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Semi-Supervised Terrain Classification PolSAR Images

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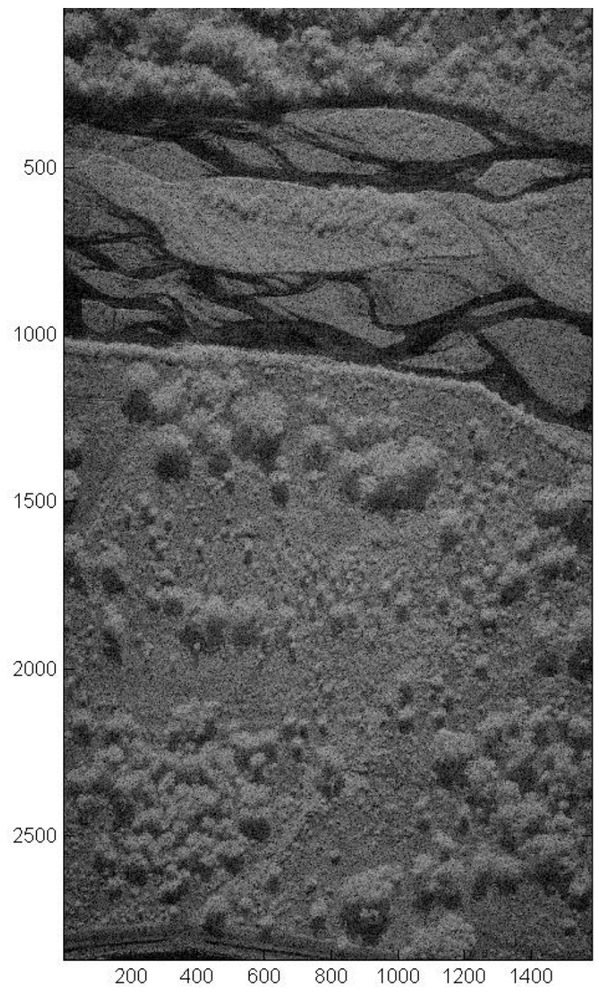
Abstract

In effort to enhance image segmentation and classification of terrain in fully polarimetric SAR images, a novel strategy is explored by analyzing the results of two decompositions: $H/A/\bar{\alpha}$ and $G4U$. From these decompositions, eight different parameters are then assigned to each pixel and these parameters are compared to the distributions of several hand-selected masks corresponding to classes of interest. Pixels are assigned to the class with the likeliest distribution.

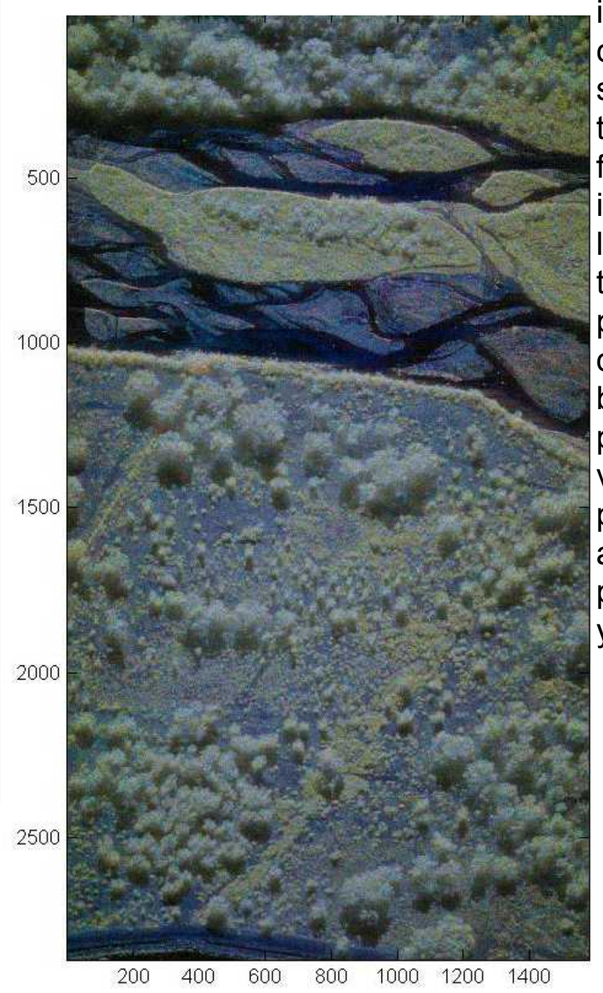
What is PolSAR?

