

HW 5, Problems 5.9

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■ Question

TextBook: Digital Image Processing, 2nd edition. By Gonzalez and Woods.

The white bars in the test pattern shown below 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) 3x3 midpoint filter?
- (b) 7x7 ?
- (c) 9x9 ?

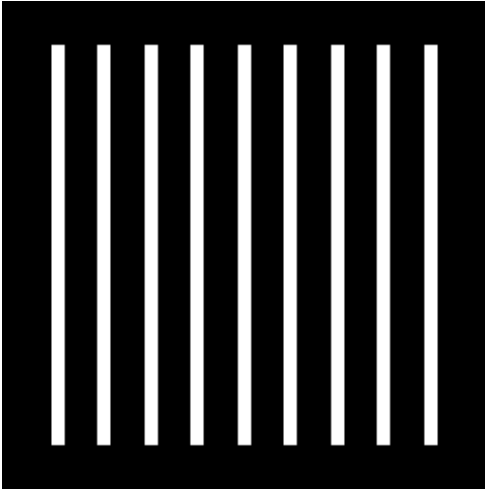
■ Answer

Median filter is given by $f(x, y) = \frac{1}{2} [\text{Max}(g(x, y)) + \text{min}(g(x, y))]$ where $g(x, y)$ is the image data under the filter.

Load the original Image and display it first. I downloaded the image from the text book website, and used InfranView to get the image information to find how many pixels the whole image is, then read in into *Mathematica* to display it.

```
In[3]:= Clear["Global`*"];
        nma`cd;
        nRow = 256;
        nCol = 256;
        data = nma`imread["Prob5.01.raw", 256, 256];
        nma`imshow[data, "problem 5.1 image"]
```

problem 5.1 image



```
Out[8]= - DensityGraphics -
```

In the original image, the vertical white bars look like this (displaying the top end of the white bar) we see that the white bar top starts at row number 24, we see that the strip is 7 pixels wide.

```
Take[data, {23, 27}, {26, 34}] // MatrixForm
```

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 255 & 255 & 255 & 254 & 255 & 255 & 255 & 0 \\ 0 & 255 & 255 & 255 & 255 & 255 & 255 & 255 & 0 \\ 0 & 255 & 255 & 255 & 255 & 255 & 255 & 255 & 0 \\ 0 & 255 & 255 & 255 & 255 & 255 & 255 & 255 & 0 \end{pmatrix}$$

■ 3x3 Filter

Now construct each filter, and apply them to the above image

```
In[9]:= F[n_] := Table[1, {i, 1, n}, {j, 1, n}]
        F3 = F[3];
        MatrixForm[F3]
```

```
Out[11]//MatrixForm=
```

$$\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

Filter the image with Min 3x3 and display result

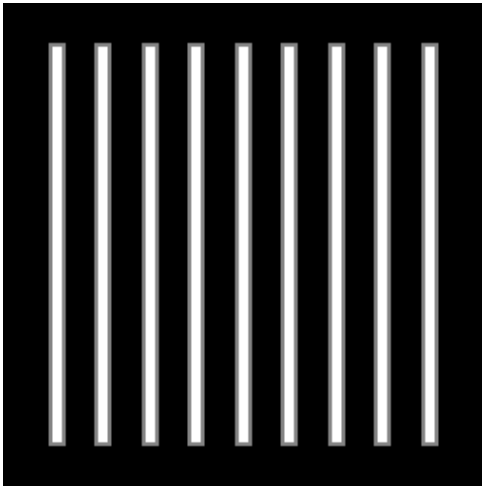
```
In[12]:=
  nImage3 = nma`filterMidpoint[data, F3];
  nma`imshow[Round[N[nImage3]], "Midpoint 3x3"]

startingRow = 2 endingRow = 255 startingCol=2 endingCol=255

ncol= 256 nRow= 256 n=3

Dimension of new image is ={254, 254}

Midpoint 3x3
```



```
Out[13]= - DensityGraphics -
```

Show the top edge of the white bar BEFORE processing

```
In[14]:= nma`imshow[Round[N[Take[data, {23, 27}], {26, 34}]]], ""]
```



```
Out[14]= - DensityGraphics -
```

Show the top edge of the white bar AFTER processing

```
In[15]:= nma`imshow[Round[N[Take[nImage3, {21, 27}, {23, 34}]]], ""]
```



```
Out[15]= - DensityGraphics -
```

Look at the data before:

```
Take[Round[N[data]], {23, 27}, {26, 34}] // MatrixForm
```

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 255 & 255 & 255 & 254 & 255 & 255 & 255 & 0 \\ 0 & 255 & 255 & 255 & 255 & 255 & 255 & 255 & 0 \\ 0 & 255 & 255 & 255 & 255 & 255 & 255 & 255 & 0 \\ 0 & 255 & 255 & 255 & 255 & 255 & 255 & 255 & 0 \end{pmatrix}$$

Look at the data after filtering

```
In[19]:=
```

```
Take[Round[N[nImage3]], {20, 27}, {23, 34}] // MatrixForm
```

```
Out[19]//MatrixForm=
```

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 0 \\ 0 & 0 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 0 \\ 0 & 0 & 128 & 128 & 255 & 254 & 254 & 254 & 255 & 128 & 128 & 0 \\ 0 & 0 & 128 & 128 & 255 & 255 & 255 & 255 & 255 & 128 & 128 & 0 \\ 0 & 0 & 128 & 128 & 255 & 255 & 255 & 255 & 255 & 128 & 128 & 0 \\ 0 & 0 & 128 & 128 & 255 & 255 & 255 & 255 & 255 & 128 & 128 & 0 \end{pmatrix}$$

