Other Non-Linear Filters

Slides from Cornelia Fermüller and Marc Pollefeys

Corner Detection (Non-linear filter)

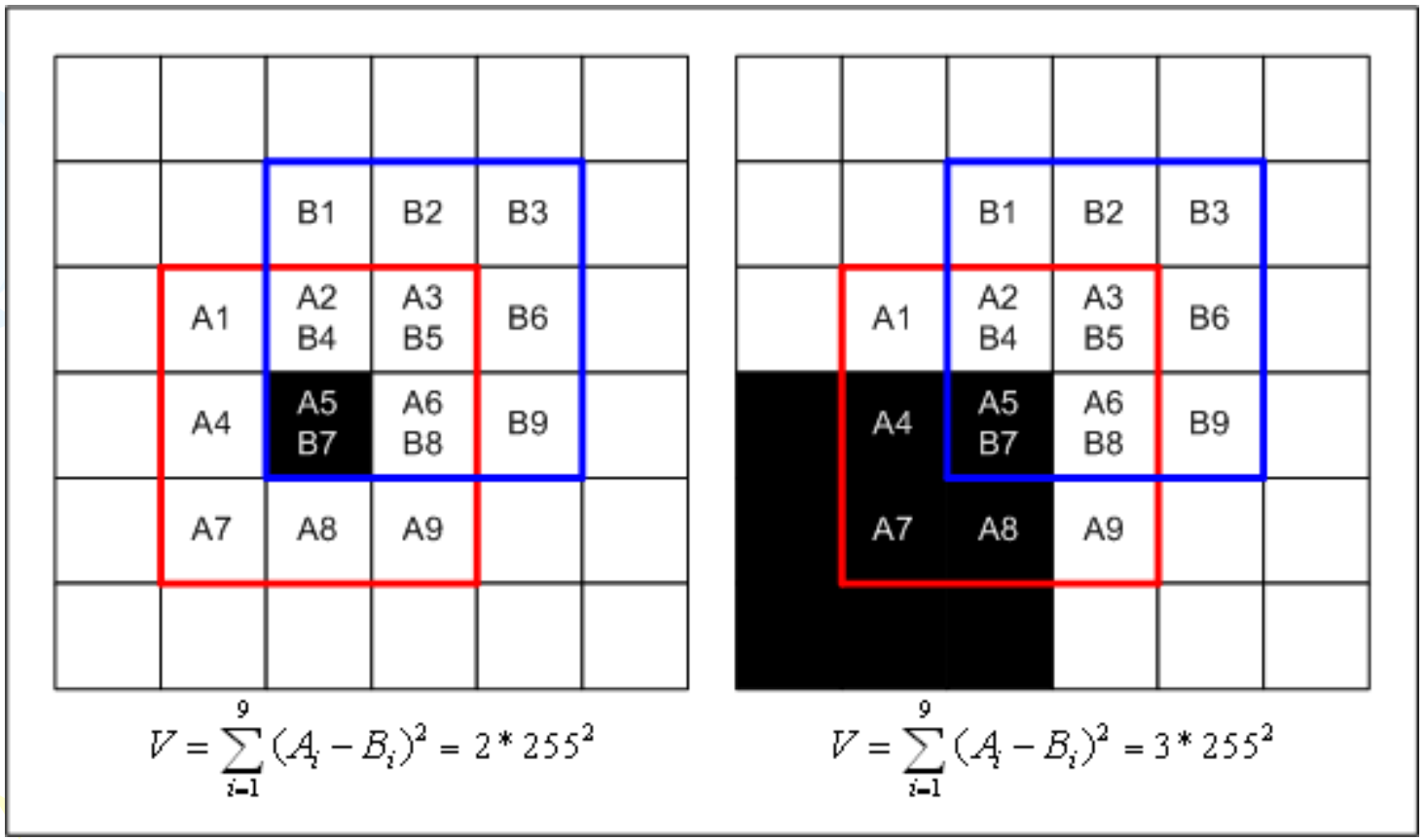
- Corners have more edges than lines
- Should be easier
- But edge detectors fail – why?
  - Right at corner, gradient is ill-defined
  - Near corner, gradient has two different values

