Citrus Grove Change Detection Using Heterogeneously Sensed Imagery

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OUTLINE

- Background
- Challenge
- Solution
- Histogram Matching for Normalization
- Experimental Results
- Conclusions

Background

- Citrus grove change detection is critical to production inventory monitoring, map updating, and policy making
- Current manual process is labor intensive and inefficient
- Automation required
- How to automate the citrus grove change detection
  - Open problem
  - Solution needed

Challenge

- Florida citrus data conditions
  - Different sensors (digital/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)
  - Unknown data acquiring conditions
    - Sun-angle
    - Atmospheric effects/Weather condition
    - Season/date/time

Original Images

Figure 1. Original 2004 16-bit image

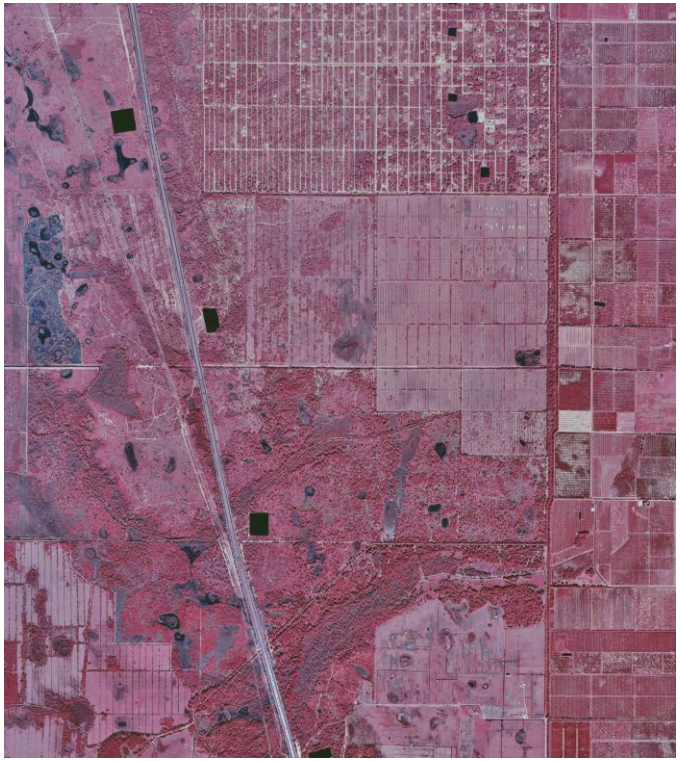
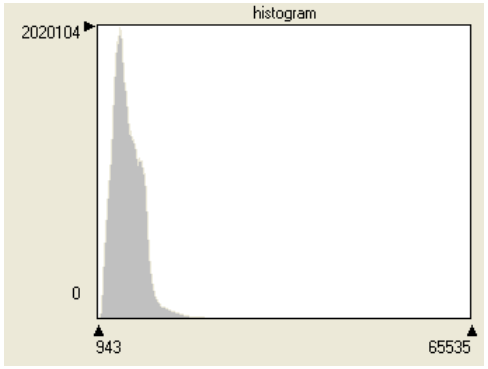
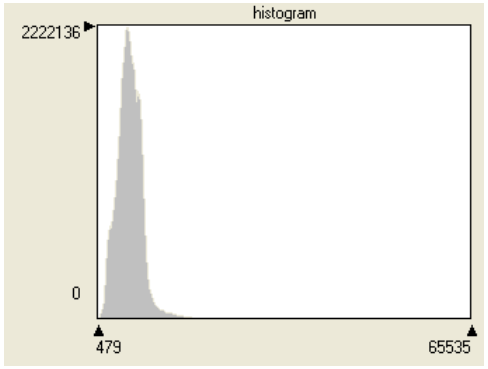


Figure 2. Original 1999 8-bit image

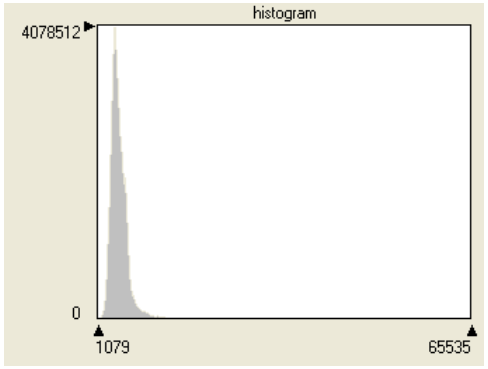
Histogram of Original Images



a) band-1 Histogram

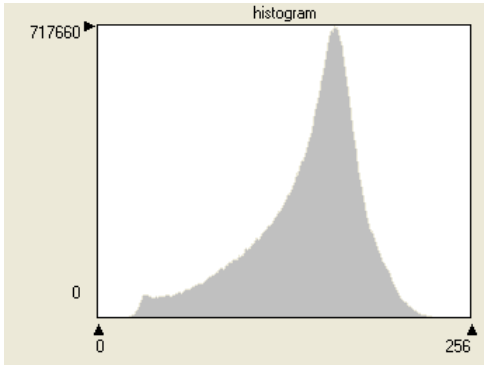


b) band-2 Histogram

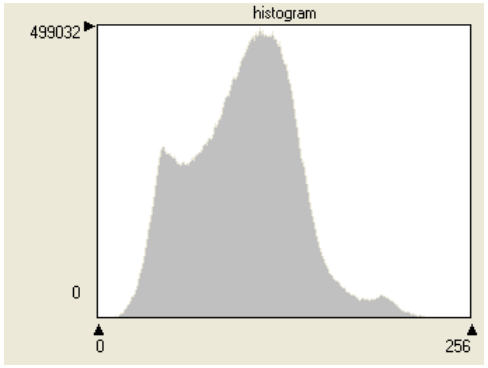


c) band-3 Histogram

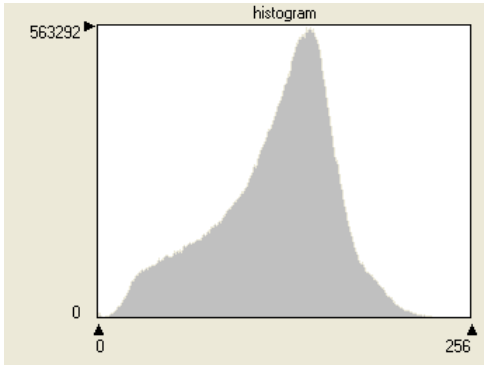
Figure 3. Original 2004 16-bit image histograms



a) band-1 Histogram



b) band-2 Histogram



c) band-3 Histogram

Figure 4. Original 1999 8-bit image histograms

Solution

- Use image differencing method - the most straightforward method
  - Sensitive to radiometric difference
  - Sensitive to dynamic range
- Quantize the 16-bit image to 8-bit to fix the dynamic range
- Use Histogram matching to normalize the radiometric response relatively

