Image Processing and Computer Vision 1

Chapter 5 – Non-linear filters for noise reduction – week 11

Martin Weisenhorn

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1 Book

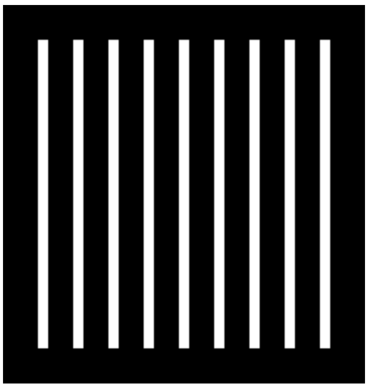
1.1 Book by Gonzalez and Woods, 5.1

The white bars in the test pattern shown are 7 pixels wide and 210 pixels high. The separation between bars is 17 pixels. What would this image look like after application of

(a) a 3×3 arithmetic mean filter?

(b) a 7×7 arithmetic mean filter?

(c) a 9×9 arithmetic mean filter?



Note: This problem and the ones that follow it, related to filtering this image, may seem a bit tedious. However, they are worth the effort, as they help develop a real understanding of how these filters work. After you understand how a particular filter affects the image, your answer can be a brief verbal description of the result. For example, "the resulting image will consist of vertical bars 3 pixels wide and 206 pixels high." Be sure to describe any deformation of the bars, such as rounded corners. You may ignore image border effects, in which the masks only partially contain image pixels.

1.2 Book by Gonzalez and Woods, 5.3

Repeat Problem 5.1 using a harmonic mean filter.

1.3 Book by Gonzalez and Woods, 5.5

Repeat Problem 5.1 using a contraharmonic mean filter with $Q = -1$.

1.4 Book by Gonzalez and Woods, 5.7

Repeat Problem 5.1 using a max filter.

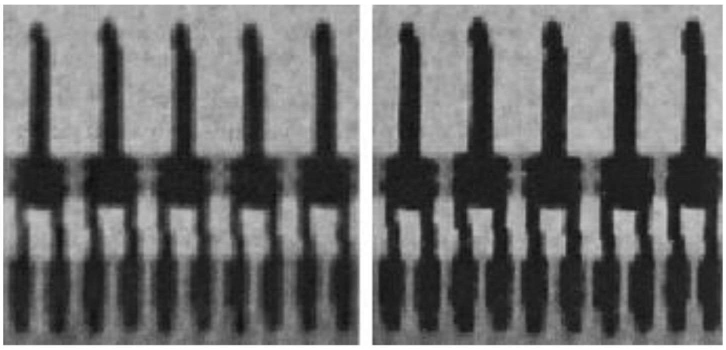
1.5 Book by Gonzalez and Woods, 5.9

Repeat Problem 5.1 using a midpoint filter.

1.6 Book by Gonzalez and Woods, 5.10

The two subimages shown were extracted from the top right corners of Figs. 5.7(c) and (d), respectively. Thus, the subimage on the left is the result of using an arithmetic mean filter of size 3×3, and the other subimage is the result of using a geometric mean filter of the same size.

(a) Explain why the subimage obtained with geometric mean filtering is less blurred.
(*Hint*: Start your analysis by examining a 1-D step transition in intensity.)



Book Fig. 5.7

2 Practical Exercise

Implement an adaptive local noise reduction filter (Eq. 5.32) for removing a additive white gaussian noise with a signal to noise ratio of one. Play with the size of the local region and observe the resulting effects.

Adaptive Mean Filter:

$$\hat{f}(x,y) = g(x,y) - \frac{\sigma_\eta^2}{\sigma_{S_{xy}}^2}\left[g(x,y) - \bar{z}_{S_{xy}}\right] \tag{5-32}$$

where S_{xy} is a neighborhood centered on coordiantes (x,y), $\bar{z}_{S_{xy}}$ is the mean over S_{xy} and $\sigma_{S_{xy}}^2$ is the variance over S_{xy}.

Additional Task

Implement an adaptive median filter (see Book p.333 or p.386) for removing a additive salt & pepper noise. Play with the parameters and observe the resulting effects.

Adaptive Median Filter:

Keep in min that the output of the filter is a single value used to replace the value of the pixel at

(x, y), the point on which region S_{xy} is centered at a gven time. We use the following notation:

$$\begin{aligned}
z_{\text{min}} &= \text{minimum intensity value in } S_{xy}\\
z_{\text{max}} &= \text{maximum intensity value in } S_{xy}\\
z_{\text{med}} &= \text{median of intensity values in } S_{xy}\\
z_{xy} &= \text{intensity at coordinates } (x, y)\\
S_{\text{max}} &= \text{maximum allowed size of } S_{xy}
\end{aligned}$$

The adaptive median-filtering algorithm uses two processing levels, denoted level A and level B, at each point (x, y).

Level A:	If $z_{\text{min}} < z_{\text{med}} < z_{\text{max}}$, go to Level B
	Else, increase the size of S_{xy}
	If $S_{xy} \leq S_{\text{max}}$, repeat level A
	Else, output z_{med}.
Level B:	If $z_{\text{min}} < z_{xy} < z_{\text{max}}$, output z_{xy}
	Else output z_{med}.