Moravec Operator

- Self-similarity
  - How similar are neighboring patches largely overlapping to me?
- Most regions - Very similar
- Edges - Not similar in one direction (perpendicular to edge)
- Corners – not similar in any direction
- Interest point detection – not only corners

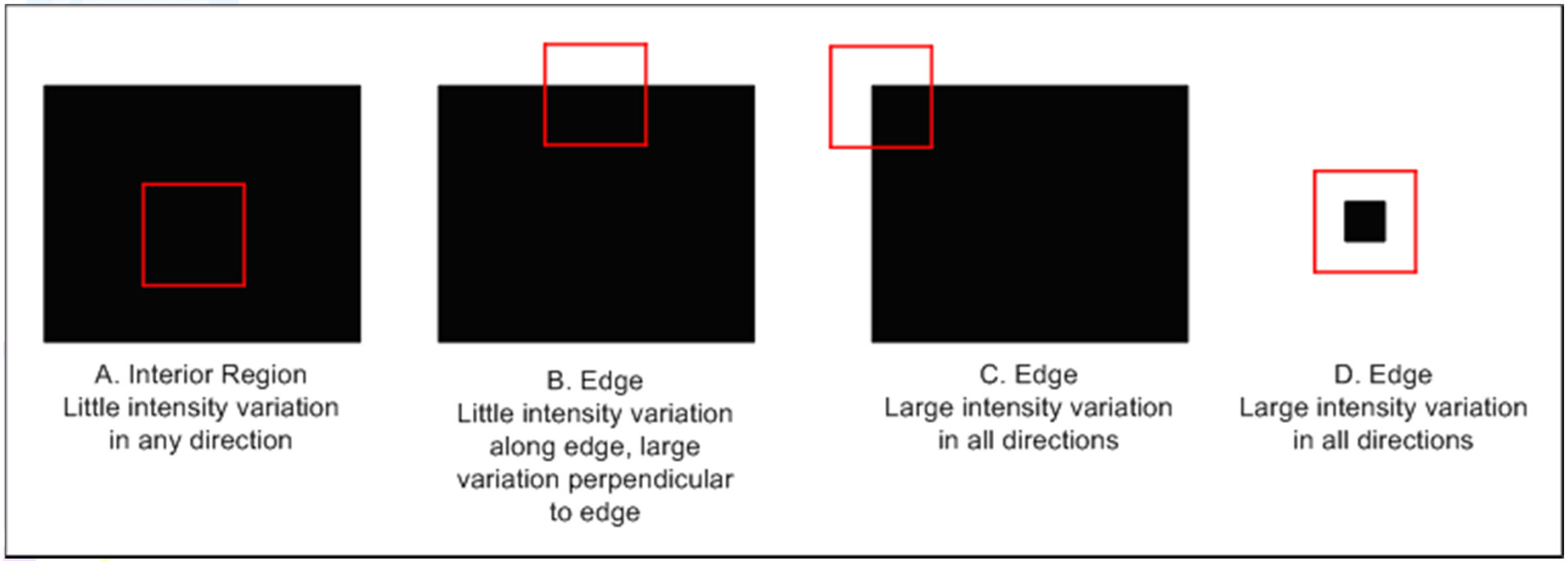
Measuring self-similarity

- SSD = Sum of squared differences
- Corner is local maxima



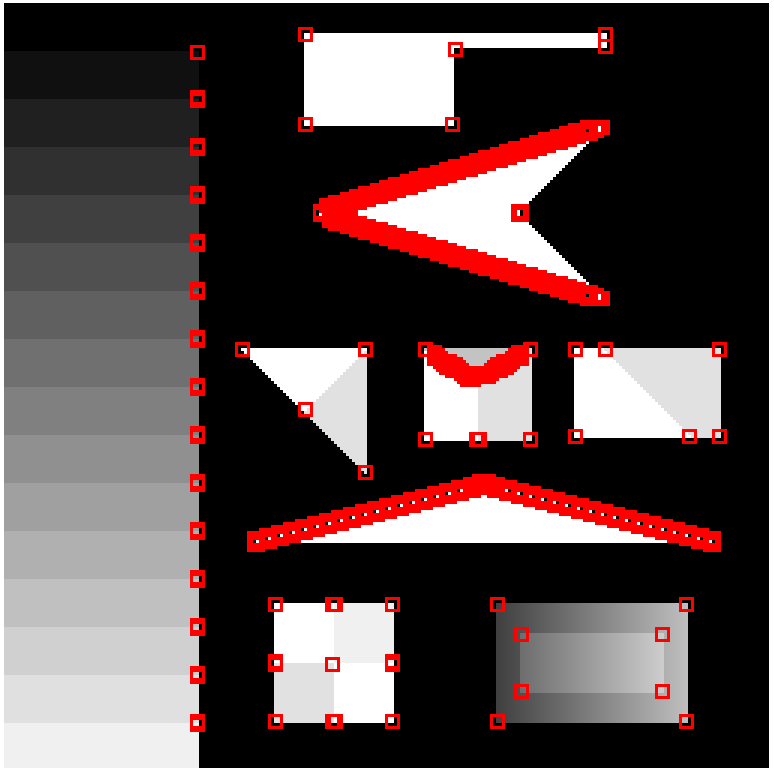
Limitations

- Sensitive to noise
  - Responds for isolated pixel
- Larger patches for robustness