Histogram Matching for Normalization

- What is histogram matching
  - Transformation from one histogram to a specified histogram
- Why histogram matching normalization
  - Changes occurred only on small portion of the images
    - Image histograms should be roughly same
  - Nonlinear transformation
    - Approximate nonlinear radiometric response relation well
  - Virtually no other methods are effective to heterogeneous sensor normalization

Experimental Results

- Histogram matching results
- Result comparison between direct image differencing and normalized image differencing
- Change detection result comparison between different reference images
- Zoomed change detection result comparison between different reference images

Images Before Histogram Matching

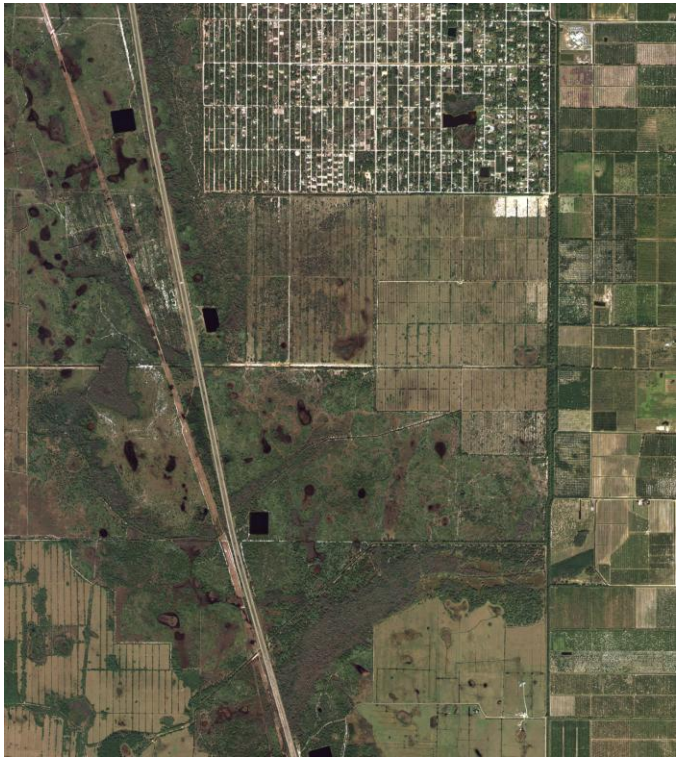


Figure 1. Clipped 2004 8-bit image

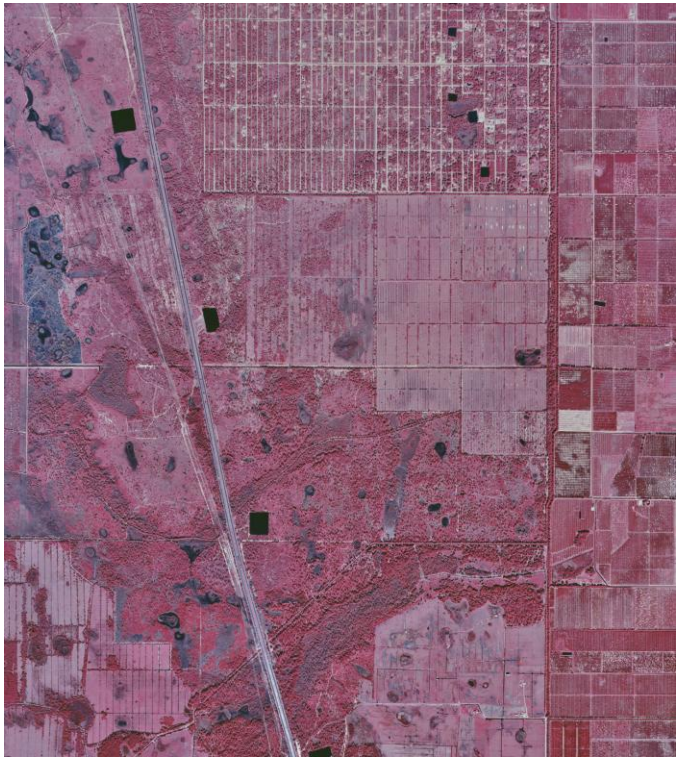
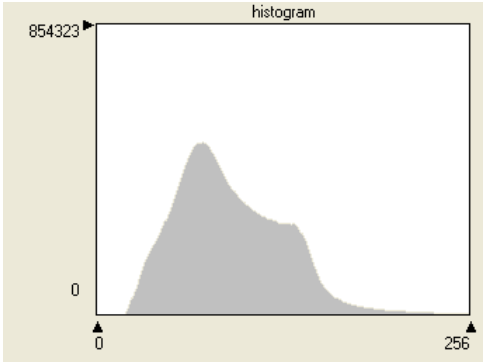
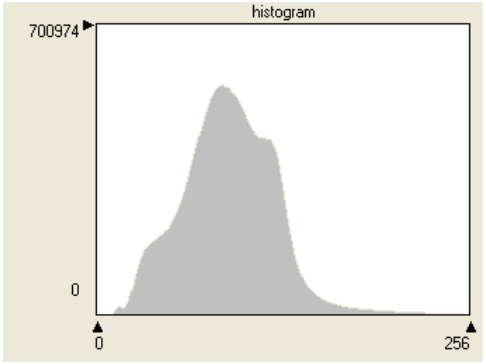


