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# Group Operators

- i). replace points with calculations from regions.
- ii). implemented by template convolution

$$N_{x,y} = \sum_{i,j \in \text{window}} w_{ij} \times O_{ij}$$

↑  
weight

$w_{ij}$  since the template is inverted on  $x$  &  $y$  for non-symmetric templates

iii). direct averaging

$$w_{ij} = \frac{1}{\text{window size in pixels template}}$$

e.g.  $3 \times 3$   $w_{ij} = 1/9$   
 $5 \times 5$   $w_{ij} = 1/25$

larger operator — more smoothing, less noise  
 more blurring  
 BLURRING

border — set it to black ✓  
BLACK

Smaller template of borders?

assume image wraps round.

iv. for large templates use Fourier.

$$T * I = F^{-1}(F(T) \cdot x F(I))$$

↑  
inverse FT.

↑  
Fourier transform

↑  
point by point

v). Gaussian averaging.

$$W_{i,j} = e^{-((i^2 + j^2) / 2\sigma^2)}$$

$\sigma$  is dependent on window size.

choose  $\sigma$  so  $w_{i,j} \rightarrow 0$  at edges of template.

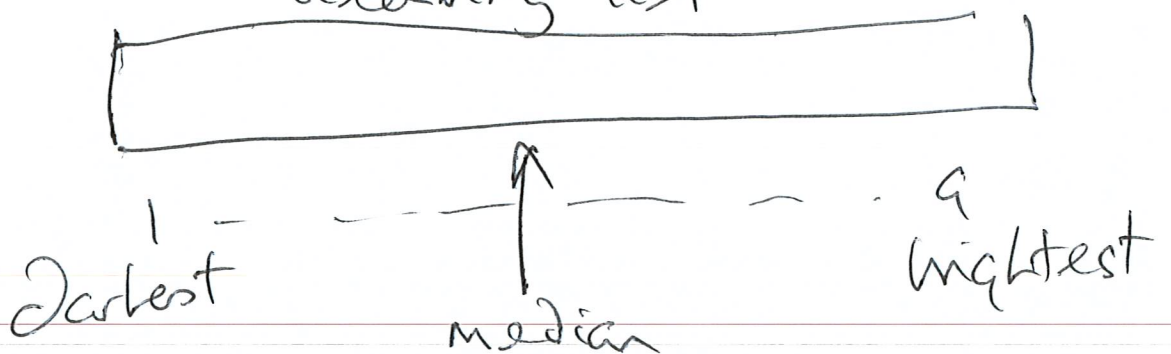
good for Gaussian distributed noise.

vi). Median filter

good for black & white noise  
clouding errors

ascending list

adj. 3x3



v. slow (no Fourier)