Synthetic Aperture Radars radiate electromagnetic waves, these waves interact with the ground and are reradiated back to the radar. The returned signals are processed and form an image. Most SAR platforms are single pole, that means that they send and receive only one polarization (see the VV image to the left). Polarimetric SAR (PolSAR) systems receive all the polarization information returned to the radar. To do this, PolSAR systems send and receive both horizontally and vertically polarized waves. So each pixel now contains information corresponding to the four different combinations of polarization states. Could this extra information help the classification of an image?



$G4U$

The General Four-Component Scattering Power Decomposition with Unitary Transformation of Coherency Matrix (**G4U**) is the *state-of-the-art* **model-based** decomposition that fits the Coherency matrix to contributions from four independent canonical scatter types. The false color image on the left colors the surface power blue, double-bounce power red, volume power green, and helical power yellow.



$H/A/\bar{\alpha}$

In 1997, Cloude and Pottier proposed a polarimetric decomposition that analyzed the eigenvectors of the coherency matrix, T_3. This decomposition produces the entropy (H), anisotropy (A), and an $\bar{\alpha}$ parameter.

Probabilistic Fusion

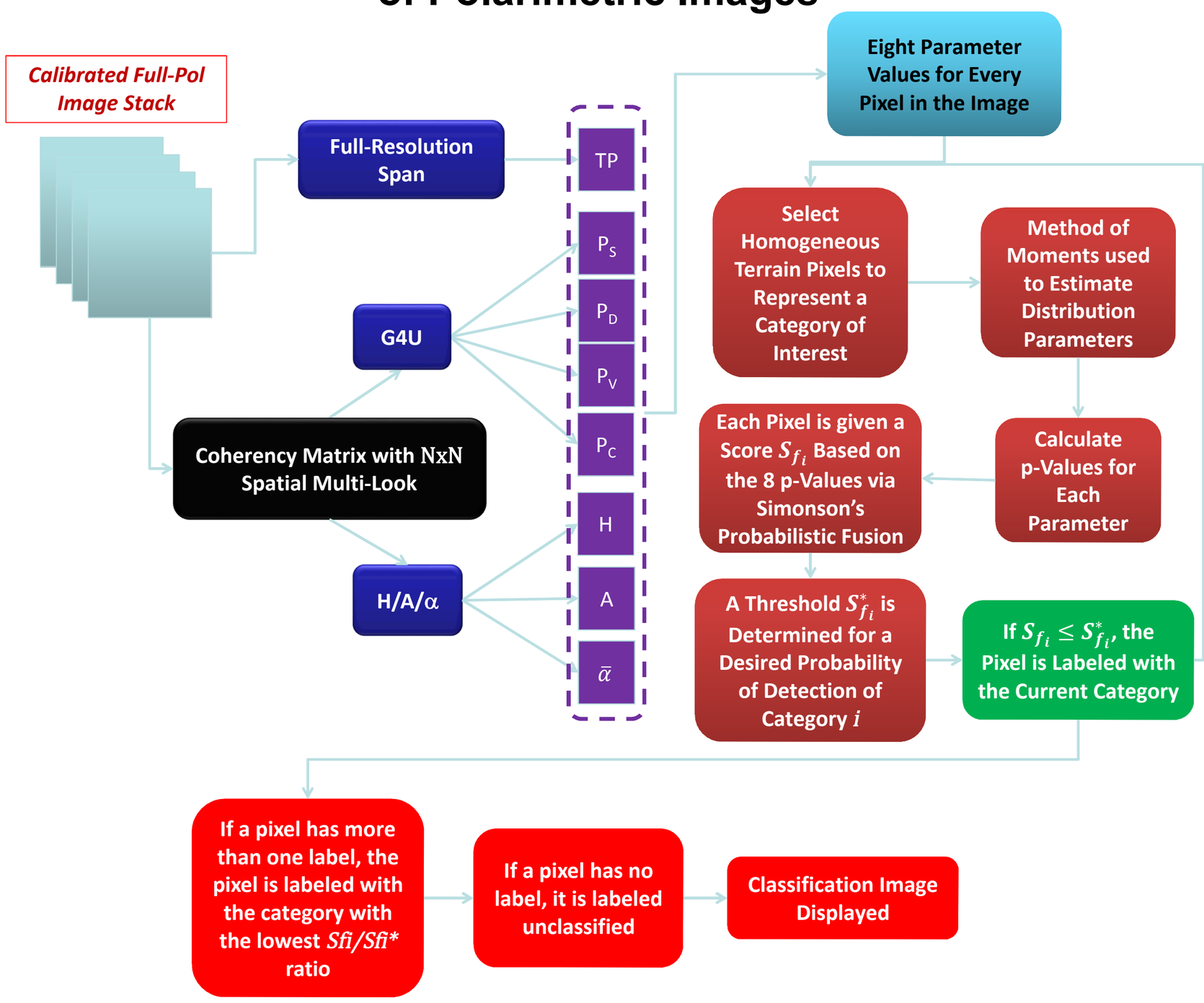
The seven results of these decompositions, together with the total power, are combined using a Simonson's probabilistic fusion approach. From hand-selected pixels representing a desired class, the method of moments is used to estimate distribution parameters. P-values are calculated, measuring the probability that each pixel's parameter fits the corresponding distribution of the hand-selected pixels. A pixel's eight p-values can be transformed and fused together into one score by

$$S_f = \sum_{i=1}^{8} -\log(p_i)\,.$$

The distribution of the p-values of pixels that belong to a terrain category have a uniform distribution on $[0,1]$. Therefore the distribution of $-\log(p_i)$ for a given i is the standard exponential. The distribution of S_f, which is the sum of standard exponentials, has a gamma distribution if the $-\log(p_i)$ values are independent. If the $-\log(p_i)$ values are not independent, the distribution of S_f can still be approximated with a gamma distribution adjusting the parameters for the estimated correlation. A threshold, S_f^*, is selected to correspond to the desired probability of detection (PD) with $G(S_f^*; \hat{r}, \hat{\lambda}) = PD$. If the fused measure S_f is less than or equal to S_f^*, the pixel is labeled with the corresponding terrain category.