Figure 2. Original 1999 8-bit image

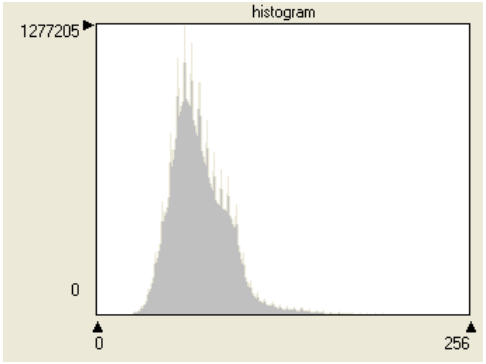
Histograms before Histogram Matching



a) band-1 Histogram

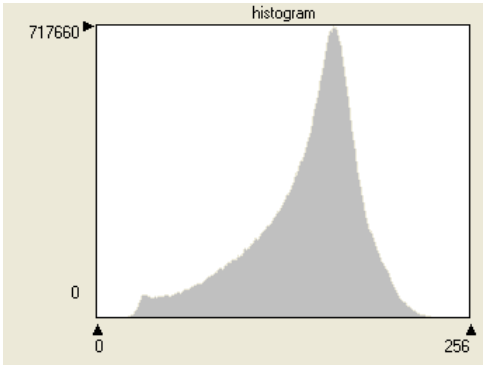


b) band-2 Histogram

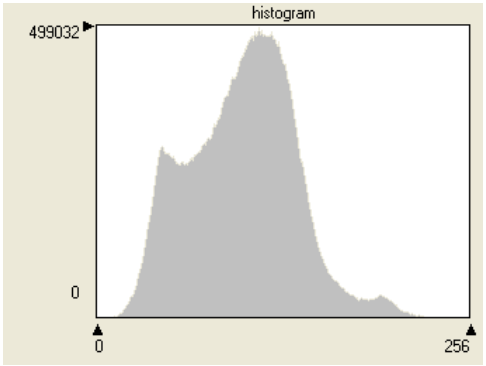


c) band-3 Histogram

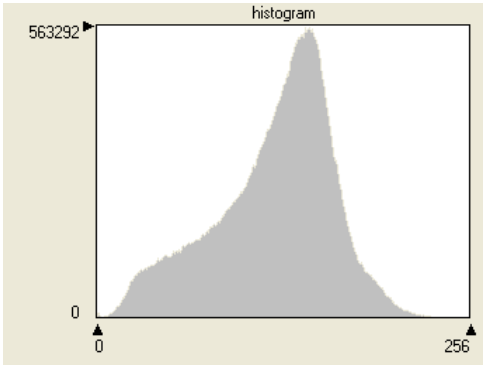
Figure 3. Clipped & Quantized 2004 8-bit image histograms



