Astronomical Data Analysis Software and Systems IV
ASP Conference Series, Vol. 77, 1995
R. A. Shaw, H. E. Payne, and J. J. E. Hayes, eds.

Object Detection Using Multi-Resolution Analysis

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Abstract. What we look for in an image is scale-dependent. Multi-resolution allows for image analysis in terms of different scales. Scale-space filtering, quadtrees, pyramid representations, and the wavelet transform have all been used to yield multi-resolution views of an image. One approach to the demarcation of significant structure, at different resolutions, is to determine statistically significant parts of each scale. A multi-resolution support data structure may be built up in this way. We can go further and incorporate a priori knowledge into the construction of this multi-resolution support. Mathematical morphology offers a convenient framework for removing detector artifacts, objects which are too small in extent to be of interest, etc. This approach is used for the detection (and subsequent analysis) of globular cluster systems around elliptical galaxies, and for image characterization and object trawling in large image databases.

1. Introduction

Content-based image retrieval can be tackled by using text annotations which characterize image content. Such an approach has been prototyped[1] for *Hubble Space Telescope* (*HST*) WF/PC-1 data. In this paper we describe the use of multi-resolution analysis for finding and making an inventory of objects in an image. For the multi-resolution transform, we used the pyramidal median image transform: see Starck, Murtagh, & Louys (1995) for further details.

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[1]http://ecf.hq.eso.org/ fmurtagh/hst-navigate.html

The use of Minkowski morphological operators allows prior knowledge relating to the objects of interest to be introduced. The structuring element is related to the morphology of the objects of interest in the image. The choice adopted is point-symmetric; and its size is related to potentially relevant objects. Image dilations expand the object in a locally adaptive manner. The dilated object area may help in providing extra faint or background pixels later when the object is characterized using ellipticity, moments, or other properties. Closings, or erosions with a suitable structuring element followed by dilations, may be used to remove linear features that are not usually of interest in astronomical imagery (e.g., extended cosmic ray impacts, bleeding and charge-overflow effects in a CCD detector, and intersections of mosaiced images).

2. Globular Clusters Surrounding Elliptical Galaxies

Earlier work by Meurs et al. (1994) aimed at finding faint, edge-on galaxies in WF/PC images. For each object found, properties such as the number of pixels in the object, peak-to-minimum intensity difference, a coefficient characterizing the azimuthal profile, and the ellipticity of the principal axis, were used to allow discrimination between potentially relevant objects on the one hand, and faint stars or detector faults on the other. This work is currently being extended with the study of globular cluster systems. NGC 4636 was discussed by Kissler et al. (1993), and characterized as a rich globular cluster system in a normal elliptical galaxy. An extracted 512×512 sub-image from an ESO New Technology Telescope (NTT) image is shown in Figure 1. A multi-resolution support of this image was obtained. This multi-resolution support image with values 0, 2, 4, and 8 represents, in one image, the four resolution levels examined. Figure 2 shows the result of transforming the support image in Figure 1 to a boolean image: any pixel with value greater than 2 was assigned a value of 1, followed by two openings. The object "islands" are labeled, and an associated report file produced principally with Gaussian profile fits in X and in Y. This information can be used to discriminate between objects of interest and those which are not.

3. Object Detection in Large Image Databases

The applicability of this approach to object detection in large image collections has been investigated. Rather than using original WF/PC data, the associated preview images provide two advantages. Firstly they are available on-line. Secondly they are smaller in size: typically about 1 MB per image when compressed, compared to 10.5 MB in original form. On the negative side, the compression scheme used in these preview images produces artifacts, and in particular the image texture may be considerably affected. Mosaicing the WF/PC quadrants also leaves the intersections bare.

