Strategies for masking astronomical images in the context of Large Photometric Surveys

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Abstract

With the increasing volume of images and catalogues produced by current photometric surveys, the need for accurate and reliable masks to identify and exclude unwanted objects has become crucial. Several tools have been developed to mask, for example, stars containing saturated pixels overlapping circular patches on them, as well as cosmic-rays. However, some features still remain, like the bleeding of saturated stars, which causes that automatic detection and measurement softwares like Sextractor generate spurious objects contaminating the resulting catalogues.

In this poster we present first steps toward an automatic construction of masks for wide-field (1×1 deg²) images obtained in the context of the Southern Photometric Local Universe Survey (S-PLUS). At this first stage, we worked on S-PLUS fields centred in the Fornax cluster (D⁰-20 Mpc) for which Sextractor catalogues were previously obtained. As we noticed a high contamination of these catalogues by spurious objects, different masking experiments were performed on the detection images of those fields. For example, we built star masks based on Gaia DR3 coordinates and we also masked the borders of the frames.

Our goal is to compare the catalogues obtained from running Sextractor on the masked images with the previously obtained ones in order to assess if this kind of masks are good enough to significantly diminish the contamination by spurious objects in the catalogues, or if a more sophisticated approach is needed.

1. Borders

As can be seen in Figure 1, the physical edges of the image (indicated with a black rectangle) do not match the area of the image that contains astrophysical information. This means that there is an area, which we will refer to as the “border,” that is a part of the image file but is not relevant for source detection. As depicted in Figure 2, the statistics of the border area and the image exhibit distinct dispersions. While this discrepancy might occasionally be hard to discern in a file visualization, this distinction is significant enough to employ an automated edge detection method such as OpenCV, so that the image can be split into the physical edges of the image and the actual area of interest.

2. Saturated objects

In most cases saturated areas found in the CDD images come from saturated stars. One potential strategy involves masking these areas using GAIA astrometric data.

To mask stars identified by GAIA in our fields, we employ KungPao (⁴,⁵). It offers various functionalities, including the determination of the appropriate geometry to mask each source based on its brightness.

Figure 3 displays the bottom part of the reference image, masked using a magnitude-based threshold. Note that the effects of the bleeding of saturated stars are not entirely corrected, but such strategies enhance the background level calculation for the entire image.

3. Other detecting contaminants

Furthermore, there are other image contaminants that can be partially or fully corrected using convolutional neural networks (CNN).

We conducted tests using MAXIMASK, which identifies cosmic rays, hot pixels, residual patterns, saturated pixels, and diffraction spikes. The software generates masks for each detected feature and produces a final image with all these effects masked. Simplifying the process by working with each effect separately is advantageous.

While the effect of saturated stars can be addressed through GAIA’s astrometric information, the statistics of the border area and the image exhibit distinct dispersions. While this discrepancy might occasionally be hard to discern in a file visualization, this distinction is significant enough to employ an automated edge detection method such as OpenCV, so that the image can be split into the physical edges of the image and the actual area of interest.

4. Results and conclusions

Taking an example to test image masking strategies, we utilized one of the central fields of the Fornax cluster (s27s34). In Figure 5, you can observe how edge detection in the field, owing to the signal variation, can aid in cropping out areas without astrophysical information. Initially, we perform this cropping using a rectangular shape, but since the actual field shapes slightly vary in both size and rotation, this variation can be seen at any of the four corners in Figure 5. This could be enhanced by employing deep learning techniques that pixel-wise identify and classify image information, generating contours to enclose the relevant information.

In Figure 3, we show how GAIA’s astrometric information can be used to mask saturated objects in an image. The utility of this technique varies based on the subject of study. If the goal is to measure the brightness profile of large galaxies, this method might enable masking point-like objects within the extended brightness of the main source. This technique is also valuable when conducting sky measurements unaffected by saturated objects across one or multiple fields.

Finally, the utilization of convolutional neural networks to detect image contaminants in CCD images seems to be a promising strategy to encompass most of the effects present in the images. It would be possible to train the network to identify the specific diffusion patterns present in S-PLUS images, or, for instance, the edges of each image, and subsequently mask them.

Bibliography and tools

You can check some of these examples in our github repository: https://github.com/Astrophysics-Large-Astronomical-Surveys/

[²] https://github.com/te-quentao/KungPao/
[³] https://github.com/mpaillassa/MaxiMask/
[⁴] https://opencv.org/

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