a) band-1 Histogram



b) band-2 Histogram



c) band-3 Histogram

Figure 4. Original 1999 8-bit image histograms

Histogram Matched Images

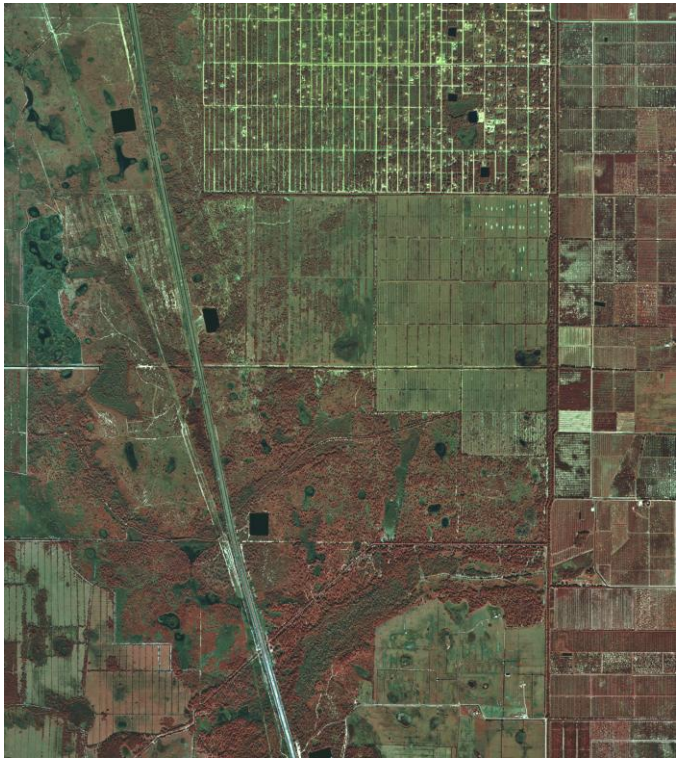


Fig 5. Histogram matched 1999 image
Using 2004 image as reference

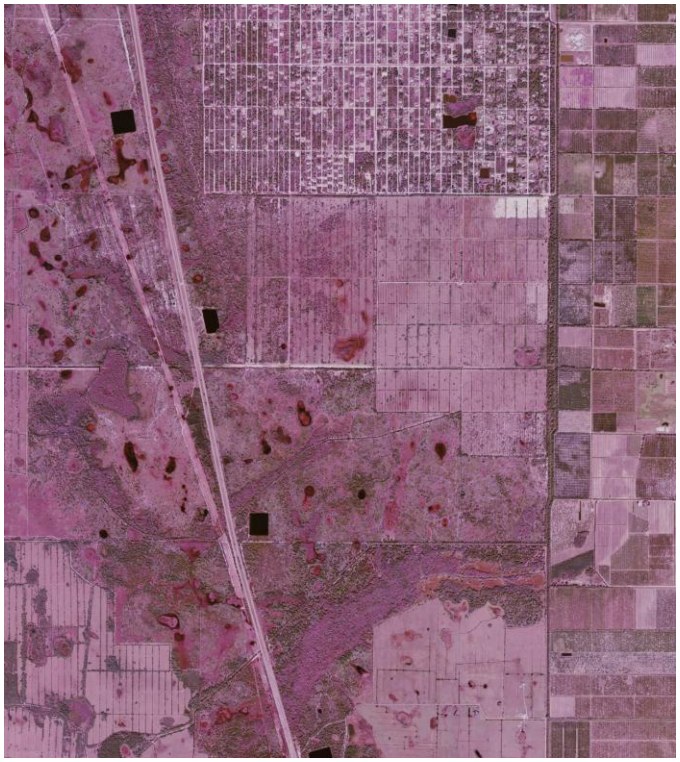
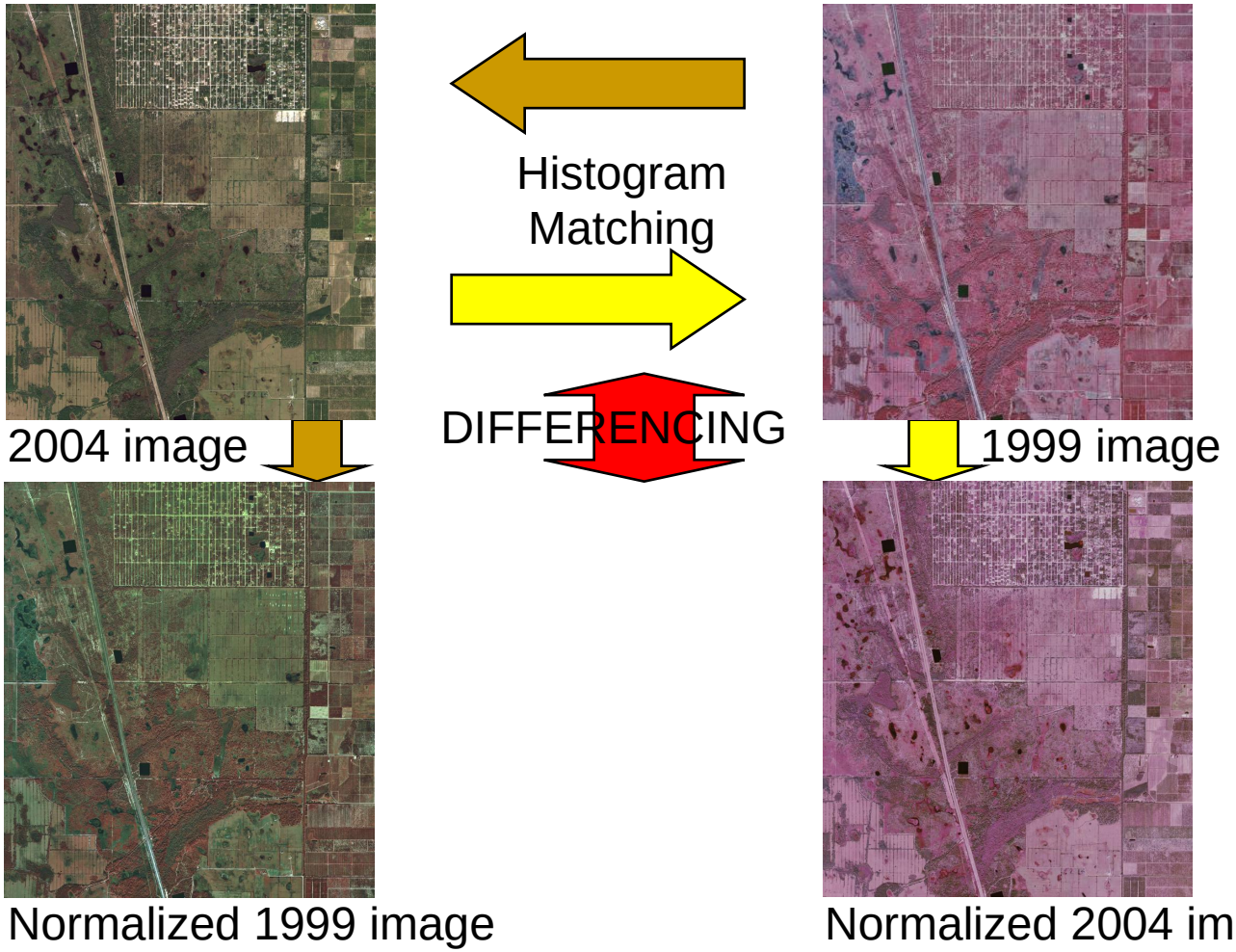
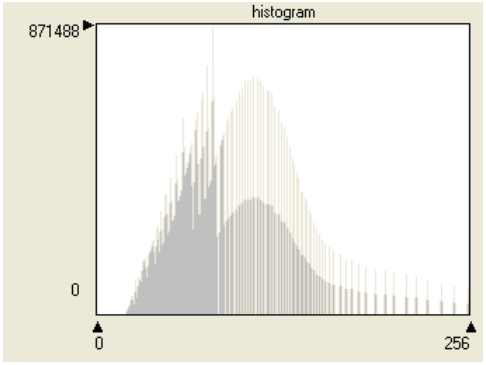


Fig 6. Histogram matched 2004 image
Using 1999 image as reference

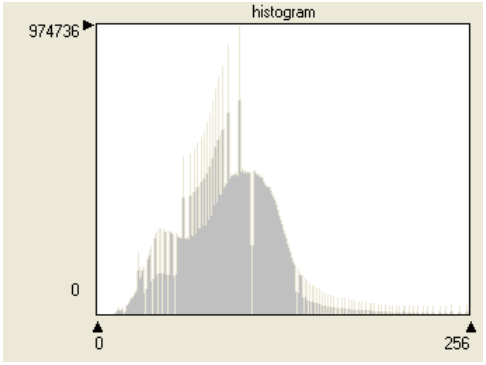
Reference and Normalized Image Relationships



