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Democratic treatment of pixels in the image cleaning

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Usually in the image cleaning cuts of the kind

$$N_{ph,j} \ > \ \gamma \cdot \sigma_j \tag{1}$$

are applied. $N_{ph,j}$ is the number of photons, σ_j the pedestal RMS in pixel j and γ is a number in the order of 3 to 5, usually chosen to be independent of the pixel. The purpose of the cuts is to retain only those pixels, in which the number of photons is well above the noise level, characterized by σ_j.

The question arises whether this procedure is reasonable also in the case where the pixels are very different. For example, the area of an outer pixel (A_{outer}) is about 4 times as big as that of an inner pixel (A_{inner}), implying the pedestal RMS to be by a factor of about 2 bigger for an outer than for an inner pixel. As a consequence, the threshold of the number of photons per pixel area (N_{ph}/A), above which pixels are kept, would be different for the inner and outer pixels :

$$\frac{N_{ph,inner}^{threshold}}{A_{inner}} = \gamma \cdot \frac{\sigma_{inner}}{A_{inner}} \tag{2}$$

$$\frac{N_{ph,outer}^{threshold}}{A_{outer}} = \gamma \cdot \frac{\sigma_{outer}}{A_{outer}} \approx \gamma \cdot \sqrt{\frac{A_{outer}}{A_{inner}}} \cdot \frac{\sigma_{inner}}{A_{outer}} = \gamma \cdot \sqrt{\frac{A_{inner}}{A_{outer}}} \cdot \frac{\sigma_{inner}}{A_{inner}} < \gamma \cdot \frac{\sigma_{inner}}{A_{inner}} \tag{3}$$

The threshold would also be different for the different inner pixels, because σ_j varies from pixel to pixel.

For the calculation of image parameters (SIZE, LENGTH, WIDTH, ...) one would like to have identical thresholds of N_{ph}/A for all pixels :

$$\frac{N_{ph,inner}^{threshold}}{A_{inner}} = \frac{N_{ph,outer}^{threshold}}{A_{outer}} \tag{4}$$

If the thresholds are different, the contributions from individual inner and outer pixels to the image parameters would not be in the right proportion to each other. It is therefore proposed not to use in the cuts the individual pedestal RMS σ_j but rather a global σ_{inner} :

$$N_{ph,j} \ > \ \gamma \cdot \sigma_{inner} \cdot \frac{A_j}{A_{inner}} \tag{5}$$

where A_j is the area of pixel j and σ_{inner} is an 'average' of the pedestal RMS of all inner pixels, which are not affected by bright stars and which are not too noisy :

$$\sigma_{inner} = \sqrt{\frac{\sum \sigma_j^2}{N}} \tag{6}$$

N is the number of pixels contributing to the sum.
With (5) the new cuts then read

$$N_{ph,j} > \gamma \cdot \sigma_{inner} \qquad \text{for an inner pixel} \tag{7}$$

and

$$N_{ph,j} > \gamma \cdot \sigma_{inner} \cdot \frac{A_{outer}}{A_{inner}} \qquad \text{for an outer pixel} \tag{8}$$

The cuts (7) and (8) ensure a unique threshold of N_{ph}/A for all pixels :

$$\frac{N_{ph}^{threshold}}{A} = \gamma \cdot \frac{\sigma_{inner}}{A_{inner}} \tag{9}$$

The level of noise suppression is different for different pixels, because in general

$$\sigma_{inner} \cdot \frac{A_j}{A_{inner}} \neq \sigma_j \tag{10}$$

In particular, for an outer pixel

$$\sigma_j \approx \sigma_{inner} \cdot \sqrt{\frac{A_{outer}}{A_{inner}}} < \sigma_{inner} \cdot \frac{A_{outer}}{A_{inner}} \tag{11}$$

This means, that with (5) or (8) the noise suppression is stronger for an outer pixel. This, however, is not a problem.
The proposed procedure (5) is, of course, equivalent to replacing in (1) γ by

$$\gamma \Longrightarrow \gamma \cdot \frac{\sigma_{inner}}{\sigma_j} \cdot \frac{A_j}{A_{inner}} \tag{12}$$