Method

Semi-Supervised Terrain Classification of Polarimetric Images



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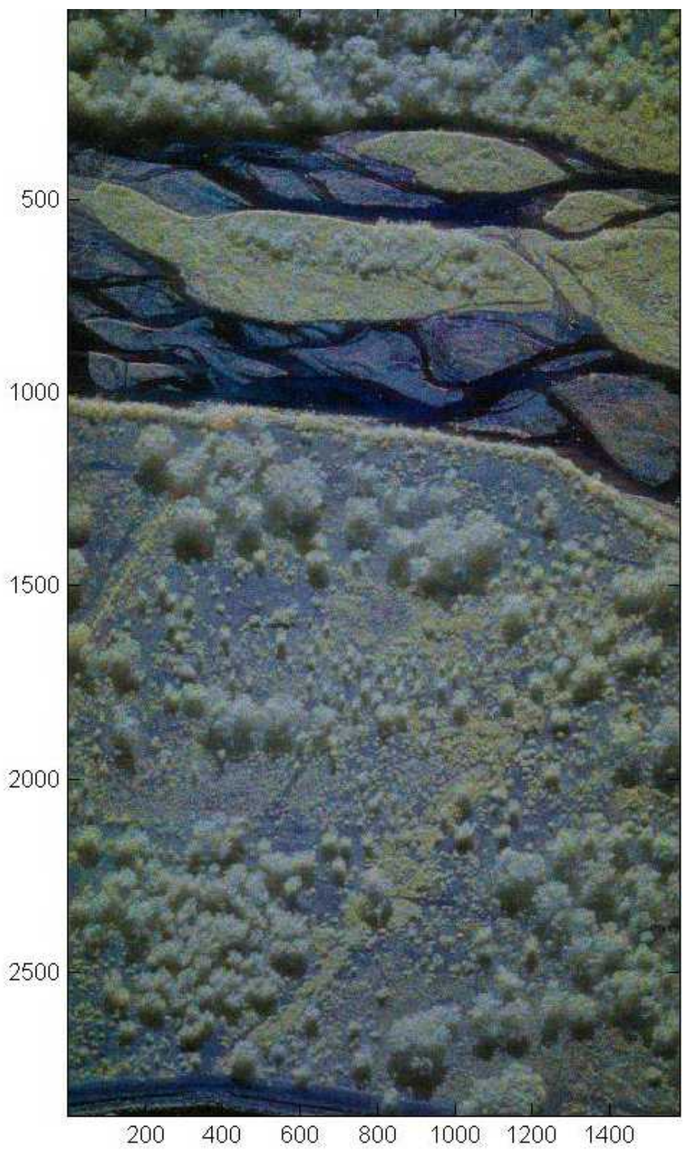
