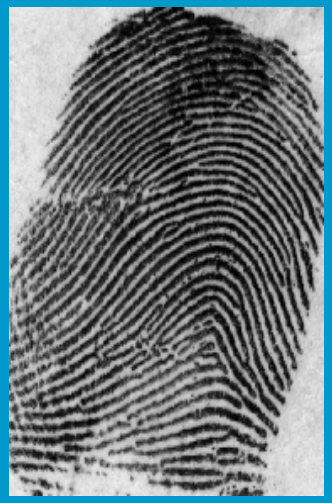


Image 2.

Rotation 5.00 Deg.

Image 1

Image 2.

Translation

Translation (x,y) 2 pixels

Image 1

Image 2.

Translation (x,y) 26 pixels

Image 1

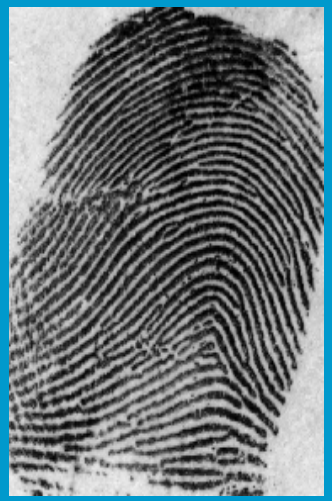
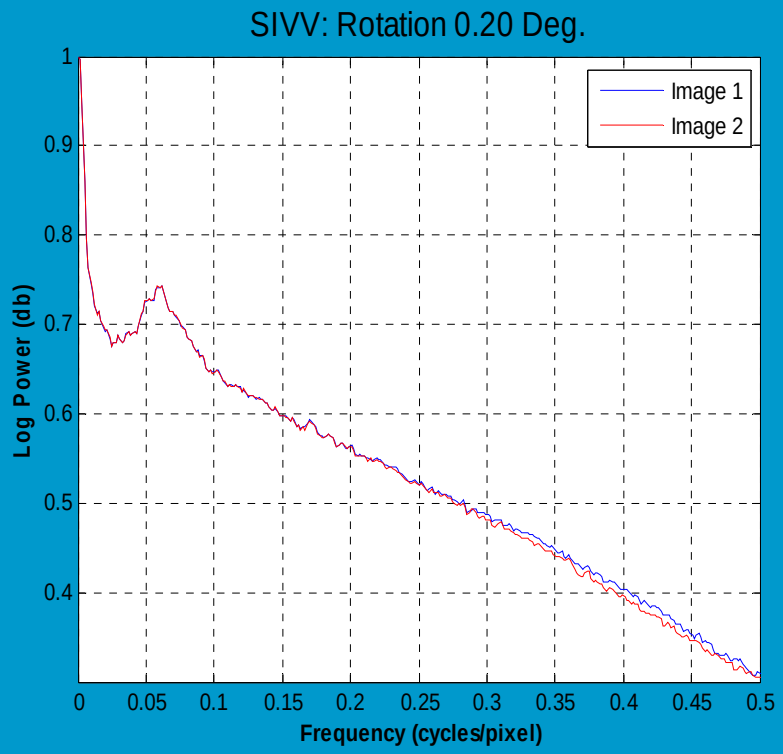
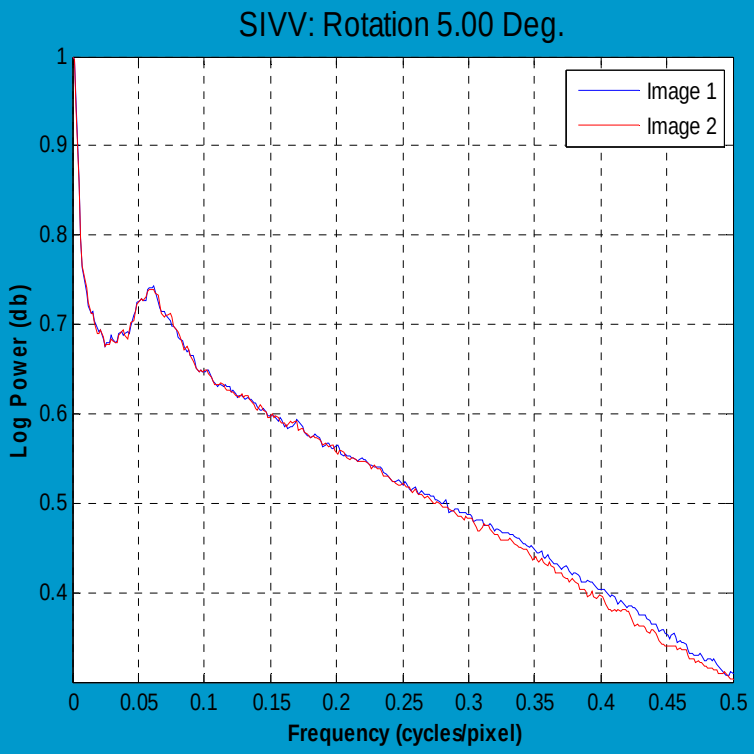


