# Other Non-Linear Filters

Slides from Cornelia Fermüller and Marc Pollefeys

# Corner Detection (Non-linear filter)

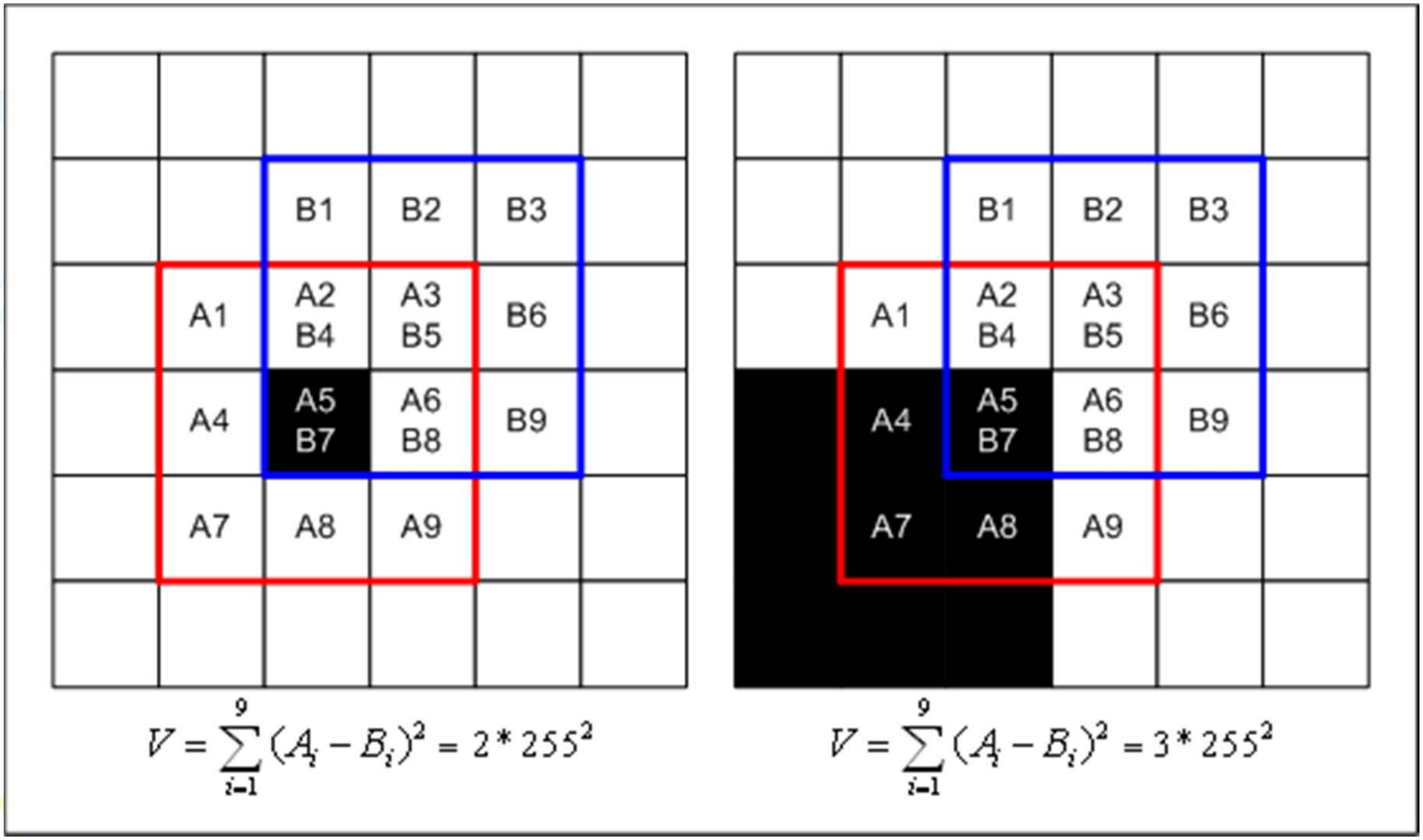
- Corners have more edges than lines
- Should be easier
- But edge detectors fail – why?
  - Right at corner, gradient is ill-defined
  - Near corner, gradient has two different values