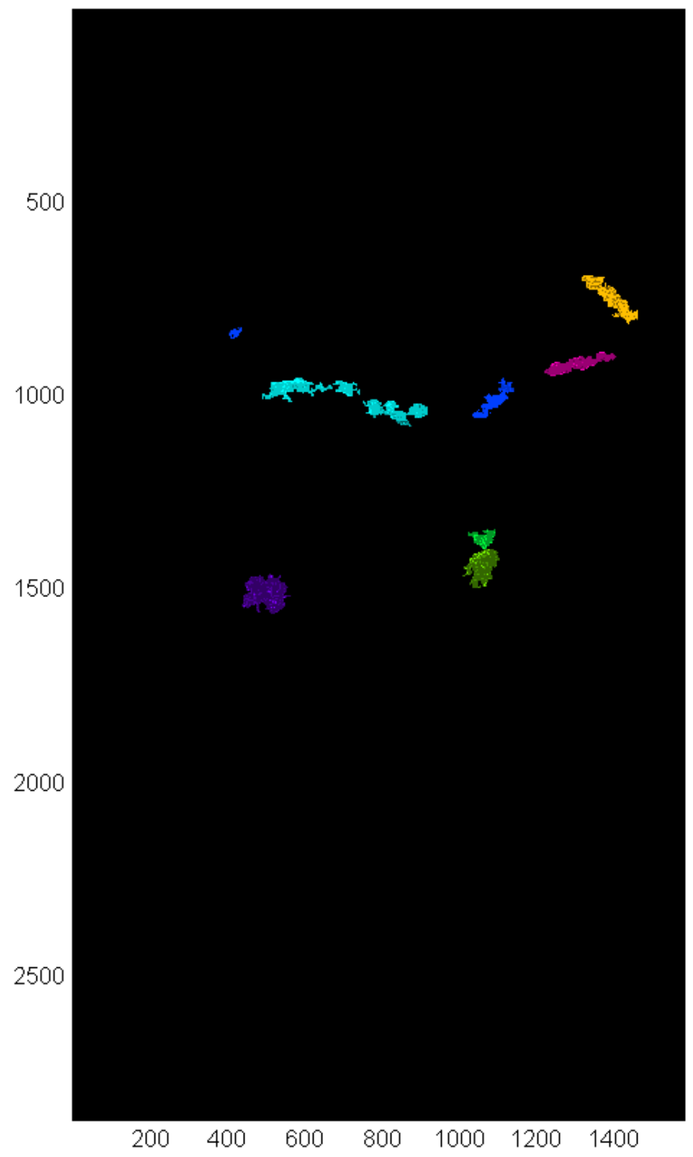
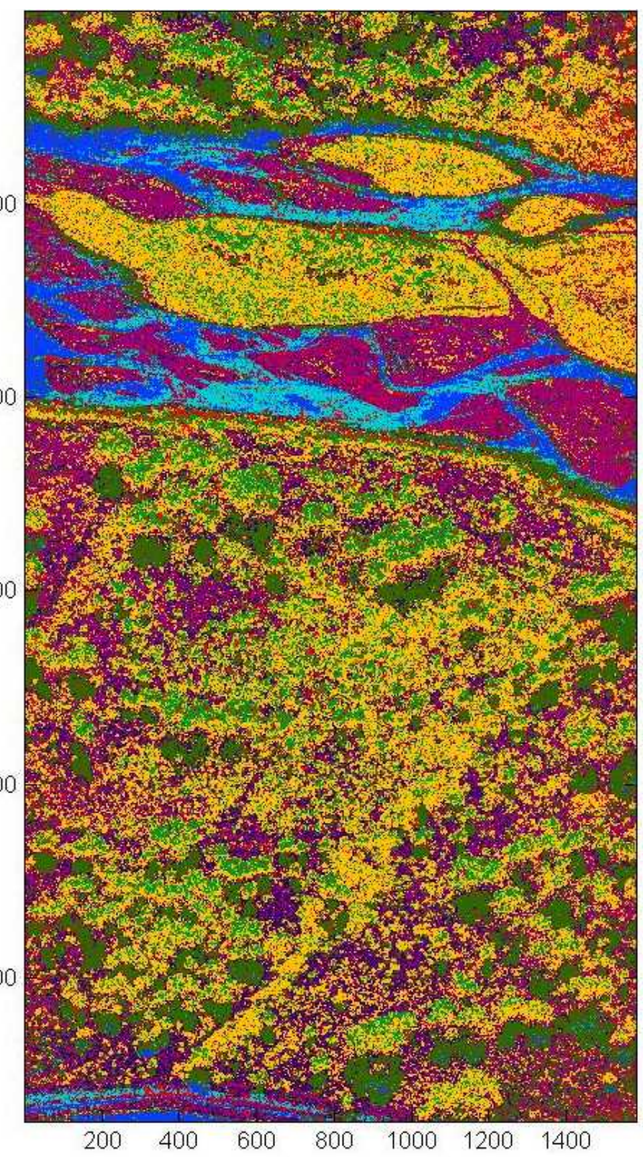
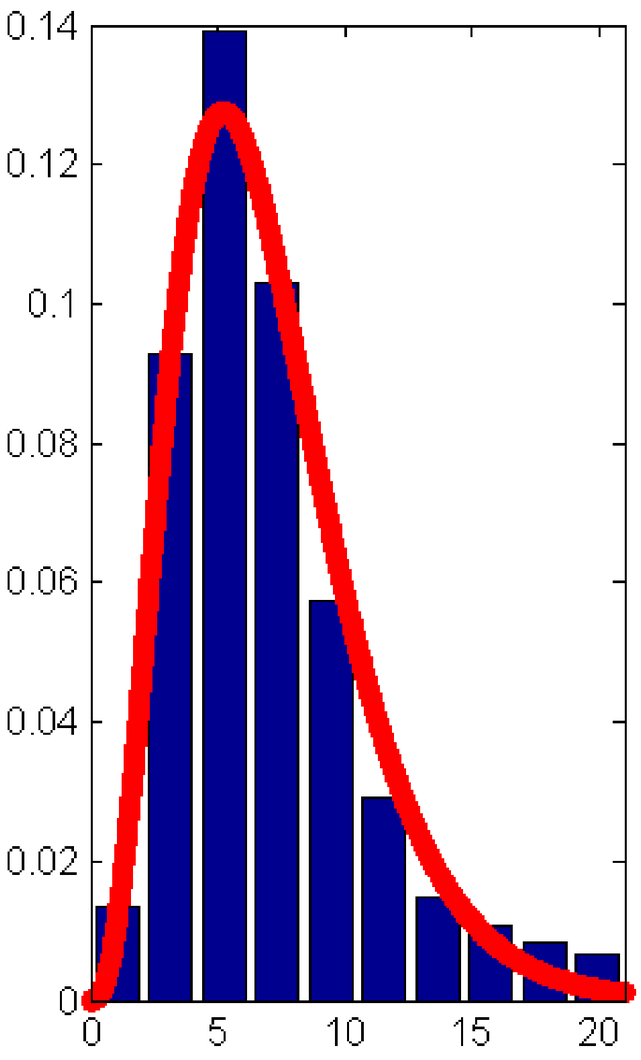
Results