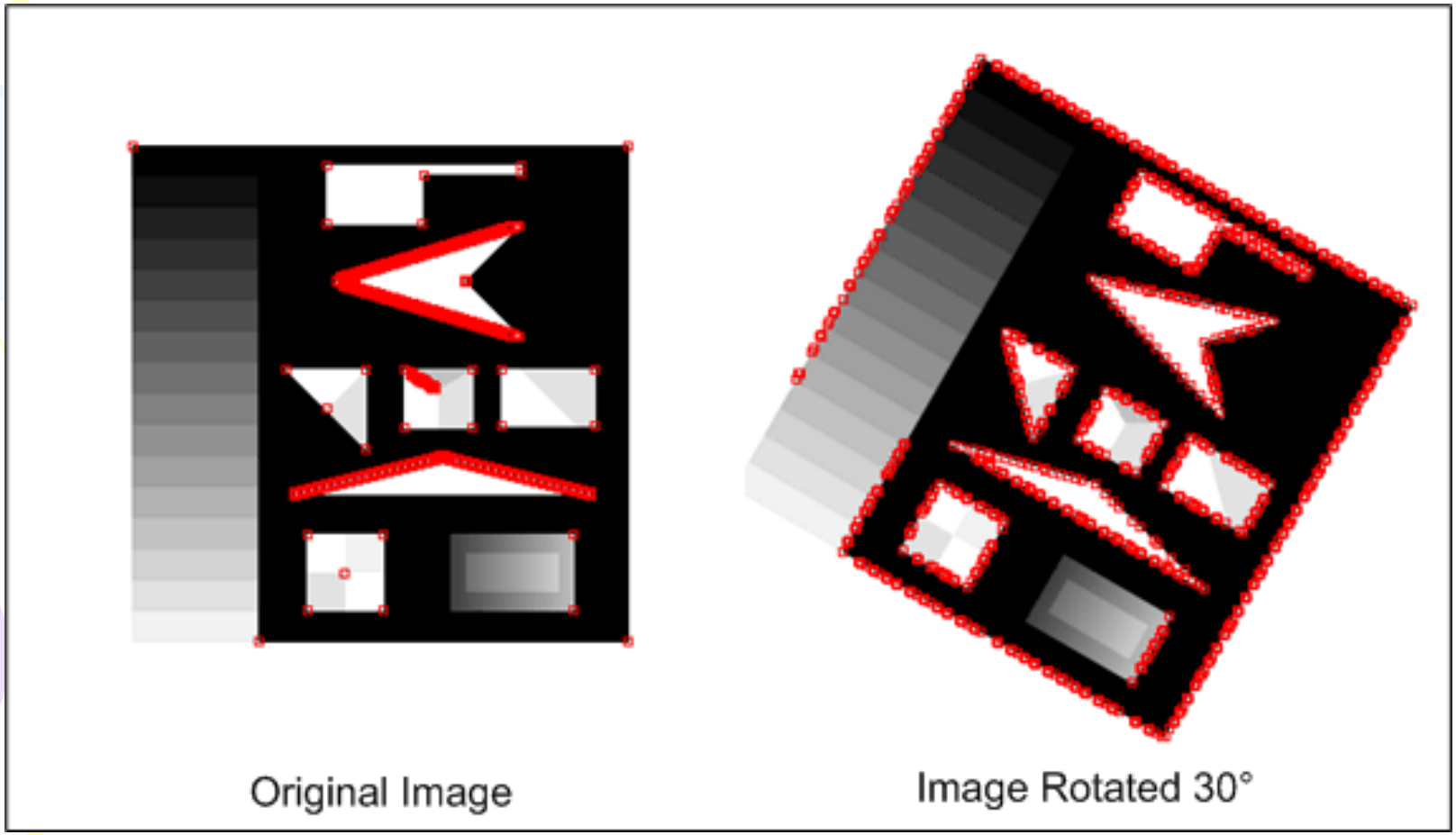
Limitations

- Responds also to diagonal edges



Limitations

- Anisotropic (Not rotationally invariant)



Harris & Stephens/Plessey Corner Detector

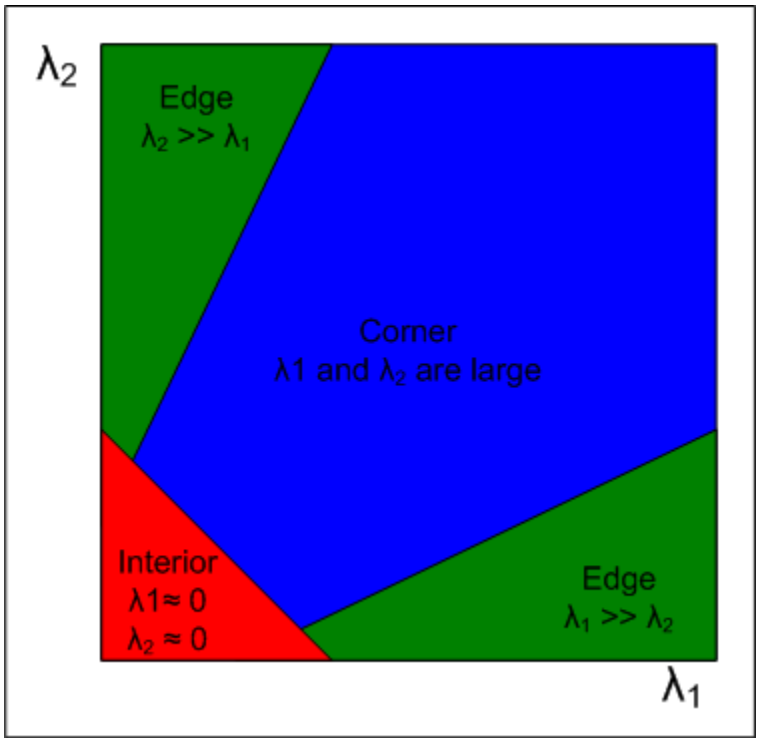
- Consider the differential of the corner score with respect to direction
- Describes the geometry of the image surface near the point (u,v)

$$A = \sum_u \sum_v w(u,v) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = \begin{bmatrix} \langle I_x^2 \rangle & \langle I_x I_y \rangle \\ \langle I_x I_y \rangle & \langle I_y^2 \rangle \end{bmatrix},$$

Hessian Matrix
(Second derivatives of multi-variate function)

How to find the corner?