# 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

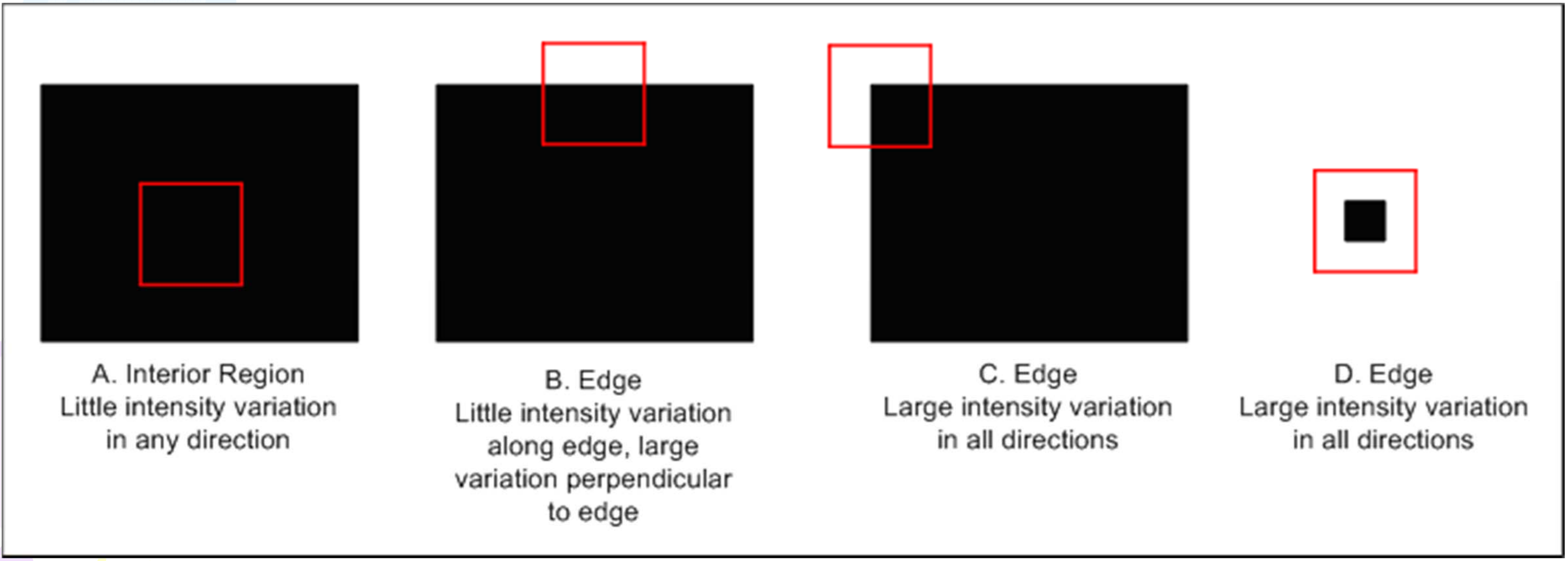
# Measuring self-similarity

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



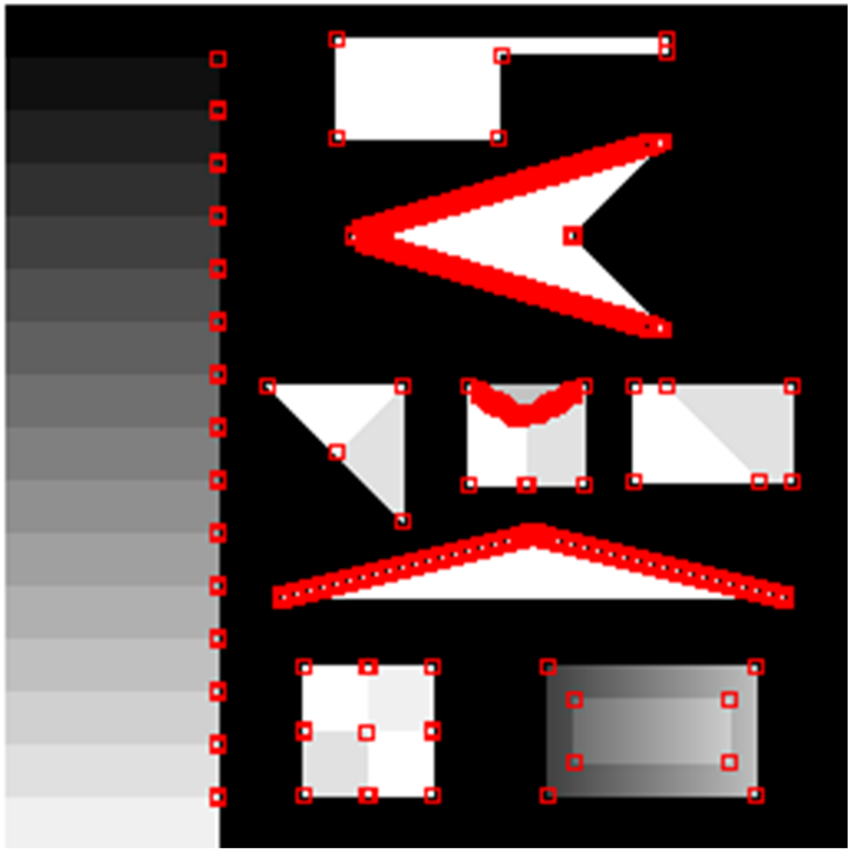