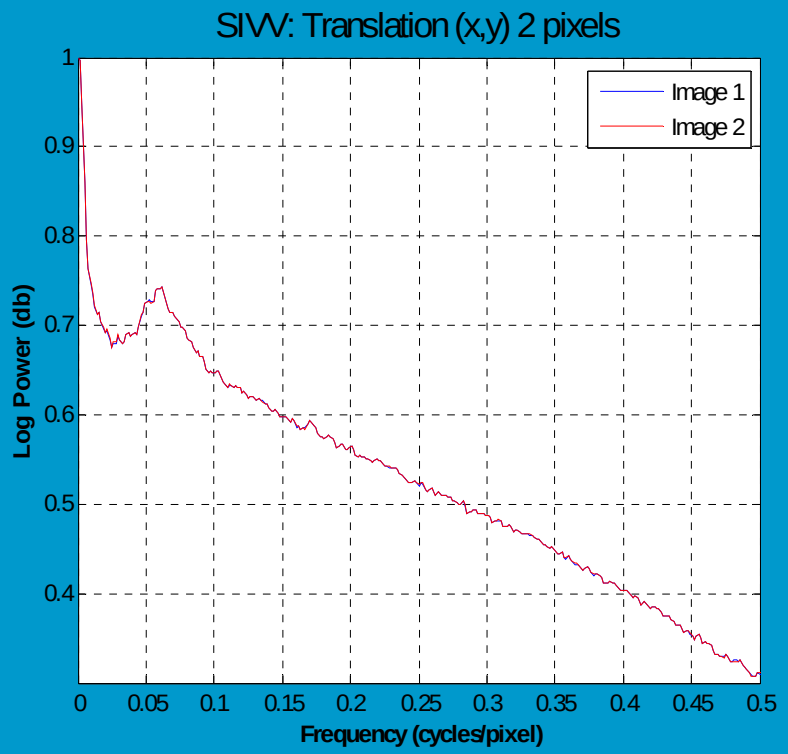
Image 2.