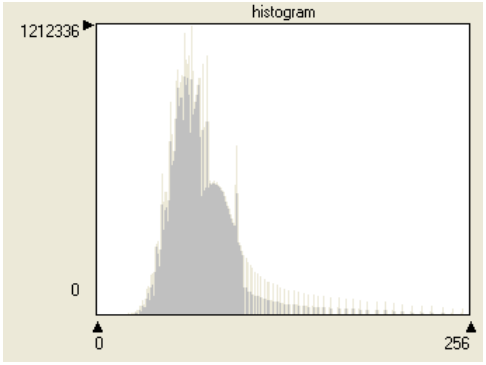
Histograms of Histogram Matched Images



a) band-1 Histogram

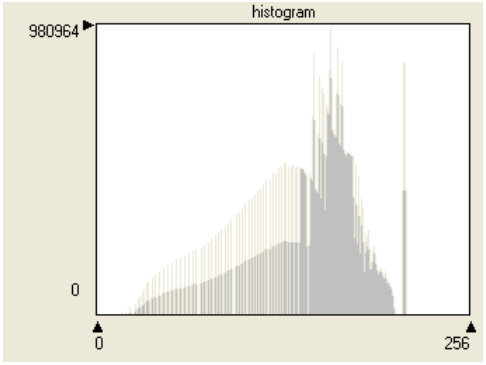


b) band-2 Histogram

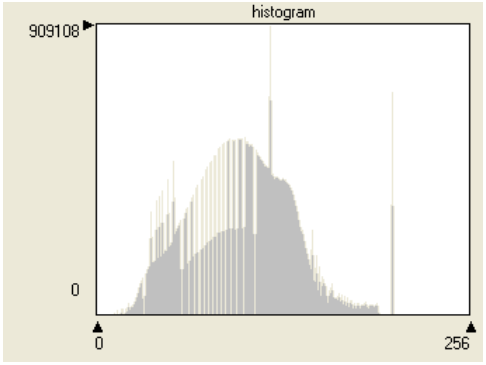


c) band-3 Histogram

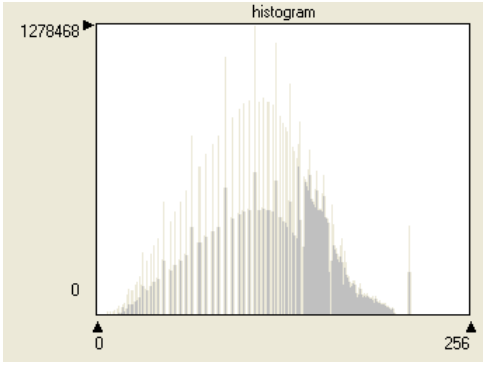
Figure 7. Histogram matched1999 8-bit image histograms