# Limitations

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



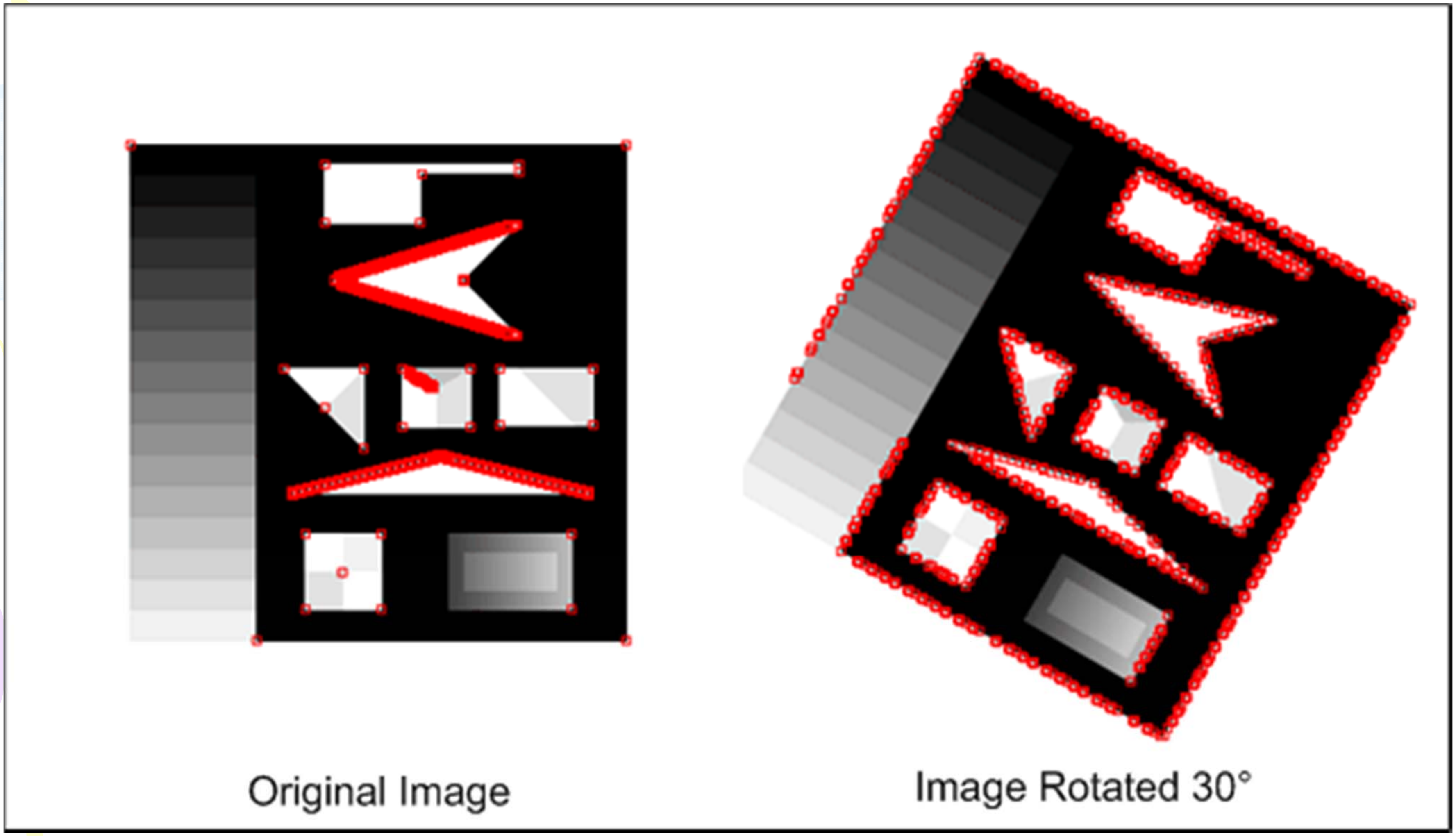
# Limitations

- Responds also to diagonal edges



# Limitations

- Anisotropic (Not rotationally invariant)