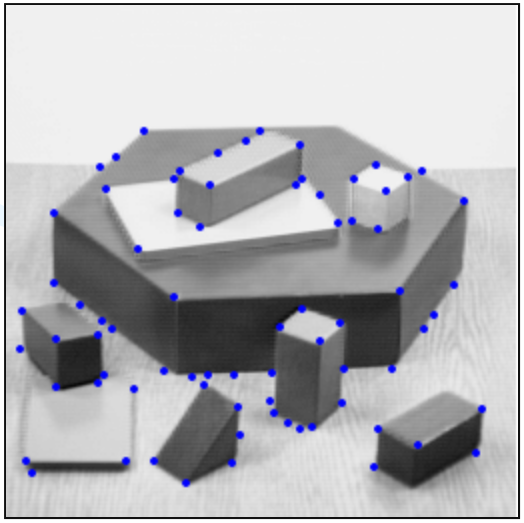
- The eigenvalues are proportional to the principal curvatures
- If both small, no edge/corner
- If one big and one small, edge
- If both big, then corner

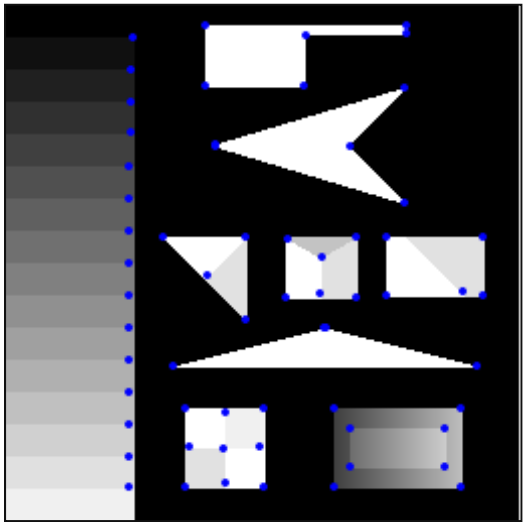


Rotationally Invariant

- If w is Gaussian, then this is isotropic

$$A = \sum_u \sum_v w(u,v) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = \begin{bmatrix} \langle I_x^2 \rangle & \langle I_x I_y \rangle \\ \langle I_x I_y \rangle & \langle I_y^2 \rangle \end{bmatrix},$$

