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Software for Multi-wavelength catalogs

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Abstract. ConvPhot a specific software for the accurate "PSF–matching" of space and ground based images of different resolution and depth. MWCWI is a web service designed to support the execution of large multicolor surveys.

Key words. software – data analysis

1. ConvPhot

Multi-wavelength imaging surveys often collect images of different quality and depth, typically high resolution HST images with lower resolution images obtained by ground based telescopes or by the Spitzer telescope. The difficulties originating in the analysis of these often inhomogeneous data sets prevents a full exploitation of the multicolor information, especially in the field of faint, high red-shift galaxies.

ConvPhot is an application designed to work especially for faint galaxies and allows to accurately measure colors in relatively crowded fields, making full use of the spatial and morphological information contained in the highest quality images.

1.1. The algorithm

The technique that we adopted has been introduced for the first time by the Stony-Brook group (Fernandez-Soto 1999) and can be applied to any combination of data sets, provided that the following assumption are satisfied:
a. A high resolution image (hereafter named *"detection image"*) is available, that is used to detect objects and isolate their area;
b. Colors are to be measured in a lower resolution image (hereafter named *"measure image"*);
c. The PSF in both images is accurately estimated, and a kernel has been obtained to smooth the *"detection image"* to the PSF of the *"measure image"*.
Conceptually, the method is quite strait-forward, and can be resumed as follows: *1.* Each object is extracted from the *detection* image, making use of the parameters and area defined by SExtractor: in practice, we use the segmentation image produced by SExtractor, that is obtained from the isophotal area.
2. Each object is individually filtered to match the *measure* image PSF and normalized to unit total flux: we refer to the resulting thumbnails as the model profiles of the objects.
3. The intensity of each model object is then scaled in order to match the intensity of the objects in the *measure* image. The free parameter for this scaling, named F_i, is computed with a χ^2 minimization over all the

Send offprint requests to: C. De Santis pixels of the images, and all objects are fitted simultaneously to take into account the effects of blending between nearby objects.

1.2. The minimization procedure

The minimization procedure allows to obtain the scaling factors F_i of each object that best reproduce the measure image. The best fit solution will be found by minimizing the χ^2:

$$\chi^2 = \sum_{m,n} \left[\frac{I(m,n) - B_i - M(m,n)}{\sigma(m,n)} \right]^2 \tag{1}$$

where

$$M(m,n) = \sum_{i=1}^{N_{\rm obj}} F_i P_i(m,n) \tag{2}$$

is the sum of all profiles, B_i is the background (in the *measure* image) of each objects, $\sigma(m,n)$ is the r.m.s. of the *measure* image and m and n run over the pixels.

The best–fit solution is found by solving the linear system:

$$\frac{\partial \chi^2}{\partial F_i} = 0 \quad (i = 1, \ldots, N_{\rm obj}) \tag{3}$$

whose Hessian matrix is

$$A_{ij} = \sum_{m,n} \frac{P_i(m,n) P_j(m,n)}{\sigma(m,n)^2} \tag{4}$$

and right–hand term is:

$$R_i = \sum_{m,n} \frac{P_i(m,n)[I(m,n) - B_i]}{\sigma(m,n)^2}. \tag{5}$$

Since the model profiles are non-zero only within the area provided by the dilated segmentation, most of the A_{ij} terms are actually null, such as the matrix is very sparse. The solution of sparse linear system can be very efficiently performed with the linear biconjugate gradient method (Press et al. 1992). Statistical uncertainties on the fitted fluxes F_i are the diagonal terms of the matrix A^{-1}.

1.3. Output quantities

ConvPhot produces in output several parameters and images. The most important output is the best-fit solution of the minimization procedure. The total magnitude in the measure image is:

$$m_{meas} = -2.5 \log(F_i) + ZP_m \tag{6}$$

where ZP_m is the zero-point of the measure image. Colors are estimated using the total flux Di measured by ConvPhot in the detection image. The magnitude color is:

$$m_{meas} - m_{det} = -2.5 \log(\frac{F_i}{D_i}) + ZP_m - ZP_d \tag{7}$$

In addition, ConvPhot produces a Residual image of the fit residuals and a so-called Drop image, where each detected object which is fitted by ConvPhot is multiplied by zero (drop) in order to leave only bright galaxies in the *measure* image not detected in the *detection* one.