# Harris & Stephens/Plessey Corner Detector

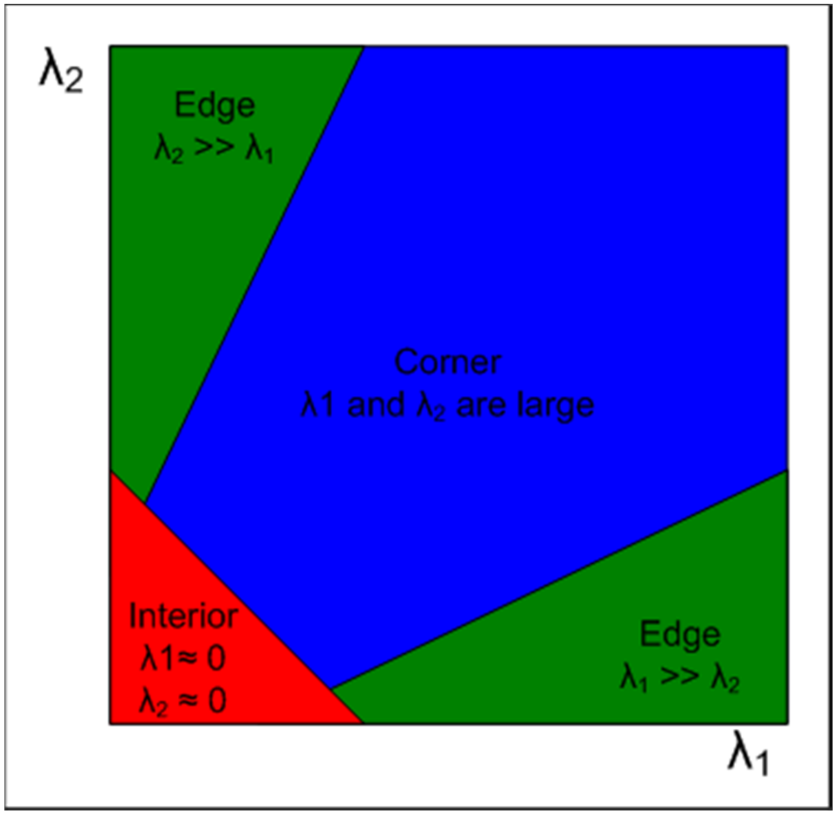
- Consider the differential of the corner score with respect to direction
- Describes the geometry of the image surface near the point (u,v)

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

Hessian Matrix
(Second derivatives of
multi-variate function)

# How to find the corner?

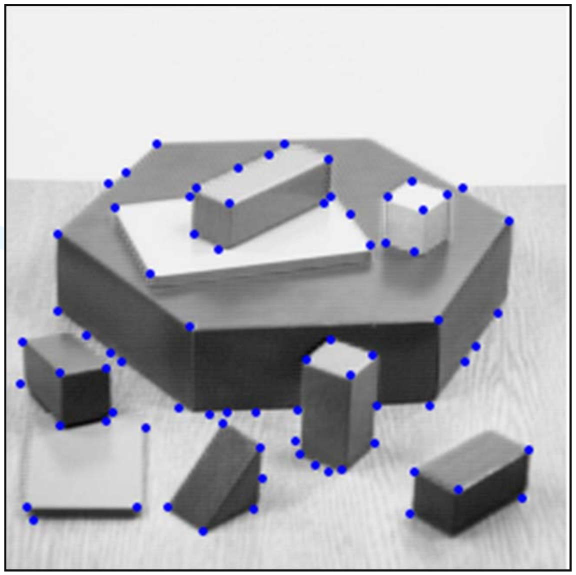
- The eigenvalues are proportional to the principal curvatures
- If both small, no edge/corner
- If one big and one small, edge
- If both big, then corner