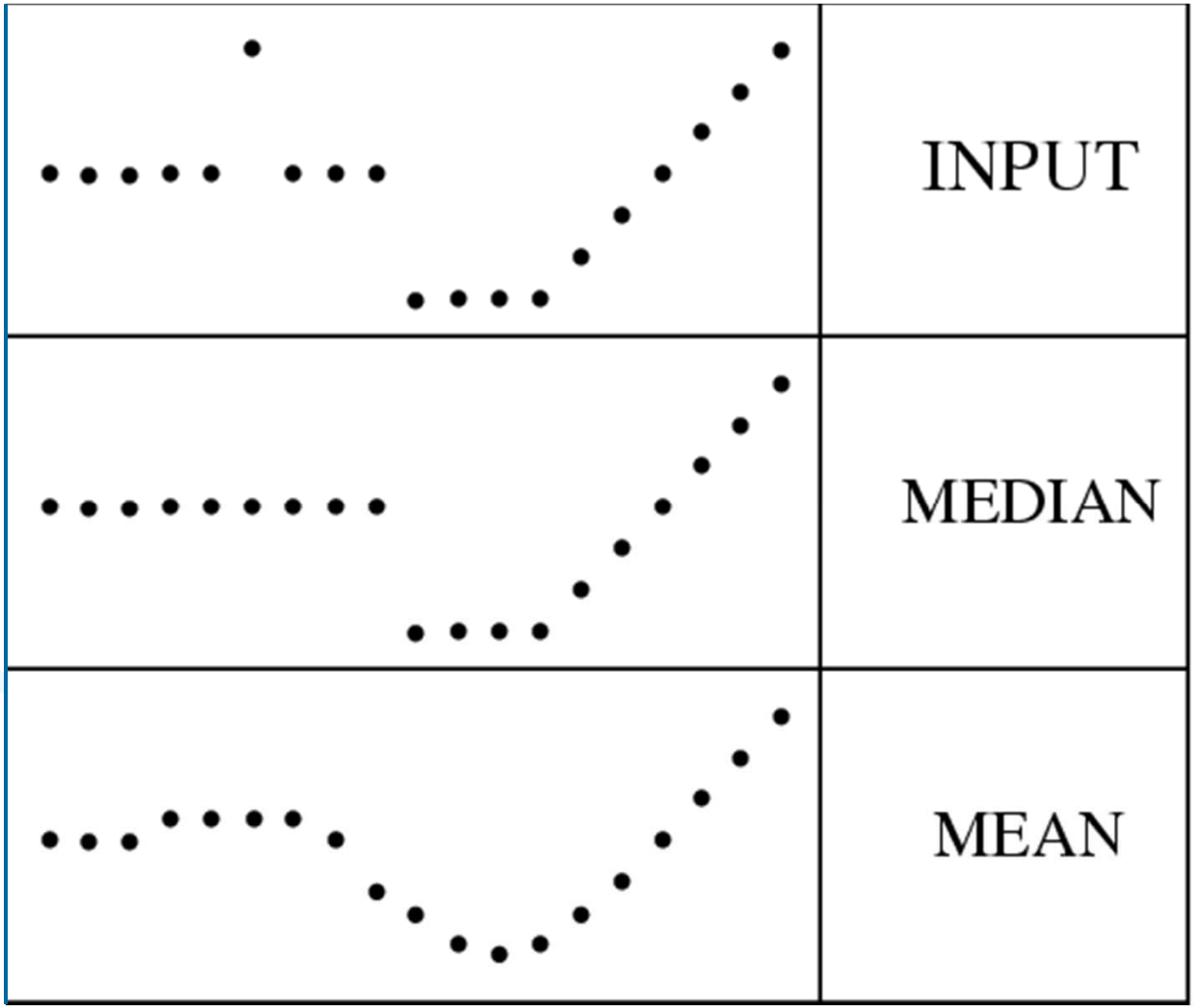




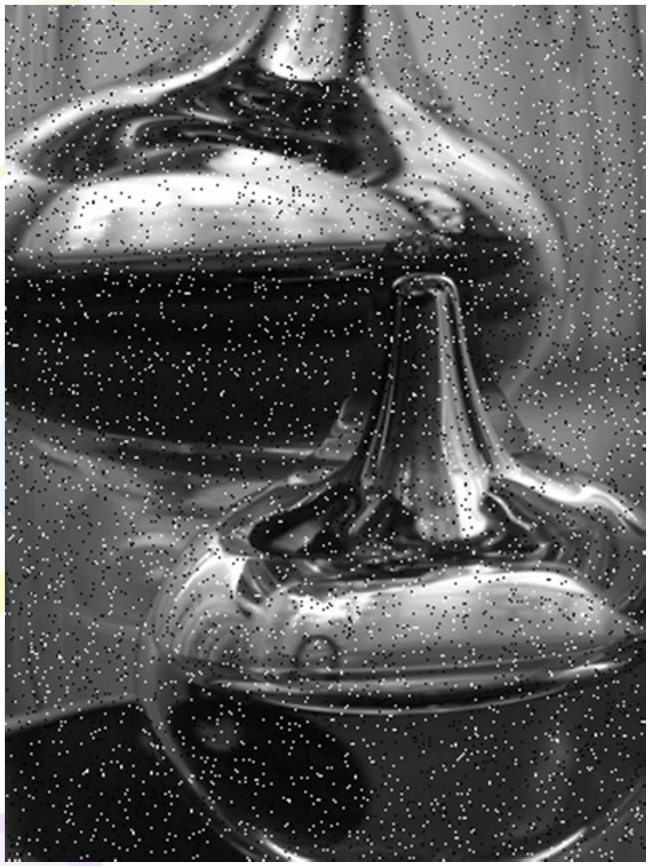
Median filter

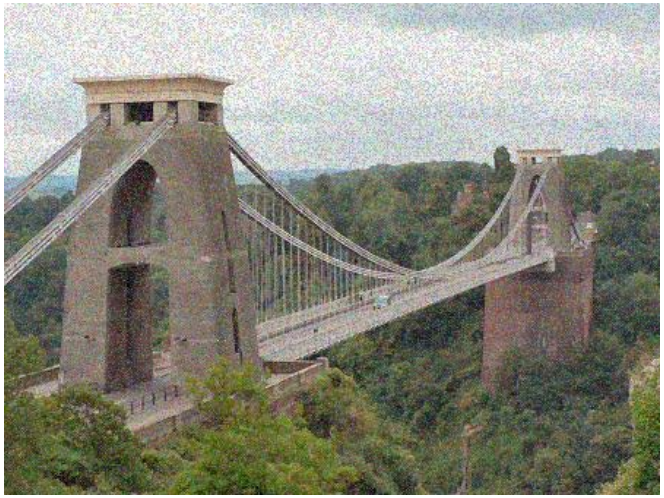
- Replace by median of the neighborhood
- No new gray levels
- Removes the odd man out
  - Good for outlier removal
- Retains edges

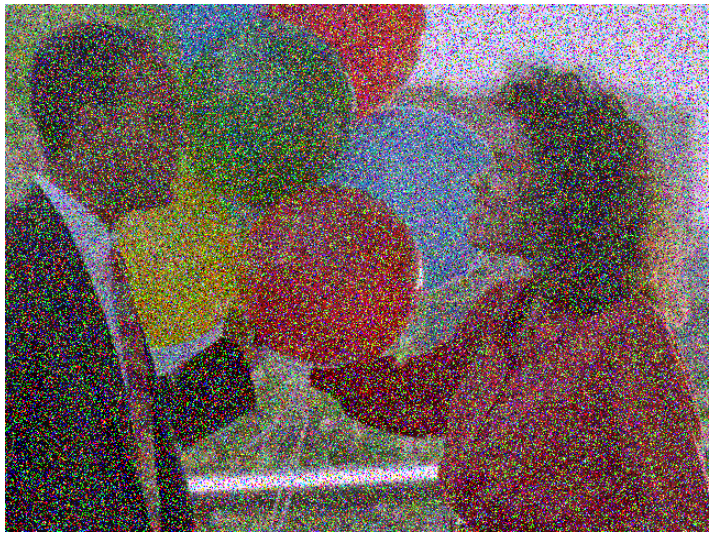