a) band-1 Histogram



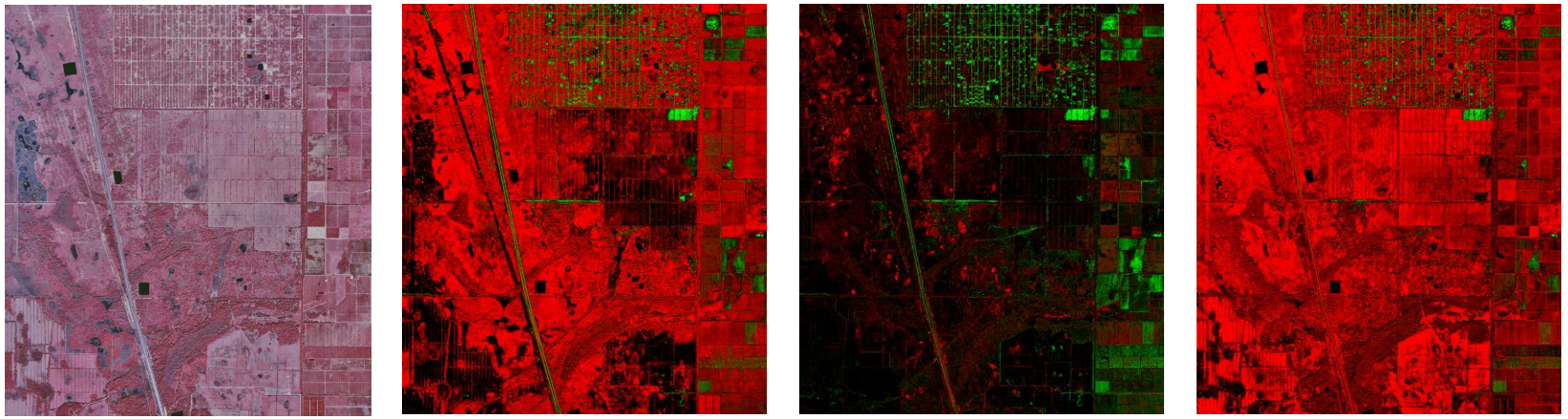
b) band-2 Histogram



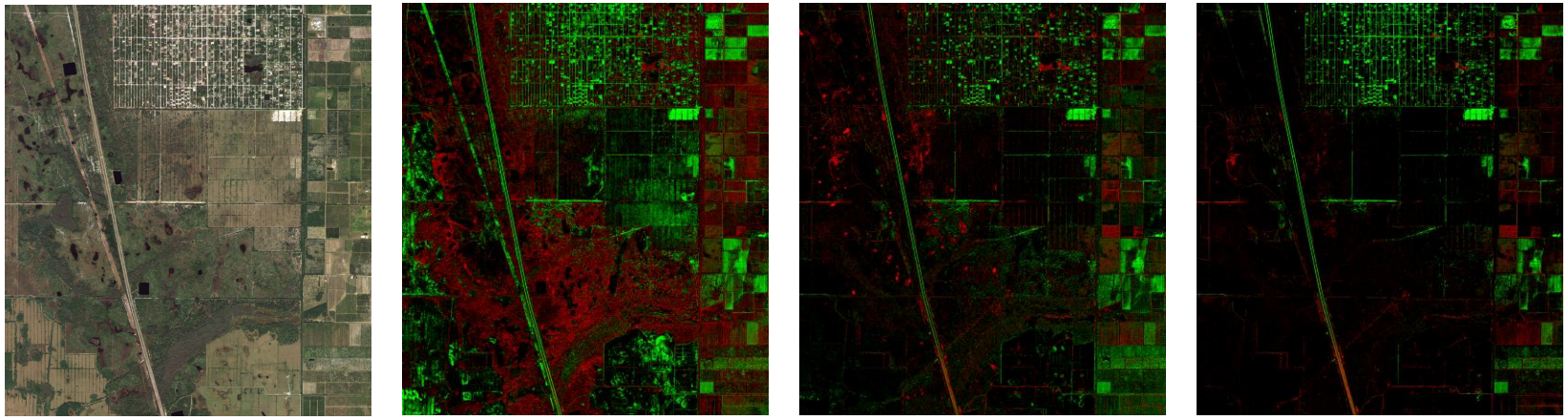
c) band-3 Histogram

Figure 8. Histogram matched 2004 8-bit image histograms

Compare with Direct Image Differencing

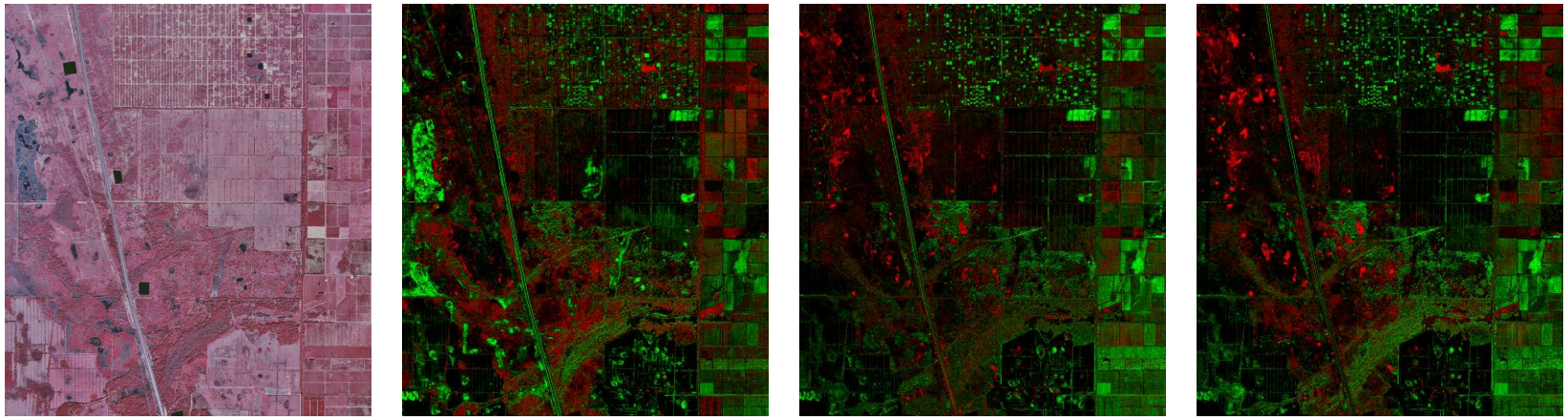


Direct image differencing

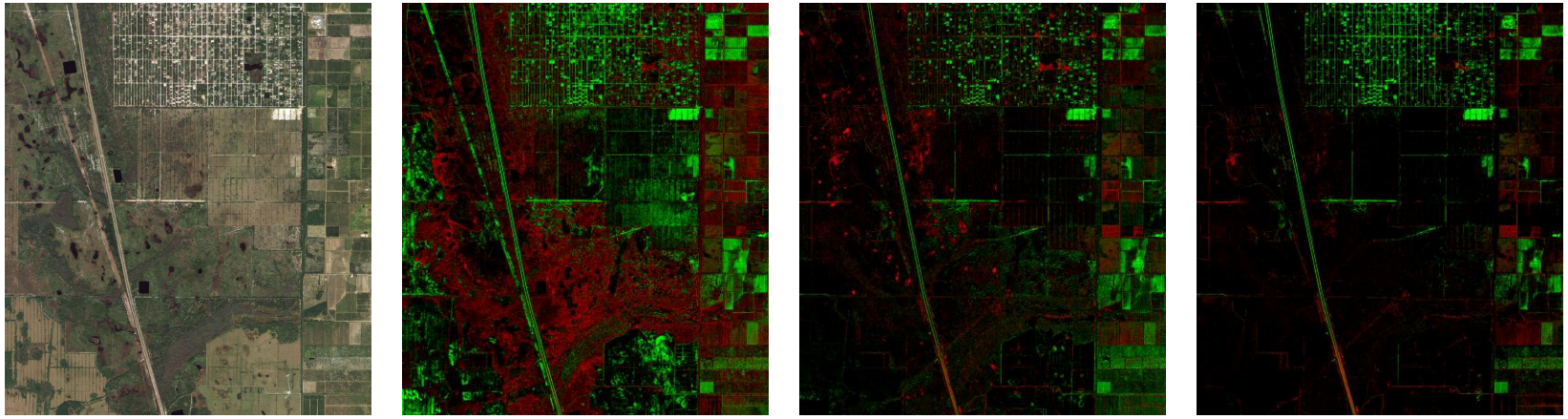


Histogram matching normalized, change map with 2004 image as reference

Overall Change Maps with Different reference image

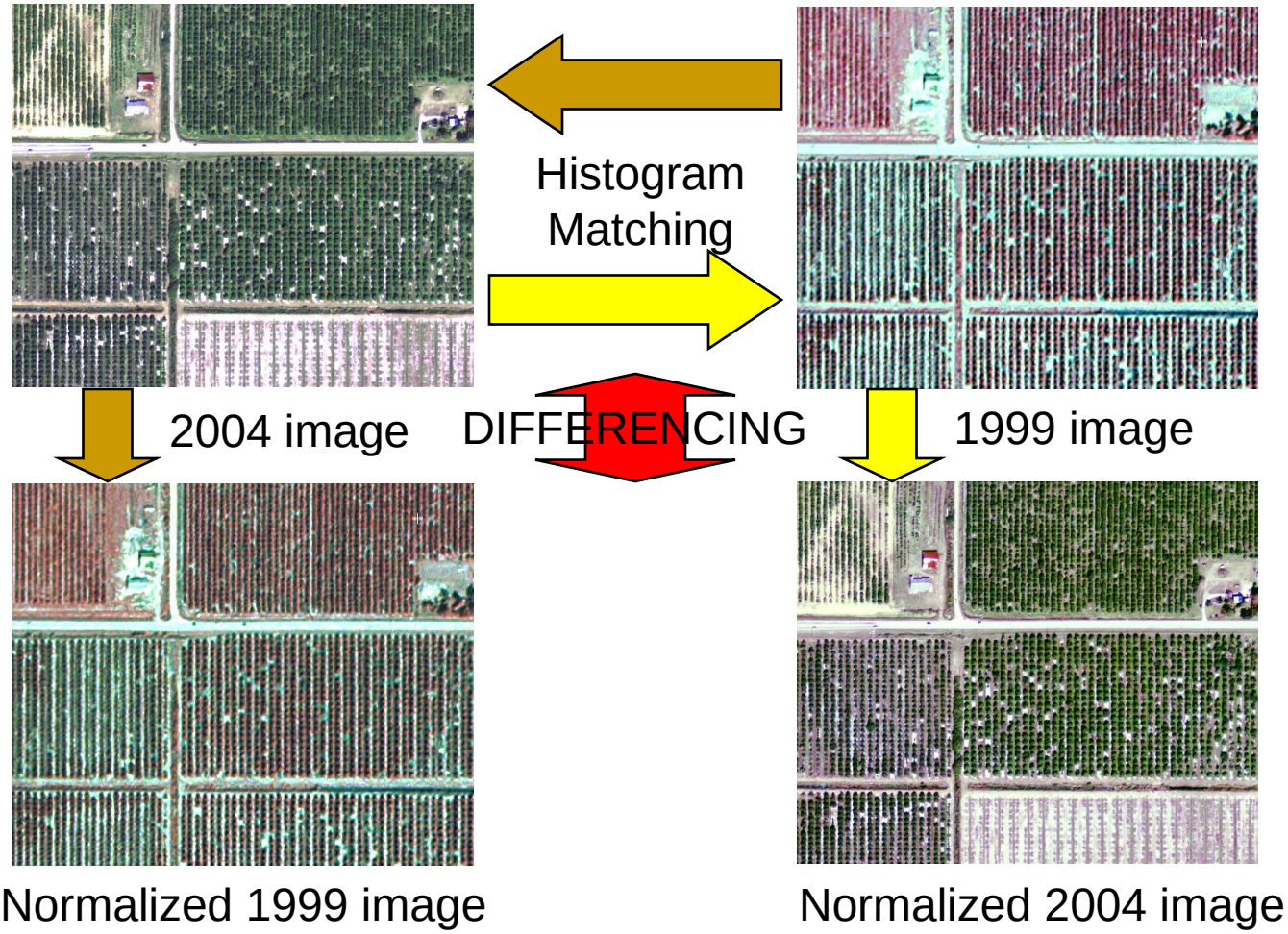


change map with 1999 image as reference

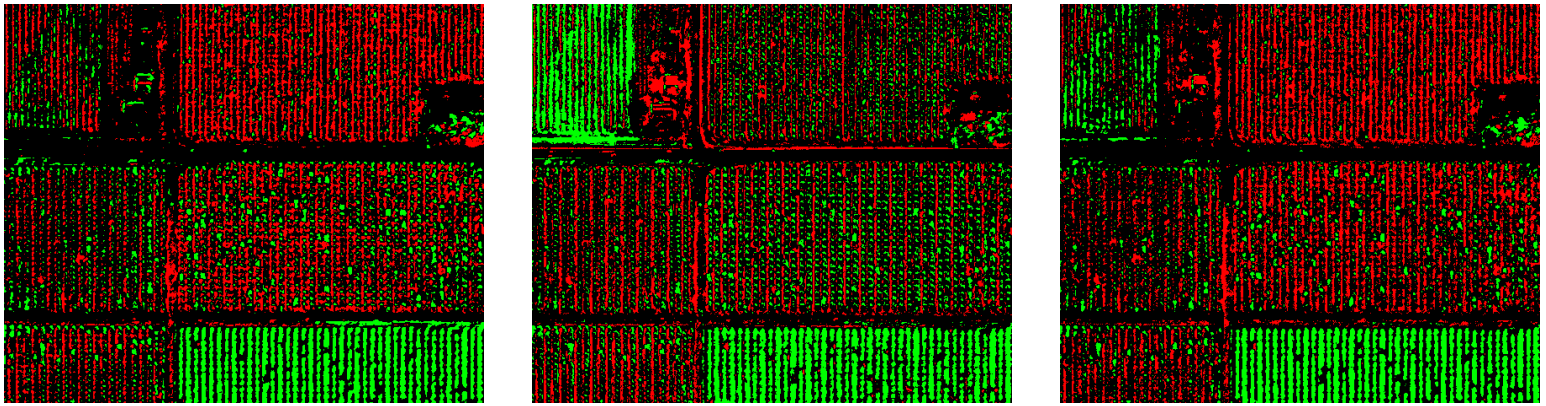


change map with 2004 image as reference

