Transcending PSNR: SIVV as an Image Fidelity Metric

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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

Translation (x,y) 26 pixels
SIVV - Rotation

SIVV: Rotation 0.20 Deg.

SIVV: Rotation 5.00 Deg.

Log Power (db) vs. Frequency (cycles/pixel) for different rotation angles.
SIVV - Translation

SIVV: Translation (x,y) 2 pixels

SIVV: Translation (x,y) 26 pixels
Effect of Image Rotation on Fidelity

- Image RMSE
- SSIM
- SIVV RMSE
- SIVV Corr

Rotation Angle (degrees)

Values Rescaled 0.0 to 1.0
Effect of Image Translation on Fidelity

Values Rescaled 0.0 to 1.0

- Image RMSE
- SSIM
- SIVV RMSE
- SIVV Corr

Translation in x and y (pixels)
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 OS X)
  - Released as NBIS 4.1.0
  
  [http://www.nist.gov/itl/iad/ig/nbis.cfm](http://www.nist.gov/itl/iad/ig/nbis.cfm)
Selected References

  http://www.nist.gov/customcf/get_pdf.cfm?pub_id=903078

  http://www.nist.gov/manuscript-publication-search.cfm?pub_id=910658

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