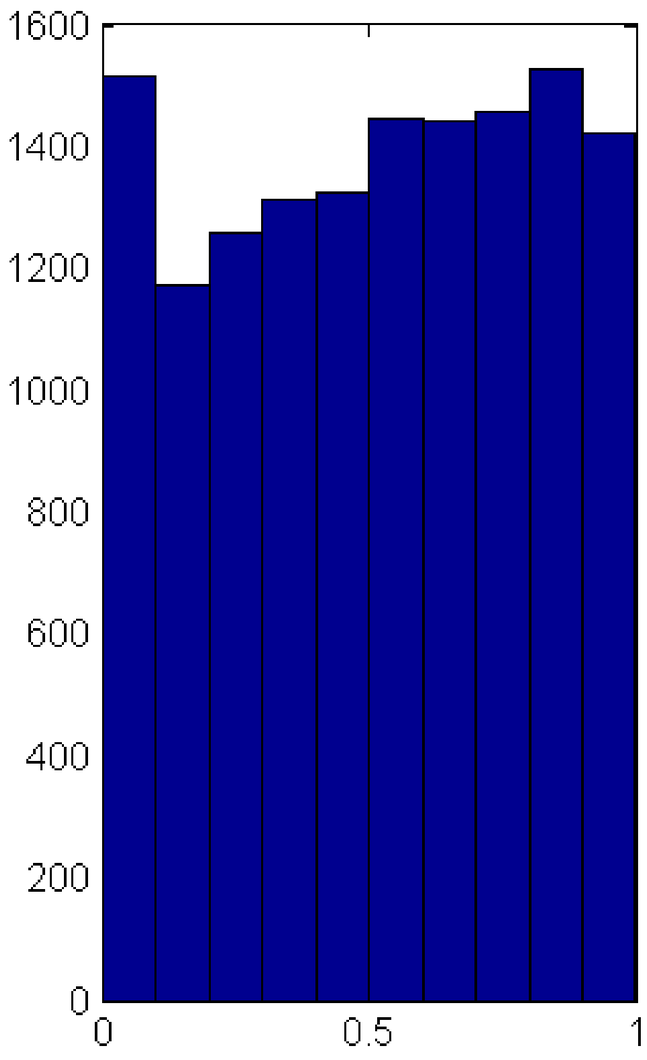






Results





Conclusions

I have demonstrated that using the results from both the G4U and $H/A/\bar{\alpha}$ decompositions and using Probabilistic Fusion is an effective way to classify the terrain of a fully polarimetric image.

Acknowledgements

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