Change Detection

The comparison of two or more geographically identical, but temporally separate images to identify variation in surface cover components.

Change Detection Project Design

The design process of a change detection study is similar to the design requirements of most remote sensing projects. The problem is defined, anticipated outcome (hypothesis) and data are evaluated relative to availability, cost and processing requirements. Any of these steps can modify the initial problem statement and anticipated outcome.

Change Detection Processing Steps

Data processing steps that are mandatory for change detection are the radiometric and geometric corrections followed by data normalization. These steps allow the analyst to compare surface driven changes derived from images of different dates. These crucial steps account for non-surface variances affecting the spectral values recorded by the sensor.
1. One image is selected to serve as a master image to which all other images are normalized to. The master image should represent a period of time with superior atmospheric conditions.

2. Each subsequent image in the time series is considered a “slave image” to the master. Slaves are normalized to the master.

3. Master image is converted to exo-atmospheric reflectance using the COST correction algorithm.

4. Slave images are also converted to exo-atmospheric reflectance using the same COST algorithm.

5. The output, COST corrected master image serves as the standard.

6. The output, COST corrected slave is ready for comparison with the master.

7. The pseudo-invariant feature (PIF) algorithm is used to locate spatially coincident pixels in both slave and master that have not changed through time.

8. The PIF algorithm is used to normalize the slave image to the master.

9. All normalized imagery (including the master) is converted to NDVI.

10. NDVI values for each image is normalized into fractional vegetation cover (Fv).

11. All Fv images are added to the temporal database of fractional vegetation cover.

12. Land cover and Land use maps can be used to parameterize individual cover and use categories.
1. Samples of land cover that have not changed within the database time period can be sampled to identify average and variance Fv. This will show how Fv of specific land cover naturally varies throughout the time period.

2. Land use polygons can likewise be sampled to establish mean and normal variance conditions.

3. Statistically significant deviations from established means and variances can be identified on a per pixel basis within a particular land cover or land use category.

4. Pixels within specific land use and cover categories that have significantly deviated from normal conditions can be compared to the "library" of Fv mean and variance statistics for all catalogued land cover and use categories to determine possible new associations.

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**Image Normalization**

- **Master**
  - September 1, 1997
  - Mean = 1.11
  - SD = 0.228
  - Min = 0.181
  - Max = 2.385

- **Slave**
  - August 23, 1988
  - Mean = 1.30
  - SD = 0.272
  - Min = 0.181
  - Max = 2.548

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**Brightness Component Images**

- **Master**
  - September 1, 1997
  - Mean = 159.14
  - SD = 33.13
  - Min = 91.84
  - Max = 375.18

- **Slave**
  - August 23, 1988
  - Mean = 103.70
  - SD = 33.13
  - Min = 91.84
  - Max = 418.86
Identification of Brightest and Darkest Brightness Image Pixels

Locations of Common Dark and Bright Pixels (Pseudo-invariant Features)

Regression Between Master and Slave Radiance Images based on Pseudo-invariant Features

\[ B_{\text{5,988}} = -0.0270759 + 0.8433521997 \]

This regression between the master 1997 radiance image (Band 5) and the corresponding radiance Band 5 of the slave 1988 image provides a linear model to correct the 1988 Band 5 image to fit the distribution of the 1997 image. Notice however that we are developing this model on only two clusters of points.
These plots show the difference between two Landsat Thematic Mapper images (NIR band only) collected at two different time periods. The upper left plot shows the original pixel values used in the standardization model. The upper right plot shows the same pixels after standardization.

The plots below show the same two images before and after (axis titles are identical to the plots above.) In this case a random sample of 400 pixels from each image are plotted against each other around a 1:1 line. The standardized image shows a better correspondence with the 1:1 line.

These histograms show absolute (non-negative) differences between uncorrected and corrected radiance images. The histograms show an expected skew towards 0 with the corrected 1988 image difference from 1997 highly skewed and a definite modal value at or near 0.
Change Detection Algorithms

- Post-Classification
- Pre-Classification

Classification Algorithms (after Jensen 1996)
- Write Function Memory Insertion
- Image Differencing
- Multi-Date Composite Image
- Change Vector Analysis
- Multi-date Change with Binary Mask
- Multi-date Change with Ancillary Data

Multi-date Visual Change Detection

Using Write-Function Memory Insertion

Multi-Date Composite Image

Red image plane
Green image plane
Blue image plane

Advantages:
- Visual examination of 2 or 3 years of nonspecific change

Disadvantages:
- Nonquantitative
- No "from-to" change class information

Figure 9.6 Diagram of Multi-Date Visual Change Detection using Write Function Memory insertion.

Multi-Date Visual Change Detection

Write-Function Memory Insertion (RGB Control)

R = Band 4 1975
G = Band 4 1986
B = Band 4 1986

Difference SAVI images for Camp Williams between 1993 and 1988. Greener areas in the large internal polygon identifies a 1988 fire that has begun recovery.

Post-Classification

Figure 3-2 Diagram of Multi Data Post Classification Comparison Change Detection.
Modified Post-Classification

Comparison to Recent Image Generated Map

Comparison to Recent Image Generated Map (cont.)

Accuracy assessment for is a critical component for thematic change detection. We not only have to deal with errors with the first date map, but also errors in the second date map.
This and the following images are SAVI differences between specific dates. Land cover polygons provide context.
Sagebrush Grass Change

Agriculture Change

Non-Image Generated Date 1 Map

Change Detection Using Ancillary Data Source on Date 1

Ancillary data source: Hydrological, Vegetation, Landcover, Map layers.

Classification map of Date 2

Figure 9-18: Diagram of Multidate Change Detection Using Ancillary Data Source on Date 1.
Change Vector Analysis

- SAVI
- Date 1
- Date 2
- Date 3
- ISODATA Cluster
- Pixel by Pixel Evaluation
- Grouping of similar signatures

Change Vector Analysis (cont.)

- Change Detection

Change Vector Analysis (cont.)

- Change Detection

Change Vector Analysis (cont.)

- Change Detection