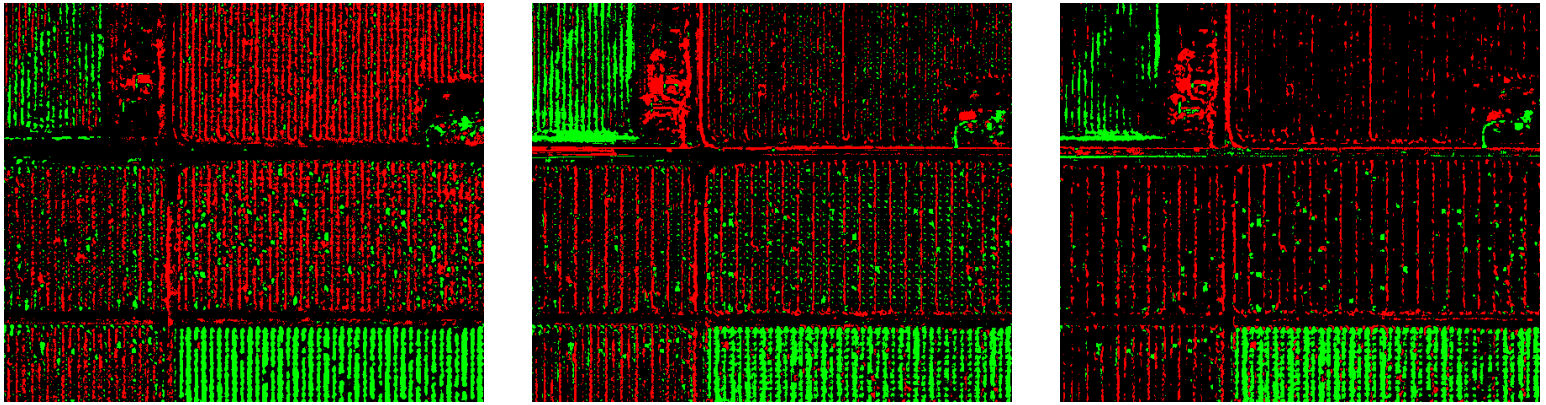
Zoomed Reference and Normalized Image Relationships



Zoomed Change Maps of Different Bands/References - Citrus Field (20%)

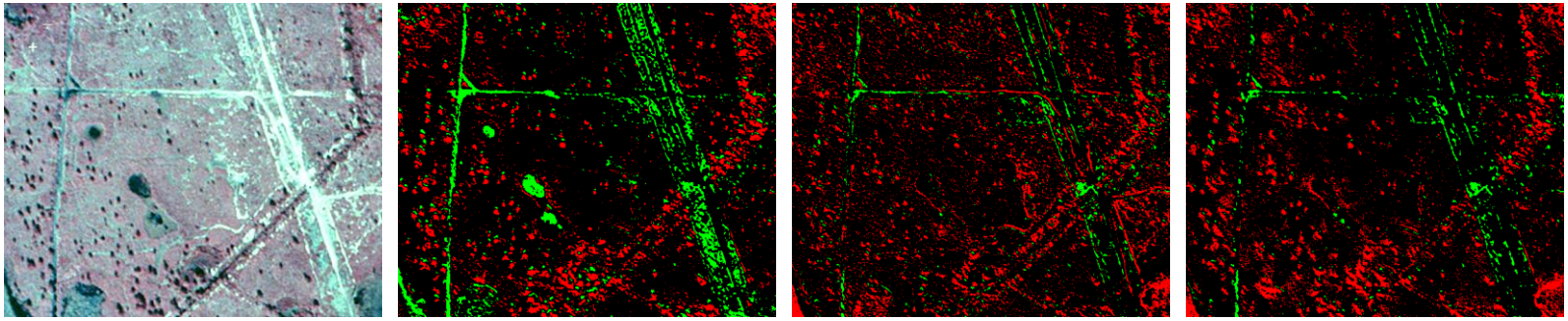


Histogram matched, image differencing change map with 1990 image as reference

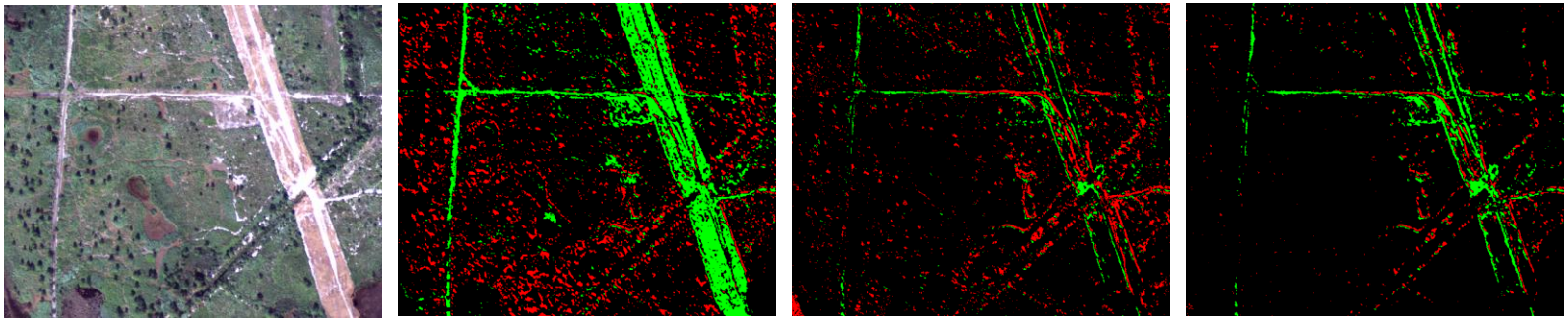


Histogram matched, image differencing change map with 2004 image as reference

Zoomed Change Maps of Different Bands/References – Non-Citrus field (20%)



Histogram matched, image differencing change map with 1990 image as reference



Histogram matched, image differencing change map with 2004 image as reference

Conclusions

- Direct Image differencing change detection method completely fails for some bands of heterogeneously sensed images
- Histogram matching normalization is effective to the images acquired from different sensors
- Histogram matching normalization greatly improves the change detection results to the heterogeneously sensed images
- Normalization result is band-dependent. The worst result comes from the normalization among different spectral bands (histograms differ dramatically)
- Histogram matching results is reference image-dependent.
- The best change detection results come from optimizing the reference image, band and threshold!

THANK YOU!

QUESTION?