1.4. Systematics in the PSF-matching

1.4.1. Alignment errors

It is easy to show that, for 2-D Gaussian shape object, the resulting flux is systematically underestimated by a factor $f = exp(-\frac{3}{4}\frac{\Delta r^2}{\sigma^2})$, where Δr is the offset in pixel of the center position. For an alignment error of 1 pixel in the detection image the resulting underestimate may be of about 3%. We have included in ConvPhot an option to recenter any object before minimization.

1.4.2. Variable FWHM or object profile

Another source of uncertainty may result from a variation of the object profile from the detection image to the measure image. This can be due to either a physical change of the object profile (as due, for instance, to a more prominent bulge in the IR) or to an incorrect estimate of the PSF transformation kernel. In this case, assuming that the profile of an isolated objects in the model image and in the measure image are both Gaussian with same center and different σ, the resulting flux is incorrectly estimated by a factor $f = 2\sigma^2_{model}/(\sigma^2_{model} + \sigma^2_{measure})$. In this case, the resulting flux can be therefore either under- or over-estimated, depending on the sign of the error in the PSF estimate. An error of 10% in the object PSF will result in a 5% error in the output flux. The small systematic effects that have been described above can be efficiently corrected by taking into account the flux in residual image. At this purpose , we have included in the code an option to compute the total residual flux contained in the segmentation area of the original frame.

1.5. Validation tests

We have performed several validation tests on the ConvPhot code, during the debugging phase and to estimate the efficiency in the correction for systematics. The most obvious have involved the use of simulated images, with a range of luminosities, PSF and morphologies, by which we have verified that the code is computationally correct.

Simulations, however, cannot reproduce the complexity of real objects and data. To obtain a more stringent and independent test we have made use of the z band FORS image of the K20-CDFS. We have already analyzed the K20 data set in a previous paper (Cimatti et al. 2002), applying a standard technique based on aperture photometry obtained with SExtractor. Here, we have used ConvPhot to obtain a new estimate of the $z_{ACS} - z_{FORS}$ color in the FORS image of the K20, and compared them with the previously published catalog. The results of this test show that ConvPhot is not biased in the magnitude determination in respect to standard aperture photometry.

2. MWCWI: a web service for multi-wavelength catalogs

MWCWI is a web service designed to support the execution of large multicolor surveys. It includes a database system to store multiwavelength catalogs, images and supplementary information for any object in a given survey. *Beyond the standard browsing facilities, we have designed a complete user interface that enable any (authorized) user to add new data or modify the existing data, in order to make it a working system used during the execution of surveys, and not simply for the final data dissemination*. Such a web interface is user-friendly and does not require any particular knowledge about database languages like SQL.

MWCWI is a multi-user service with different levels of privileges. Simple users can access the public available data by simply compiling a registration form. The user can execute query over a range of values, consult the information about a single object in a given catalog (magnitudes , red-shifts, ...), visualize images of plots or of an object in different bands. Privileged users can create new catalogs and populate them uploading ASCII files and images. Moreover, they can update records via HTML form or file upload and add, modify or drop columns. The application is written in PHP4 and Javascript, uses XHTML1.0 and CSS1, and interfaces a MySQL database to handle data.

Currently, the public user can consult the latest release of the K20 catalogs, and in the nearby future we will add HDF and GOODS catalogs. The GOODS catalog is described in the paper by Grazian et al in this proceeding. We also make the system publicly available for other users.

The service is available at the following address:

http://lbc.mporzio.astro.it/mwcwi

User can be access to the service filling a simple registration form whose link can be found in the home page.

References

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