IMPROVED CLASSIFICATION AND LABELING OF HIGH RESOLUTION SAR IMAGES BY TIME SERIES DATA

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Introduction

Time series of high resolution SAR images can be used profitably to classify the given images and to label them. SAR images are typically affected by speckle noise, multiple reflections and overlay effects. Time series acquisitions offer the chance for clutter reduction and the robust identification of transient effects such as slowly evolving phenomena or sudden events. In the following, we will show typical cases where the analysis of time series data helps to understand high resolution SAR images.

Clutter Reduction

When we look at multiple acquisitions of a non-changing scene then the stacking and co-addition of co-aligned images will result in low-noise average images. This is illustrated in Figure 1 that shows an averaged time series of a selected urban area.

We have to be aware that several effects such as radiometric noise, small surface cover changes, different soil moisture conditions, and residual geometrical shifts will be simply averaged out. Outlier effects can be reduced by discarding offending images.

Ideally, brightness averaging is equivalent to optimal feature clustering during classification and robust labeling of image patches. The clustering efficiency can be validated by determining the spreading extent of the feature vectors.

Fig. 1: Averaged radiometrically enhanced MGD HH image time series of Stuttgart, Germany seen by TerraSAR-X [1]. Single trees and their radar shadows become clearly visible. The resolution of the original images is 2.85 m, their incidence angle is 48.2 deg. The image covers an area of 1250 $\times$1250 m.

Transient Phenomena

When we obtain sets of geometrically overlapping images with varying content, we have to be aware of the nature of the variations. Typical examples are slowly varying phenomena such as plant growth effects during a vegetation cycle, more quickly varying vehicles on roads and parking lots, construction activities extending over weeks and months, or sudden events such as a flooding with pre-event and post-event images.

In these cases, simple averaging would lead to misleading results. Instead, one can imagine that we track the dynamic evolution of local feature vectors in feature space. Then the temporal trace of the local feature vectors yield a higher level descriptor of the transient phenomena.

Figure 2 shows the temporal evolution of an agricultural area near Ludwigshafen, Germany over more than two years depicted as the total sum of differences and as color-coded changes (red: positive changes, green: negative changes, blue: total changes).

