NORMALIZED SPATIAL-SPECTRAL CROSS CORRELATION -- A NEW METHOD FOR CHANGE DETECTION

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THE PROBLEM:

Florida citrus change detection requires :

- Automatic, minimum human-machine interaction;
- User-friendly--minimum experience and training;

Under Conditions:

- Imagery data from various sources with different SPECS;
- Different sensors, different data acquiring conditions;
- No cross sensor calibration, and unknown parameters;

=>NEED NEW METHOD!

DATA CONDITIONS FOR CHANGE DETECTION

- Different sensors (digital and film)
  - Radiometric differences
  - Dynamic range differences (8-bit and 16-bit)
  - Resolution differences (1m and 2m) =>mixed-pixel
  - Spectral coverage differences (R/G/IR and R/G/B)
- Non-sensor factors
  - Sun-angle
  - Weather condition
  - Season/date/time

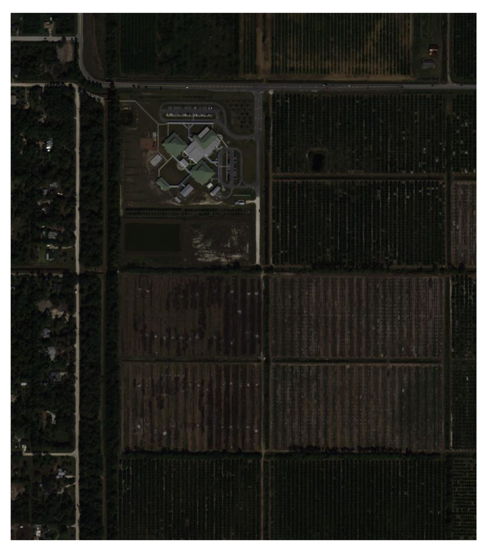
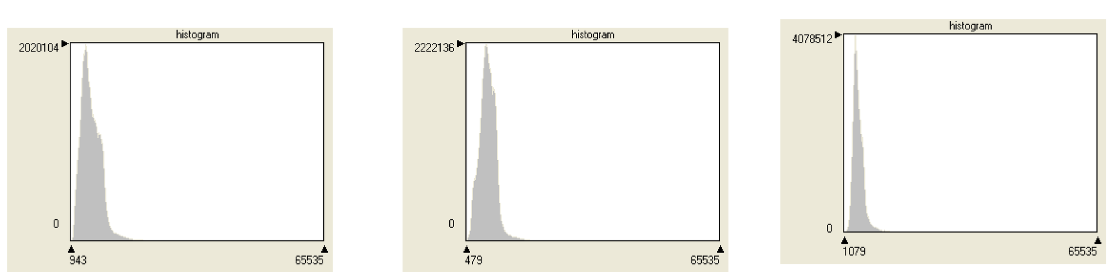


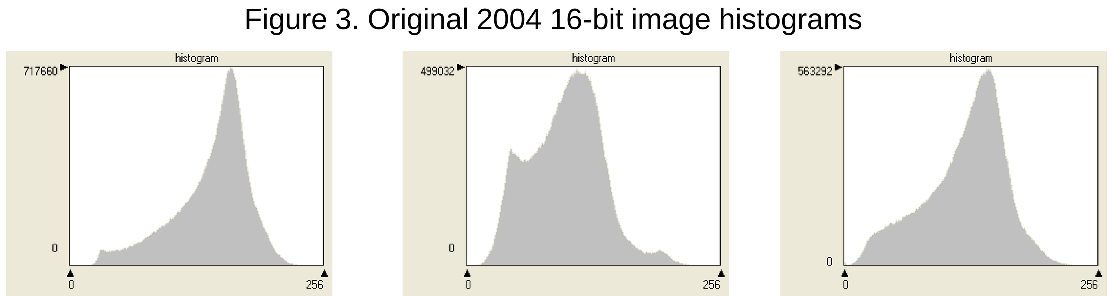
Figure 1. Original 2004 16-bit image

Figure 2. Original 1999 8-bit image



a) band-1 Histogram b) band-2 Histogram c) band-3 Histogram

Figure 3. Original 2004 16-bit image histograms



a) band-1 Histogram b) band-2 Histogram c) band-3 Histogram

Figure 4. Original 1999 8-bit image histograms

WHY CORRELATIONS

- Spatial correlation is regional spatial feature-based
- Spectral correlation is pixel spectral signature based
- Invariant to sensor dynamic range
- Robust to radiometric differences
- Solution by generalization into Spatial-Spectral domain

