Restoration of Solar Radio Images using Adaptive Regularization Techniques

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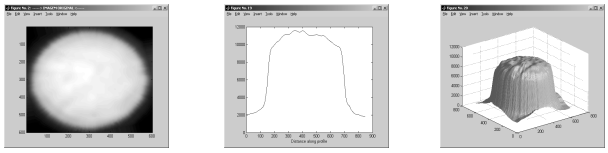
Abstract. A new algorithm for the restoration of solar radio images is proposed. The technique is based on the use of adaptive regularization procedures that incorporate the *k*-means clustering algorithm over local roughness measures.

1. Introduction

The deconvolution of a degraded radio image by the radiation diagram of an antenna can be put in terms of an image restoration problem. To solve this problem, we proposed a new adaptive algorithm, based on a measure of the local roughness of the degraded image.

2. Radio images degradation

The blur present in the image obtained through Itapetinga radio telescope, Figure 1(a), is caused by the finite aperture of the antenna and by the rotation of the Earth. With this blur effects, details of the solar atmosphere structure, such as filaments and limb brightening, are lost. The Figure 1(b) displays the radiometric profile and Figure 1(c) the 3-D surface graph of the degraded image, respectively.



(a) (b) (c)

Figure 1 (a) Degraded radio image of the sun, (b) Radiometric profile and (c) 3-D surface graph

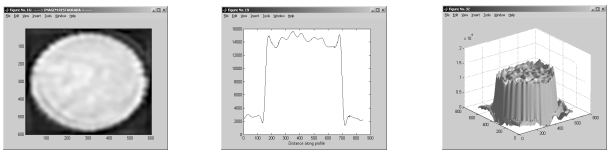
3. Adaptive restoration algorithm

This algorithm makes use of *k* prototype images obtained through the variation of the regularization parameters of a Least Squares Regularized Filter. The regularization parameters were chosen by the L-Curve method [1]. Based on the roughness calculations of the all image points, the *k*-means clustering analysis algorithm will be used to classify those roughness in their respective clusters.

The relationship between the roughness and the regularization degree is determined according to the results of Lajendijk et al [2]. Based on this relationship, *k* different regularized images will be restored, corresponding to different roughness clusters.

4. Experimental results

The following experiments describe the results obtained through the application of the algorithm, Figure 2(a), shows the degraded original image. The Figure 2(b) displays the radiometric profile and Figure 2(c) the 3-D surface graph.



(a) (b) (c)

Figure 2 (a) Restored image by the proposed algorithm, (b) Radiometric profile and (c)3-D surface graph

5. Conclusion

We concluded that the developed adaptive restoration algorithm results are better than those obtained by the conventional regularization filter. However, its good performance is degraded when the noise of the degraded image is very high, interfering in the roughness calculations of the pixels. From the visual point of view, the restored image presented a clear presence of the limb brightening, that was not evident in the degraded image, and traces of the sun filaments, but without great evidence.

References

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