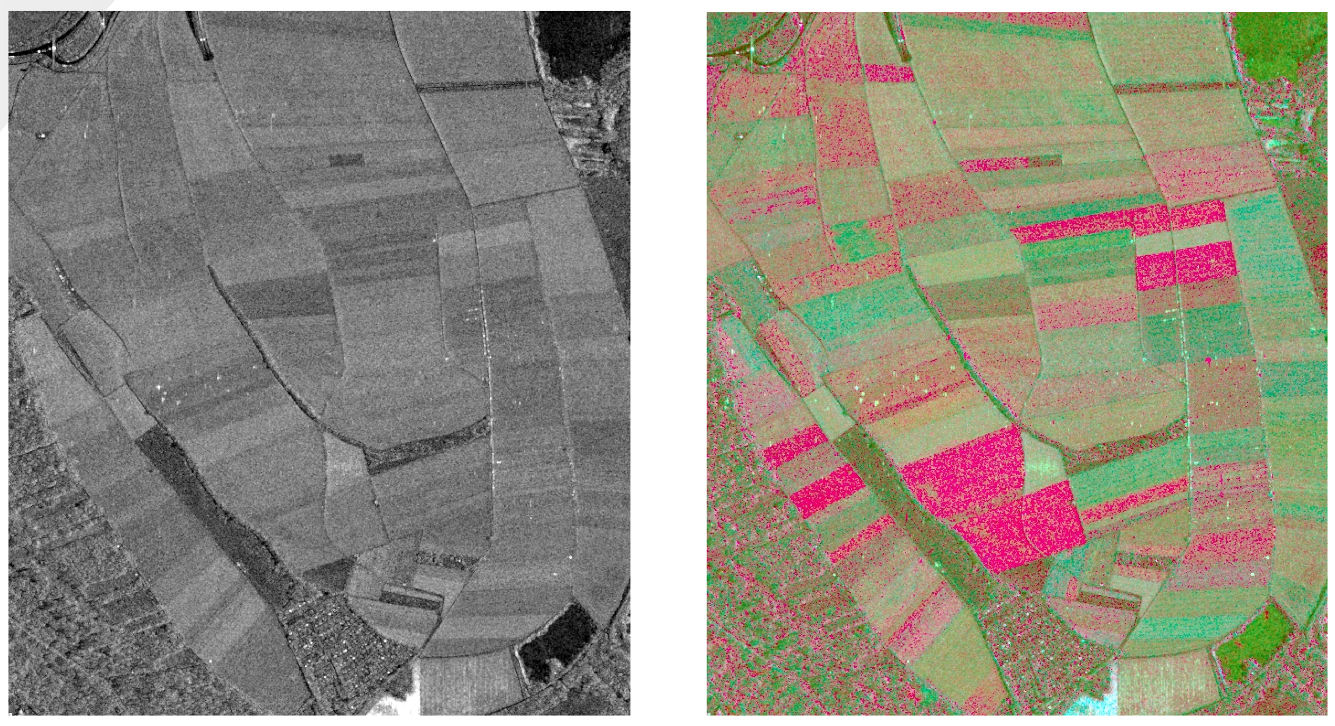

Fig. 2: Total sum of differences (left) and color-coded changes (right) based on a radiometrically enhanced TerraSAR-X MGD HH image time series with an incidence angle of 34.6 deg.

When we want to know more about the meaning of the temporal evolution, we have to look into the dynamic evolution of local features. The easiest analysis tool is the tracking of local mean values versus time. This reveals events such as continuous plant growth, harvesting or plowing.

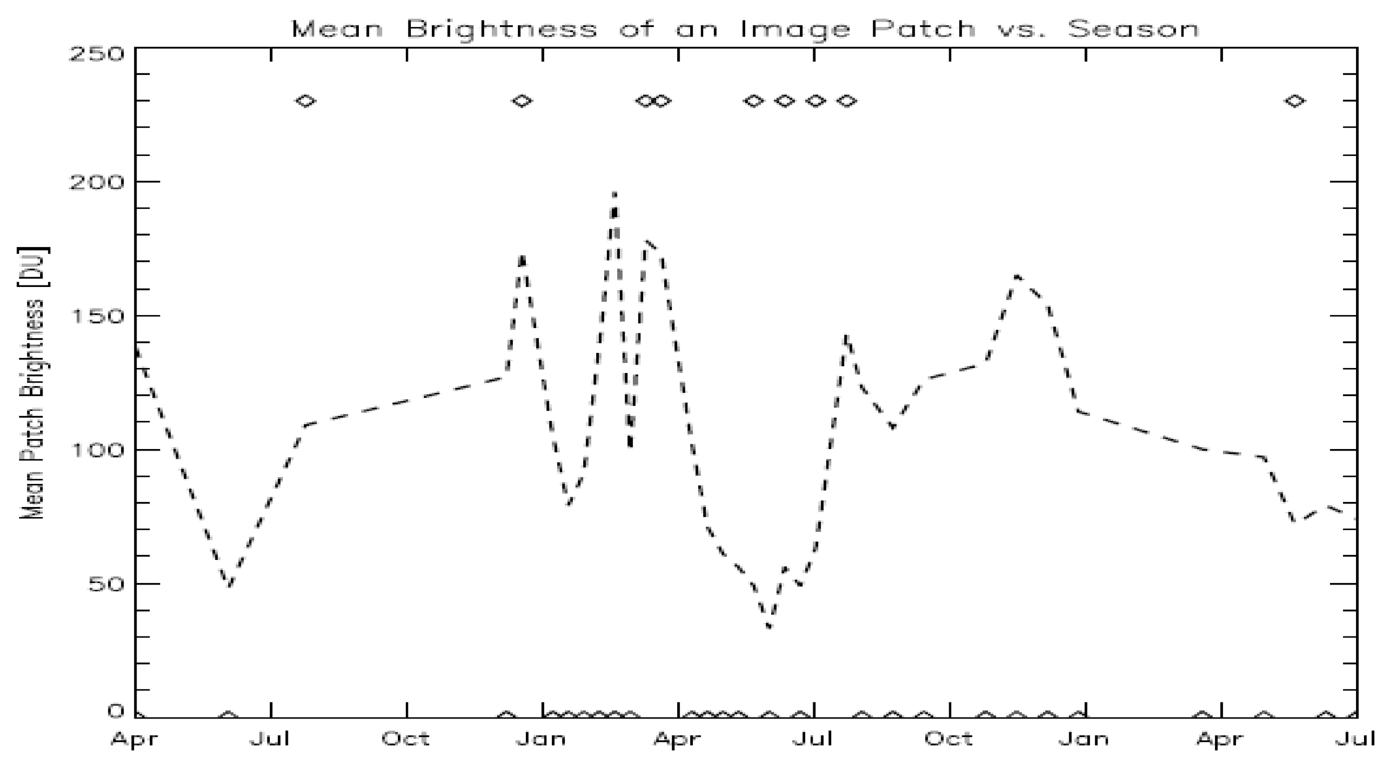

Fig. 3: Mean seasonal brightness of an image patch extracted from Figure 2 data. Diamonds near the top level of the plot denote dates with strong precipitation.

