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Comparison of image enhancement techniques for cometary comae

N. H. Samarasinha (1) and S.M. Larson (2)
(1) Planetary Science Institute, Arizona, USA, (nalin@psi.edu), (2) University of Arizona, USA.

Abstract

We will discuss the relative merits (and demerits) of a range of image enhancement techniques. In order to assess the techniques, they will be applied to numerically simulated cometary comae.

1. Introduction

Many coma features are of low contrast when compared with the adjacent regions of the coma and therefore require application of image enhancement techniques to clearly identify as well as to characterize such features. Because of this, image enhancement plays a critical role in many studies involving cometary comae. However, not all enhancement techniques are equivalent; some are better suited for identifying certain kinds of features whereas others are more apt at identifying different kinds of features [1], [2]. In addition, some techniques are more prone to introduce image artifacts than others. We will compare different image enhancement techniques and make assessments as to what techniques are more benign than others (as far as introduction of image artifacts are concerned). This will identify which techniques are better suited for feature identifications and what techniques should be avoided.

2. Application of enhancement techniques to simulated images

A range of image enhancement techniques were considered and figure 1 shows a representative sample of enhancement techniques applied to detect three jet features in a simulated image. What is shown in Figure 1 provides a glimpse as to how different techniques will enhance the features present in the coma.

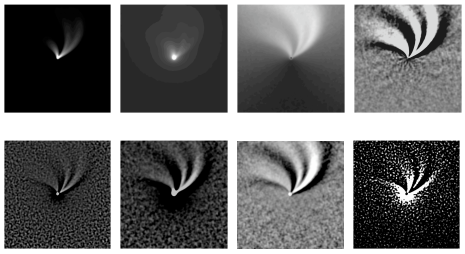

Figure 1: A demonstration of different enhancement techniques to show how three simulated jets will appear after application of the enhancement techniques. From left to right in the top row are: (a) an unenhanced but highly stretched image depicting three numerically simulated jets, (b) again an unenhanced but highly stretched image where the same three jets are superimposed on a broad asymmetric background caused by hemispherical emission (the sun is towards the top), (c) image shown in the previous panel after division by an $1/\rho$ profile, where ρ is the projected sky-plane distance from the nucleus, and (d) application of the rotational shift differencing technique with 10 degree clockwise and counterclockwise rotations for the image shown in panel (b). From left to right in the bottom row are: (e) division of the image shown in panel (b) by a gaussian convolved image — a technique that can be considered as a variant of the classical unsharp masking; standard deviation of the gaussian is 3 pixels, (f) the same enhancement as the previous panel but with a gaussian of standard deviation 15 pixels to demonstrate that as the kernal size of the smoothing function increases, large-scale spatial structures further out are enhanced whereas the smaller spatial-scale features close to the nucleus lose resolution, (g) after application of a radially variable spatial filter, and (h) after application of a Laplace filter. Note that identification of actual jets in the Laplace filtered image could lead to possible misinterpretations. For each panel, the nucleus is at

the center and the contrast is chosen to highlight many features as possible. For all the panels, the original simulation was convolved with a gaussian of 3.6 pixel standard deviation to mimic the astronomical seeing. White denotes brighter regions/features in the coma.

3. Further comparisons

By using simulated images as the original images to be enhanced, we are aware what features are intrinsically present in the images and we can assess what image artifacts are caused by image enhancement and to what extent. An immediate conclusion from Figure 1 is that each enhancement technique alters the original image in different ways while highlighting the low-contrast features. However, the image artifacts introduced are so drastic in some cases (e.g., Laplace filter) that such techniques should be avoided in preference to relatively benign ones. Nevertheless, a good practice is to confirm the presence of features (i.e., the reality of the features) using more than one technique.

This example and many other comparisons will be presented at the meeting including a discussion on how measurements can be made using enhanced images.

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References

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