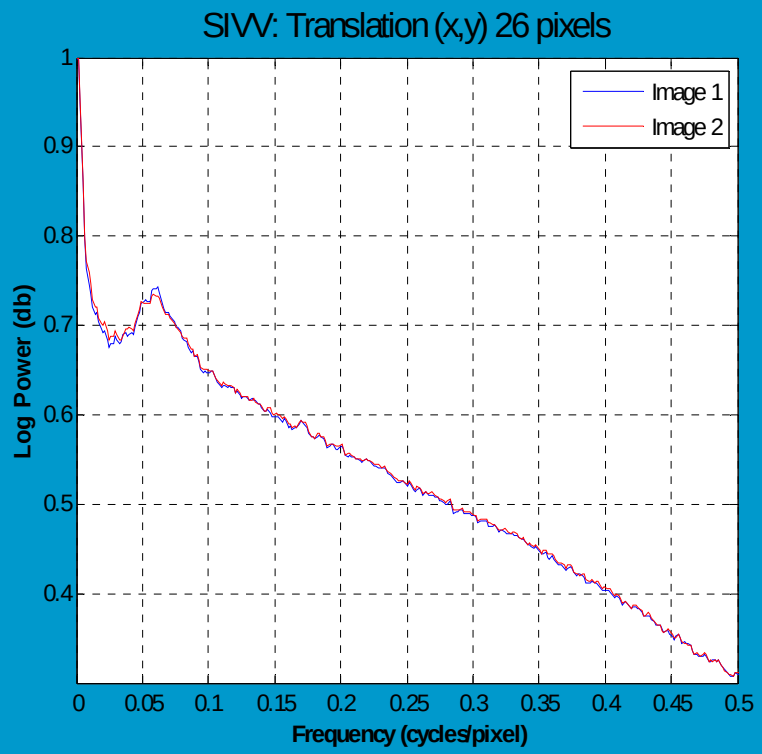
SIVV - Rotation

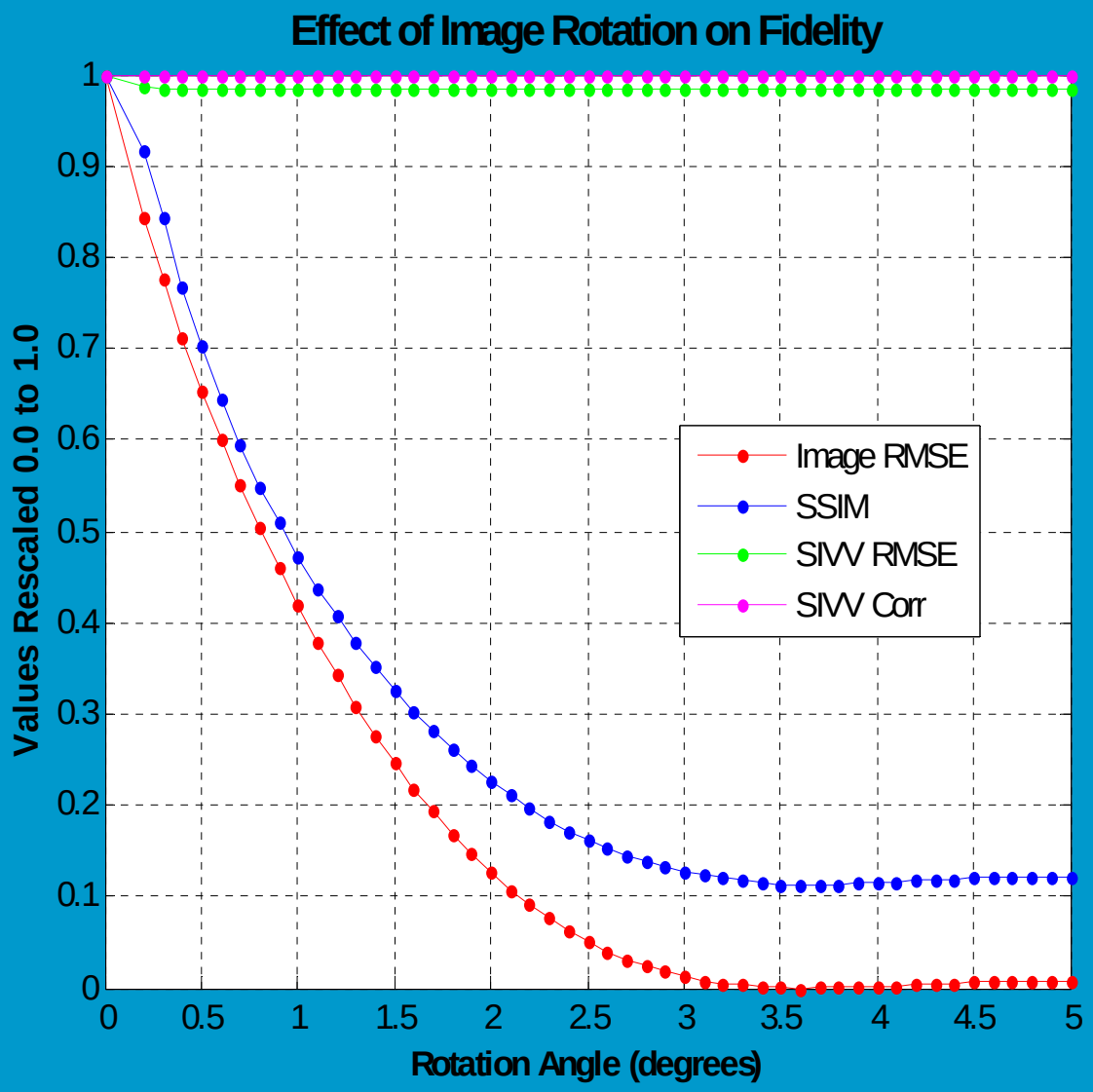


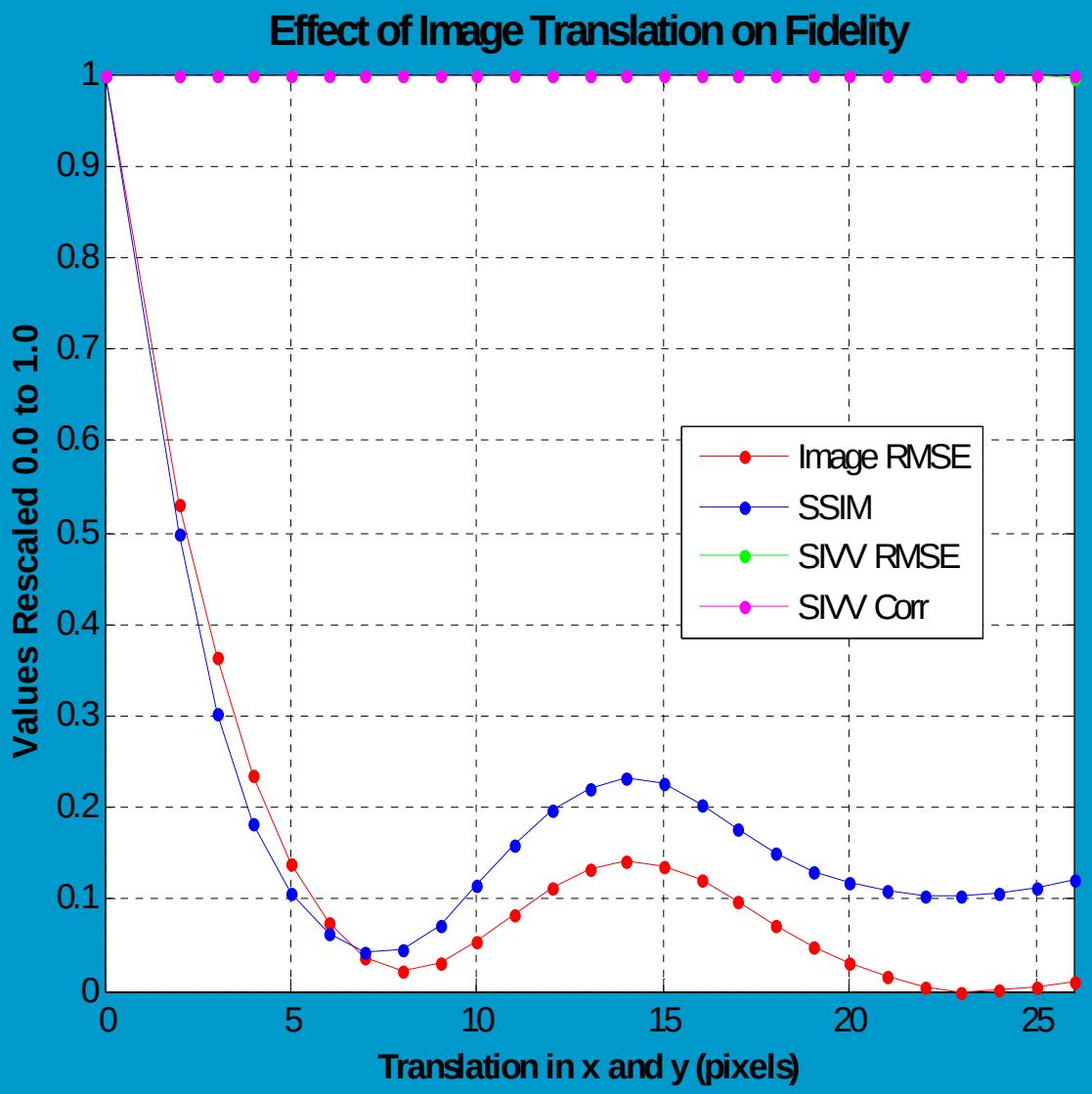


SIVV - Translation






Effect of Image Rotation on Fidelity
Values Rescaled 0.0 to 1.0
Rotation Angle (degrees)
Image RMSE
SSIM
SIVV RMSE
SIVV Corr
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


Effect of Image Translation on Fidelity
Values Rescaled 0.0 to 1.0
Translation in x and y (pixels)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
5
10
15
20
25
Image RMSE
SSIM
SIVV RMSE
SIVV Corr

Conclusions:

- Where pixel correspondence is likely
  - Pixel differencing methods have some utility
  - Frequency methods such as SIVV can provide important additional information
- Where pixel correspondence is unlikely
  - Frequency analysis may be the best option

Other SIVV Applications

- Database screening- fingerprint vs. non-fingerprint
- Preprocessor to image quality metric
- Live-scan acquisition IV&V
- Fingerprint compression-rate and downsampling studies
- Fingerprint segmentation

