

Technical University of Denmark



Kernel based orthogonalization for change detection in hyperspectral images

Nielsen, Allan Aasbjerg

Publication date:
2013

[Link back to DTU Orbit](#)

Citation (APA):

Nielsen, A. A. (2013). Kernel based orthogonalization for change detection in hyperspectral images. Abstract from 8th EARSeL Workshop on Imaging Spectroscopy, Nantes, France.

DTU Library
Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Kernel based orthogonalization for change detection in hyperspectral image data

Allan A. Nielsen

Technical University of Denmark
DTU Space – National Space Institute
Richard Petersens Plads, Building 321, DK-2800 Kgs. Lyngby, Denmark
Tel +45 4525 3425, Fax +45 4588 1397
E-mail aa@space.dtu.dk, <http://www.imm.dtu.dk/~aa>

ABSTRACT

Kernel versions of principal component analysis (PCA) and minimum noise fraction (MNF) analysis are applied to change detection in hyperspectral image (HyMap) data. The kernel versions are based on so-called Q-mode analysis in which the data enter into the analysis via inner products in the Gram matrix only. In the kernel version the inner products are replaced by inner products between nonlinear mappings into higher dimensional feature space of the original data. Via kernel substitution also known as the kernel trick these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of this kernel function. This means that we need not know the nonlinear mappings explicitly. Kernel PCA and MNF analyses handle nonlinearities by implicitly transforming data into high (even infinite) dimensional feature space via the kernel function and then performing a linear analysis in that space. An example shows the successful application of (kernel PCA and) kernel MNF analysis to change detection in HyMap data covering a small agricultural area near Lake Waging-Taching, Bavaria, in Southern Germany.

In the change detection analysis all 126 spectral bands of the HyMap are included. Changes on the ground are most likely due to harvest having taken place between the two acquisitions and solar effects (both solar elevation and azimuth have changed). Both types of kernel analysis emphasize change and unlike kernel PCA, kernel MNF analysis seems to focus on the most conspicuous changes and also it gives a strong discrimination between change and no-change regions. Ordinary linear PCA or MNF analyses do not give this beautiful discrimination between change and no-change regions.

Thanks to Andreas Müller and co-workers, DLR German Aerospace Center, Oberpfaffenhofen, Germany, for kind permission to use the HyMap data. Thanks to both Andreas Müller and Mort Canty, Research Center Juelich, Germany, for many years of interesting cooperation on the analysis of multi- and hyperspectral image data.

REFERENCES

1. B. Schölkopf, A. Smola, and K.-R. Müller, "Nonlinear component analysis as a kernel eigenvalue problem," *Neural Computation*, vol. 10, no. 5, pp. 1299–1319, 1998.
2. J. Shawe-Taylor and N. Cristianini, *Kernel Methods for Pattern Analysis*, Cambridge University Press, 2004.
3. C. M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
4. W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, *Numerical Recipes: The Art of Scientific Computing*, third edition, Cambridge University Press, 2007.
5. A. A. Nielsen and M. J. Canty, "Kernel principal component analysis for change detection," SPIE Europe Remote Sensing Conference, Cardiff, Great Britain, 15-18 September 2008, Internet <http://www.imm.dtu.dk/pubdb/p.php?5667>.
6. A. A. Nielsen, "Kernel maximum autocorrelation factor and minimum noise fraction transformations," *IEEE Transactions on Image Processing*, vol. 20, no. 3, pp. 612–624, 2011. Internet <http://www.imm.dtu.dk/pubdb/p.php?5925>.
7. L. Gómez-Chova, A. A. Nielsen, and G. Camps-Valls, "Explicit signal to noise ratio in reproducing kernel Hilbert spaces," IEEE IGARSS, Vancouver, Canada, 25-29 July 2011. Internet <http://www.imm.dtu.dk/pubdb/p.php?6004>. *Invited contribution*.

Keywords: Orthogonal transformations, dual formulation, Q-mode analysis, kernel substitution, kernel trick.