Median filter



Salt and Pepper Noise







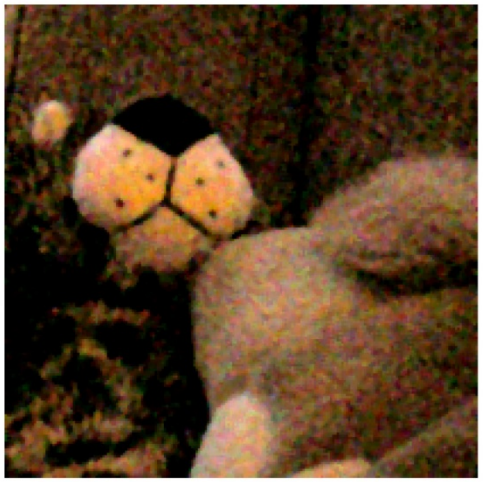
Difference from Gaussian Noise

Gaussian

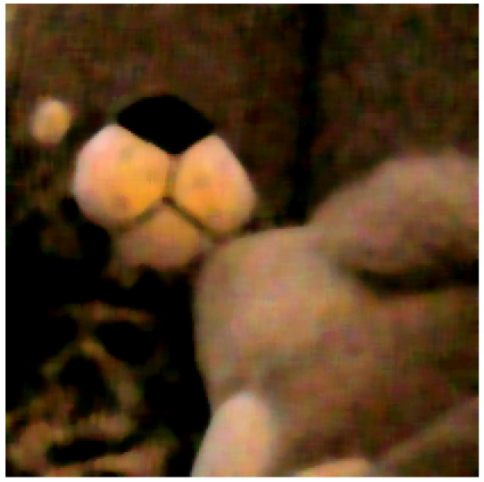
Salt and Pepper

Median Filter

original image



1px median filter



3px median filter

10px median filter

Comparison

original

added noise

average

median