Change detection by the MAD method in hyperspectral image data

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ABSTRACT

The MAD (Multivariate Alteration Detection) method [1] is used to detect change between two HyMap scenes recorded during the DAISEX campaign in 1999 over the Barrax area in Spain near the city of Albacete. Out of a series of acquisitions two scenes recorded on 3 June at 12:00 and 4 June at 15:00 were selected for analysis. The Barrax experiment was undertaken in support of a future ESA Land Surface Mission (SPECTRA). A series of flights have been conducted over the same test area at different times of the day in order to maximize BRDF effects in various surface types.

The changes observed by MAD in the two selected scenes are primarily due to the differences in flight directions (3 June N-S, 4 June E-W) and sun angle changes. In higher MAD bands differences of the two scenes can be observed that can be related to irrigation practices. MAD can also be used to highlight remaining geometrical co-registration errors.

The MAD method is based on the technique of canonical correlation analysis which is an established method in multivariate statistics. The MAD method finds differences between linear combinations of the spectral bands from the two acquisitions. These differences are orthogonal and they are constructed so that they explain maximum variance which is a healthy criterion for a change detector. Finding maximum variance in differences of linear combinations correspond to finding minimum correlation between these linear combinations. It is easy to show that the MAD variables are invariant to affine transformations of the input variables, i.e., the spectral bands. The method is therefore insensitive to any pre-processing that changes the digital numbers in a linear fashion. So whether one performs for example a linear (or an affine) relative normalization of one acquisition to the other doesn't matter. This scaling invariance is a great advantage of the MAD method over other multivariate change detectors and it can be used to identify observations that are no-change pixels over time. These time invariant pixels are well suited for use in a relative normalization between time points. This relative normalization is useful if one desires to use other change detectors than MAD such as change detectors based on simple difference imagery and if atmospheric calibration cannot be performed (for example if work is done on historical data). Also, normalization is important if one wants to study the temporal development of a vegetation index or similar.

For spectral data the variables (the spectral bands) are typically strongly correlated or collinear. This may lead to ill-conditioned, i.e., (near) singular variance-covariance matrices. Also, one might wish to smooth the elements of the eigenvectors (seen as functions of the wavelength) for improved interpretability. For hyperspectral data the number of observations may be low (relative to the number of variables). Again, this may lead to ill-conditioning. A possible remedy is regularization.

MAD is seen as an important method in future automated change detection applications and automated relative normalization for multi- and hyperspectral satellite remote sensing systems.

Figure 1 shows an example of a change image from the MAD analysis: an image consisting of the sum of standardized, squared MAD variables.

Keywords: Automatic normalization, collinearity, regularization, cross-validation, HyMap, DAISEX.

Presented at the 3rd EARSeL Workshop on Imaging Spectroscopy, Oberpfaffenhofen, May 13-16 2003

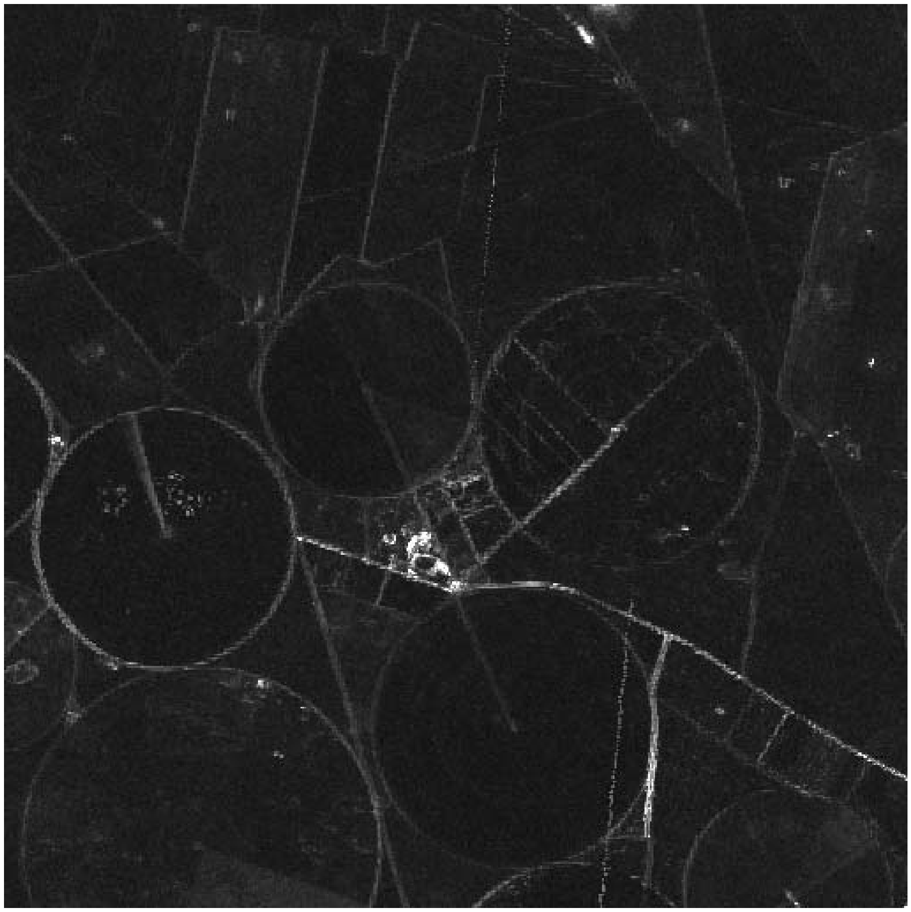

Figure 1. Sum of standardized, squared MAD variables; very bright regions are high change areas, very dark regions are low change areas.

REFERENCES

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