Software:

- SIVV Utility prototyping in MATLAB
  - Available upon request from author
- Rewritten in C++ using OpenCV library
  - Win32 and 64
  - Linux (and Mac OSX)
  - Released as NBIS 4.1.0
    http://www.nist.gov/itl/iad/ig/nbis.cfm

Selected References

- Libert, J.M.; Grantham, J.; Orandi, S. “A 1D Spectral Image Validation/Verification Metric for Fingerprints”. NISTIR7599, August 19, 2009. http://www.nist.gov/customcf/get_pdf.cfm?pub_id=903078
- Libert, J.M.; S. Orandi; and J.D. Grantham, “Comparison of the WSQ and JPEG 2000 Image Compression Algorithms On 500 ppi Fingerprint Imagery,” NIST Interagency/Internal Report (NISTIR) – 7781, April 23, 2012. http://www.nist.gov/manuscript-publication-search.cfm?pub_id=910658
- Z. Wang and A. C. Bovik, “Image quality assessment: from error visibility to structural similarity,” IEEE Trans. Image Processing, vol. 13, pp. 600 – 612, Apr. 2004. www.ece.uwaterloo.ca/~z70wang/publications/ssim.html

Q&A / Contact Info

John M. Libert
NIST Image Group
John.libert@nist.gov