A selection of WF/PC images was chosen with dense stellar fields, sparse faint object fields, and filamentary structure. These images were subjected to the following operations to allow for the great differences in the image properties, due to varying exposure lengths, the different nature of objects viewed, and presence of detector artifacts:

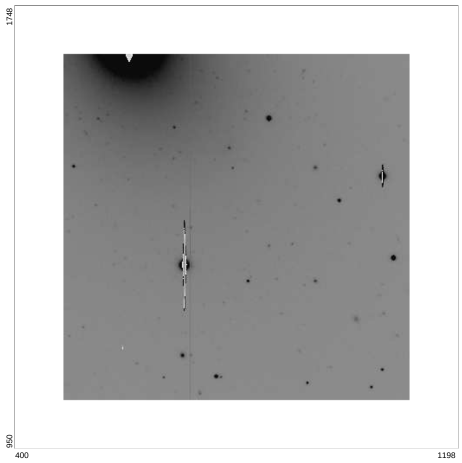

Figure 1. Part of ESO NTT image of NGC 4636.

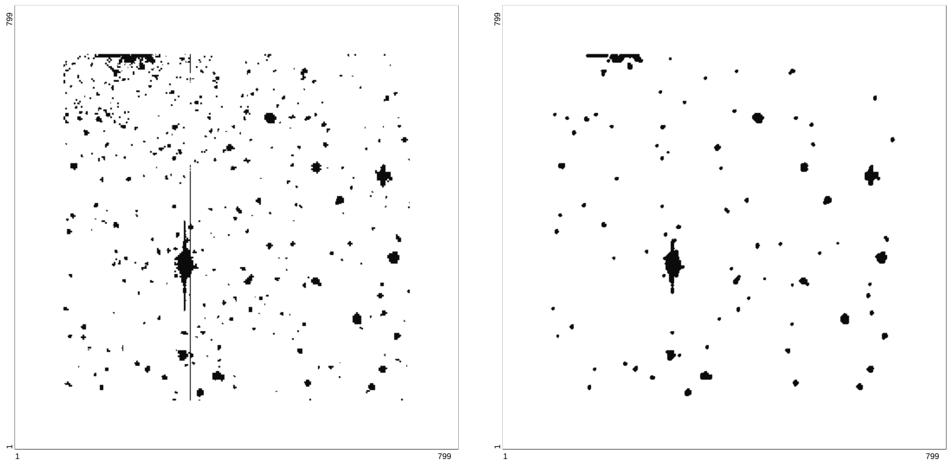

Figure 2. Booleanized multi-resolution support before and after 2 closings.

1. Multi-resolution support construction.
2. Level 4 in the multi-resolution support corresponds to large gradient local peaks—if it and level 3 accounted for more than 20% of all pixels, then level 4 alone was retained; if levels 4 and 3 together accounted for less than 20% of the image's pixels, then they were combined into a single boolean image. These rules were employed to specify what could be considered as significant objects in a given image.

3. A set of up to 3 openings with point-symmetric structuring elements were applied to remove remaining detector artifacts and cosmic ray hits.
4. Finally the contiguous regions were labeled and elementary properties were determined (object extent, defined by numbers of pixels; peak-to-minimum intensity within the object area, etc.).

This approach works well. Some remaining problems include the following: closely located objects are gathered into contiguous object “islands” in the final boolean image; and the presence of faint filamentary structure in the image in not explicitly handled when using structuring elements and a multi-resolution transform kernel which presuppose small, point-symmetric objects.

4. Conclusion

In this work, we ask ourselves whether it is feasible to consider automated image characterization through object detection and description. Traditional object inventory packages include FOCAS and MIDAS/INVENTORY, and are semi-interactive. Can a multi-resolution approach improve generality of treatment, and accuracy of results? Such established object inventory packages have been limited to relative peaks in flux intensity and/or intensity gradient. The multi-resolution transform incorporates these, and adds other potentially valuable image properties. Included among these properties are: object resolution scale (indirectly linked to gradient information); automatically ignoring the image background (through differencing the images which make up the multi-resolution transform); and facilitating incorporation of user-specified image processing rules using, for example, Minkowski image operators.

References

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