Selection of Best Candidate Images

Image time series lend themselves well to select optimal candidate images. Multiple SAR image acquisitions of the same surface area may result in images with different brightness and contrast levels. This is shown in Figure 4.

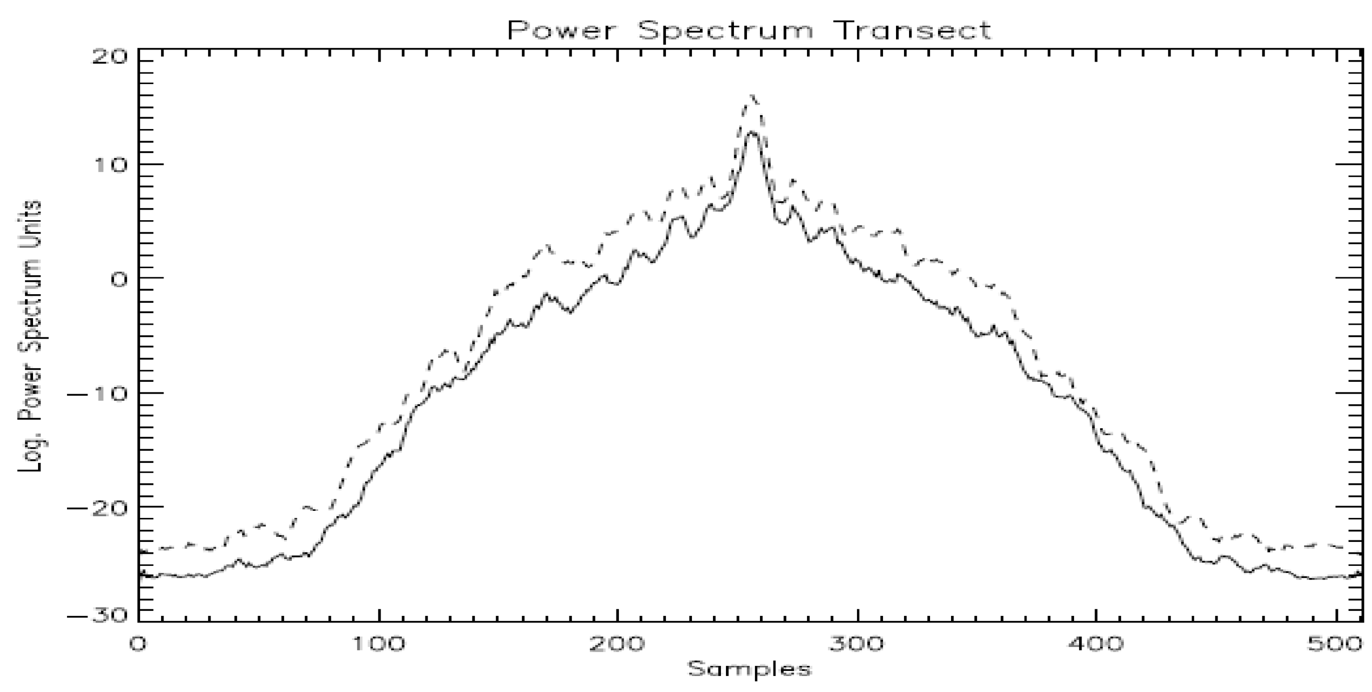

Fig. 4: Power spectrum transects of two image acquisitions.

References

[1] R. Werninghaus and S. Buckreuss, "The TerraSAR-X Mission and System Design", *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 48, Issue 2, pp. 606-614, Feb. 2010.

[2] C. Dumitru, M. Datcu, S. Cui, and G. Schwarz, "Information Content of Very High Resolution SAR Images: Semantics, Geospatial Context, and Ontologies", *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, Vol. 8 , Issue 4, pp. 1635-1650, April 2015.