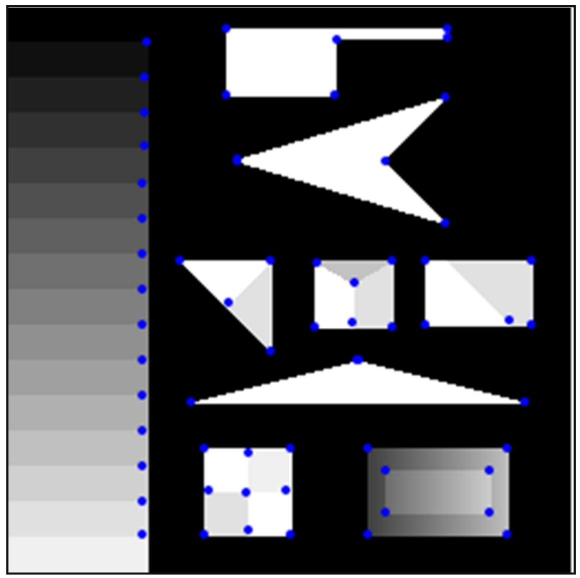


# Rotationally Invariant

- If w is Gaussian, then this is isotropic

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

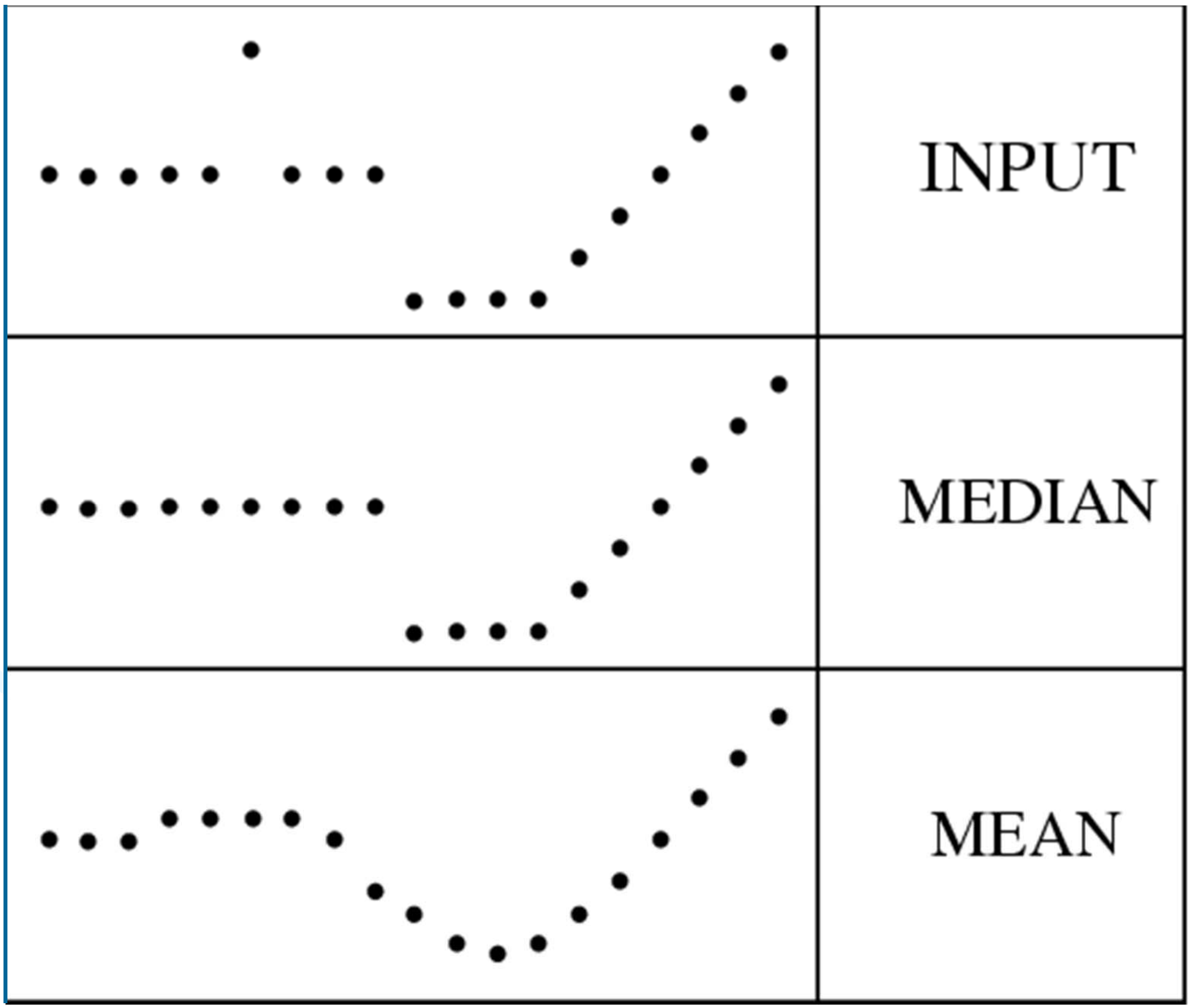




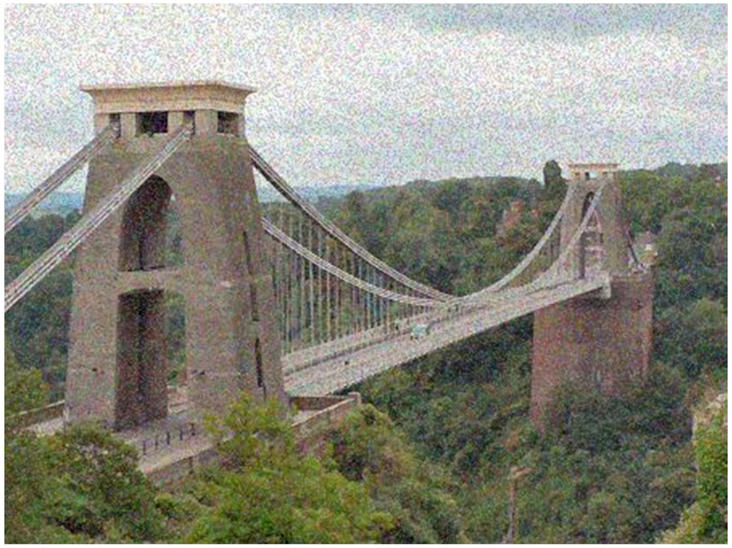
# Median filter

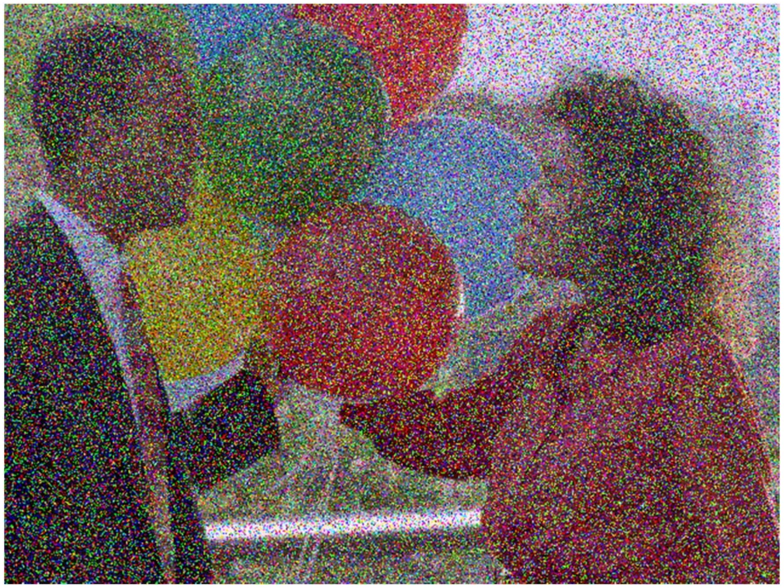
- Replace by median of the neighborhood
- No new gray levels
- Removes the odd man out
  - Good for outlier removal
- Retains edges

# Median filter



# Salt and Pepper Noise





# Difference from Gaussian Noise

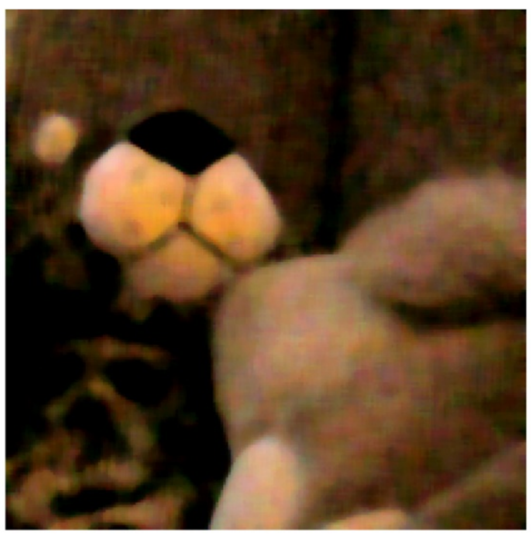
Gaussian

Salt and Pepper

# Median Filter


original image


1px median filter


3px median filter


10px median filter