# Edge Detection in Multi-Channel SAR images

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## Abstract

*A new scheme for the detection of edges in multi-channel SAR images is proposed. The first step is a low-level edge detector based on multi-variate statistical hypothesis tests. The hypothesis test is used to decide whether an edge of a given orientation passes through the current point and is repeated for a discrete number (8) of orientations. The response for the different orientations as well as for different bands is fused using a method based on Dempster-Shafer (DS) Theory. A small set of learning points is used to optimise the parameters of this fusion using classical optimisation methods.*

## 1 Introduction

Synthetic Aperture Radar (SAR) images are very important for remote sensing because they can be acquired independent of time of day or weather conditions. Due to the presence of speckle, i.e. an interferometric phenomenon with a noise-like appearance, classical image processing algorithms fail when applied to a SAR image. Specific image processing methods, that exploit the statistical properties of the speckle, need to be developed. In this paper we propose an edge detection scheme for high-resolution multi-channel SAR images. Current edge detectors were designed to work on low-resolution, single-band, multi-look SAR images. The most widely used edge detector for such SAR images is the ratio-detector [1, 2]. It is based on the speckle distribution in uniform regions in single-band multi-look intensity images. [3] proposes new edge detectors for full-polarimetric SAR images, based on multi-variate statistical hypothesis tests. The hypothesis test is applied for different orientations of a set of two scanning rectangles. For determining whether a vertical edge passes through a point P two vertical rectangles are constructed around the point P and the statistics of the pixels in both rectangles are compared using the hypothesis test. The test is repeated for 8 orientations of the rectangles. Normally the maximum of the response over all orientations is considered as the global edge response. Here we investigate a new and improved way to combine (fuse) the responses of statistical edge detectors. The method is based on Dempster-Shafer evidence theory [4, 5]. In a first step the fusion method is applied to combine the response of the statistical test over the different orientations of the scanning rectangles. In a second step the same fusion method is used to combine edge detection results obtained from two frequency-bands (L- and P-band).

## 2 Description of the method

In single-look complex (SLC) SAR images differences of radar backscattering appear as differences in variance of a zero-mean normal distribution of the speckle. For polarimetric SLC images the distribution is multi-variate normal. A multi-variate hypothesis test for the difference of variance can thus be used for building an edge detector for such polarimetric images. In this work we used a Levene test [6]. The theoretical distribution of the test-statistic when the null-hypothesis is verified is used to transform the test-statistic, in each point of the image and for a given orientation of the scanning rectangles, into the corresponding p-value. This allows to compare and combine results of different edge operators. The p-values from different orientations of the scanning rectangles are combined using a method based on Dempster-Shafer theory [4, 5]. Dempster-Shafer or evidence theory is a mathematical tool that allows to work with uncertain, imprecise and incomplete information. The uncertainty is taken into account by assigning masses to sets of different hypotheses. Several experts distribute their knowledge over these different hypotheses and a final decision is obtained after combining the masses assigned by each expert.

The edge detector for each orientation of the windows is considered as an expert giving its opinion about the presence of an edge along that direction. A small p-value means the expert has a strong opinion about the presence of the edge and consequently a high confidence should be given to that direction. The larger the p-value, the less strong the opinion is and the less confidence should be given to that particular direction. We use 8 orientations $D_0..D_7$ of the scanning rectangles and we say that if a low p-value is found for a given direction, it does not necessarily mean an edge is located along that direction; it could be oriented along neighbouring directions. Even when we find an edge in a given orientation, we do not know whether there is, in the same point not also an edge along another orientation (a corner). Therefore we need to attribute also some mass to the other directions. The following subsets of directions were defined: the singleton $\{D_i\}$, the triplet $\{D_{i-1}, D_i, D_{i+1}\}$, the complement of the direction $\overline{\{D_i\}}$ and the complete set of directions $\{D_0..D_7\}$. For each orientation the detector distributes its confidence over these 4 sets and the final result is obtained by combining the masses over all orientations (and frequency bands).

For determining the DS system's parameters, a learning set with examples of edge, corner and background points was selected. To introduce a dependence of the mass assignment on the p-values, obtained for the different orientations, the range of possible p-values was divided into 5 sub-ranges. The actual borders are fixed by studying the p-values of the set of learning points for a given edge direction. The thresholds are selected such that for the correct edge direction the p-values are very low or low; for corners they are intermediate or high and in the background the p-values are high or very high. For each of the sub-ranges we still need to determine the masses to be attributed to the 4 sub-sets. This was done by minimising a cost function evaluated on the learning set. A non-linear constrained optimisation method is used to find the optimal parameters.

The proposed method is applied to combine the results for the 8 orientations of the scanning rectangles for the edges detected on a P-band image and the same method (with the same parameters) is applied to fuse results obtained from two SAR frequency bands (P- and L-band). Some results are shown in fig. 1.

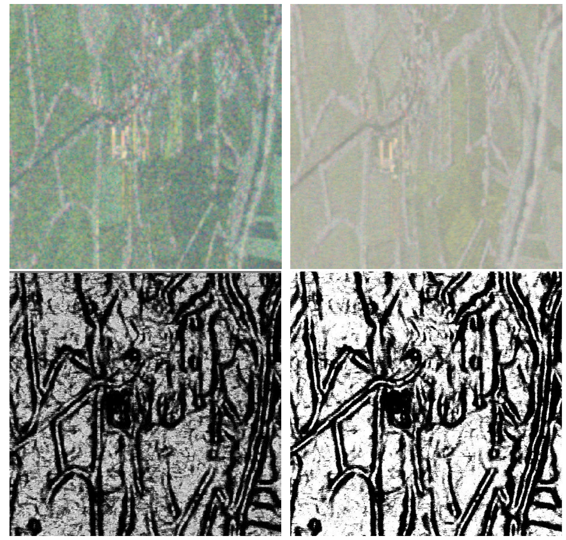

Figure 1: Results of the method (UL: P-band image,UR: L-band image, LL: edges detected in P-band image, LR: edges after fusion of P- and L-band)

## 3 Summary and Conclusions

A new edge detector scheme for multi-channel SAR images is proposed. A multi-variate statistical hypothesis test is used to obtain an edge response for a given number of possible edge directions in single-fequency, polarimetric images. Results for different directions are combined using a method based on Dempster-Shafer theory. The parameters are optimised using a small learning set. The same fusion method is successfully applied for combining the edge response from different frequency bands.


### Acknowledgments

The test image is an dual-band, full-polarimetric E-SAR image provided by the German Aerospace Center (DLR). The project is funded by IST-2000-25044 of the European Commission.


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