NORMALIZED SPECTRAL CROSS CORRELATION(SCC)

$$c(i,j)=\frac{[g(i,j)-\bar{g}(i,j)]^T[f(i,j)-\bar{f}(i,j)]}{\sqrt{\|g(i,j)-\bar{g}(i,j)\|^2}\sqrt{\|f(i,j)-\bar{f}(i,j)\|^2}}$$

where

$$\bar{g}(i,j)=\frac{1}{L}\sum_{k=1}^{L}g(i,j,k) \qquad \bar{f}(i,j,)=\frac{1}{L}\sum_{k=1}^{L}f(i,j,k)$$

NORMALIZED SPATIAL-SPECTRAL CROSS CORRELATION(SSCC)

$$c(i,j)=\frac{\sum_{x\in W}\sum_{y\in W}[g(i+x,j+y)-\bar{g}(i,j)]^T[f(i+x,j+y)-\bar{f}(i,j)]}{\sqrt{\sum_{x\in W}\sum_{y\in W}\|g(i+x,j+y)-\bar{g}(i,j)\|^2}\sqrt{\sum_{x\in W}\sum_{y\in W}\|f(i+x,j+y)-\bar{f}(i,j)\|^2}}$$

where

$$\bar{g}(i,j)=\frac{1}{W^2L}\sum_{x\in W}\sum_{y\in W}\sum_{k=1}^{L}g(i+x,j+y,k) \qquad \bar{f}(i,j)=\frac{1}{W^2L}\sum_{x\in W}\sum_{y\in W}\sum_{k=1}^{L}f(i+x,j+y,k)$$

CONCLUSION

- Generalizes spatial correlation and the spectral correlation method into spatial-spectral domain;
- Utilizes both spatial and spectral information;
- Minimal pre-processing;
- Robust to radiometric differences;
- Invariant to image dynamical range differences;
- Robust to noise;
- Robust to mixed-pixel effects;
- Robust to small misregistration;
- More smoothed correlation map;
- Better for different spatial resolutions

Figure 5. Enhanced 2004 16-bit image

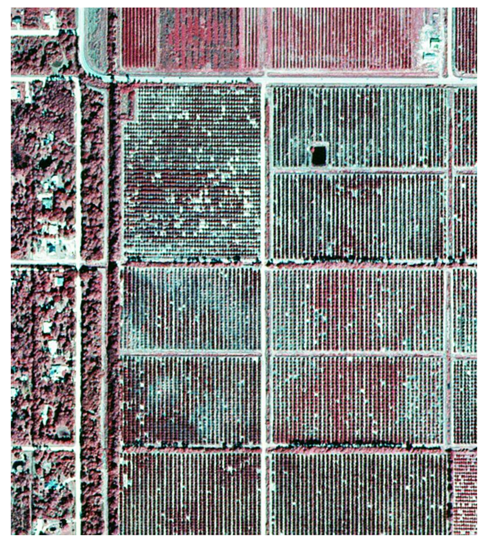


Figure 6. Enhanced 1999 8-bit image

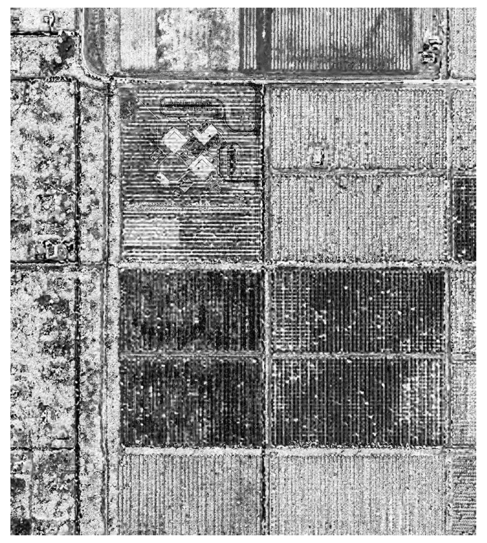


Figure 7. Spectral Correlation Map (SC) W=1

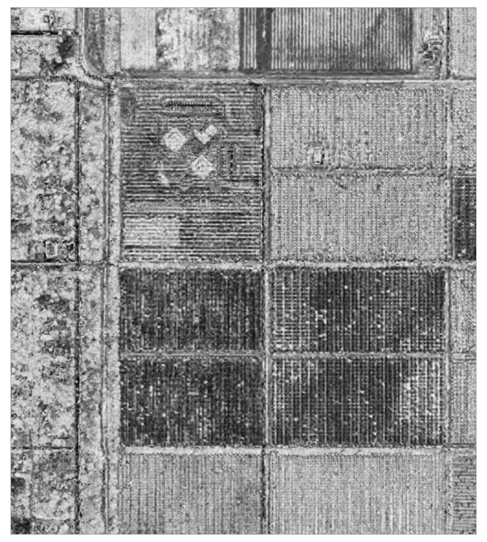


Figure 8. Spatial-Spectral Correlation Map (SSC) with W=3

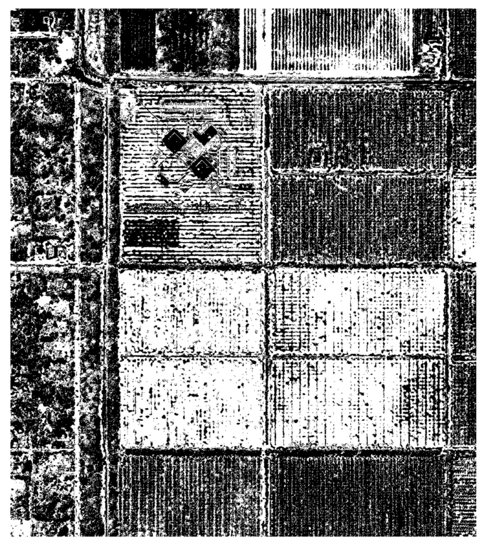


Figure 9. Threshold Change Map from SC Map W =1

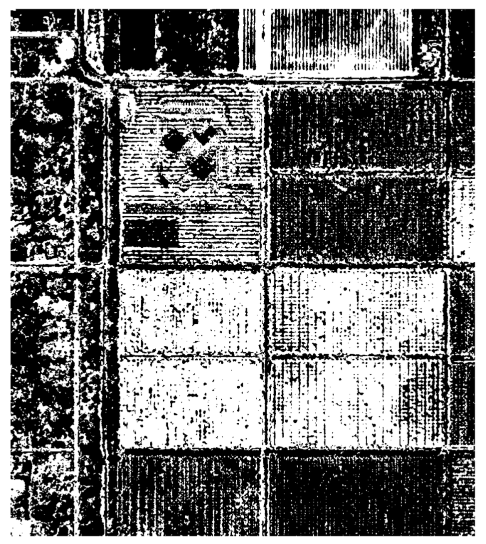
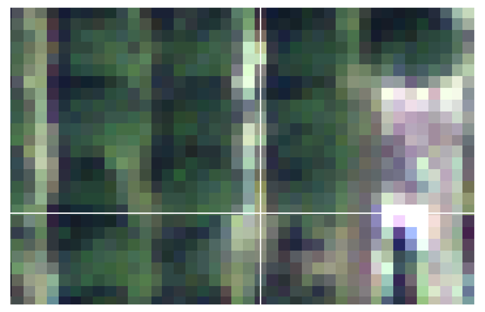
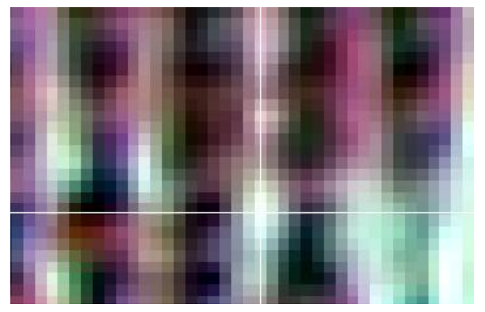


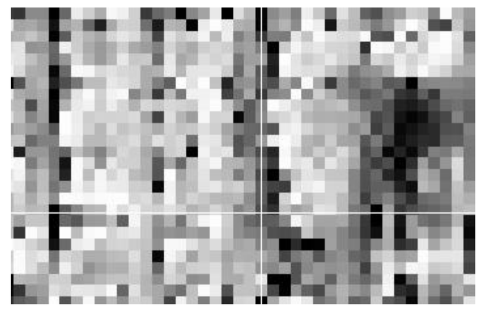
Figure 10. Threshold Change Map from SSC Map with W =3



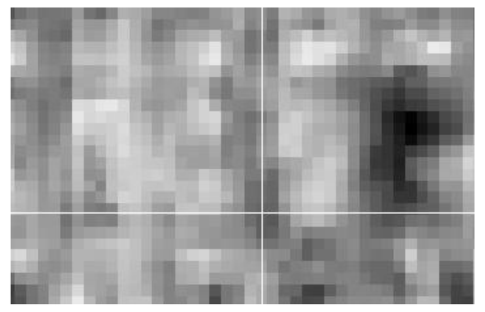
a. Zoomed in 2004 16-bit image



b. Zoomed in 1999 8-bit image



c. Zoomed in SC Map with W=1



d. Zoomed in SSC Map with W=3

Figure 11. Pixel view