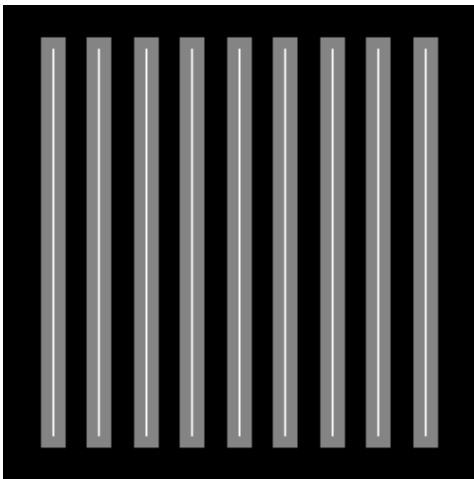
So we see that the white bar is now thinner it is **5 pixels wide**, but there is a gradual ramp to dark around the edges.

■ 7x7 Filter

```
In[20]:= F7 = F[7];
nImage7 = nma`filterMidpoint[data, F7];
nma`imshow[Round[N[nImage7]], "Midpoint 7x7"]

startingRow = 4 endingRow = 253 startingCol=4 endingCol=253
ncol= 256 nRow= 256 n=7
Dimension of new image is ={250, 250}
```

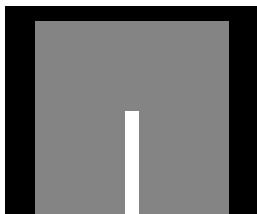
Midpoint 7x7



Out[22]= - DensityGraphics -

Now show the top of the white strip. Look now how much more wide it is

```
In[23]:= nma`imshow[Round[N[Take[nImage7, {17, 30}, {19, 35}]]], ""]
```



Out[23]= - DensityGraphics -

```
In[29]:= Take[Round[N[nImage7]], {15, 25}, {20, 36}] // MatrixForm
```

```
Out[29]//MatrixForm=
```

```
( 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
  0 128 128 128 128 128 128 128 128 128 128 128 128 128 0 0 0
  0 128 128 128 128 128 128 128 128 128 128 128 128 128 0 0 0
  0 128 128 128 128 128 128 128 128 128 128 128 128 128 0 0 0
  0 128 128 128 128 128 128 128 128 128 128 128 128 128 0 0 0
  0 128 128 128 128 128 128 128 128 128 128 128 128 128 0 0 0
  0 128 128 128 128 128 128 128 128 128 128 128 128 128 0 0 0
  0 128 128 128 128 128 128 128 254 128 128 128 128 128 0 0 0
  0 128 128 128 128 128 128 128 255 128 128 128 128 128 0 0 0)
```

So we see that the white bar is now thinner, it is **1 pixels wide**. The strip is turning to all gray level.

■ 9x9 Filter

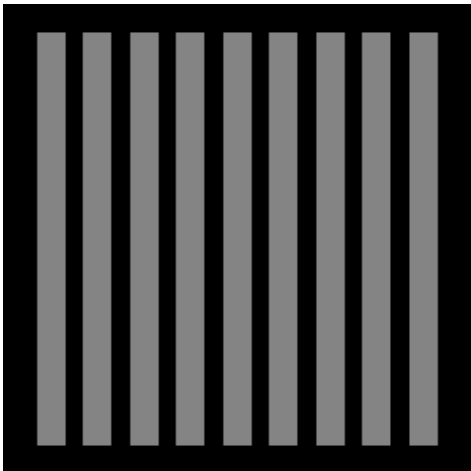
```
In[30]:= F9 = F[9];
nImage9 = nma`filterMidpoint[data, F9];
nma`imshow[Round[N[nImage9]], "Midpoint 9x9"]
```

```
startingRow = 5 endingRow = 252 startingCol=5 endingCol=252
```

```
ncol= 256 nRow= 256 n=9
```

```
Dimension of new image is ={248, 248}
```

```
Midpoint 9x9
```



```
Out[32]= - DensityGraphics -
```

```
In[33]:= nma`imshow[Round[N[Take[nImage9, {15, 26}, {18, 35}]]], ""]
```



```
Out[33]= - DensityGraphics -
```

```
In[34]:= Take[Round[N[nImage9]], {13, 20}, {17, 30}] // MatrixForm
```

```
Out[34]//MatrixForm=
```

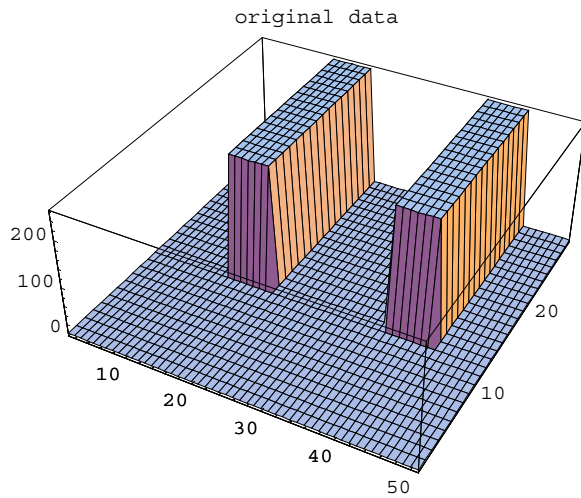
$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 \\ 0 & 0 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 \\ 0 & 0 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 \\ 0 & 0 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 \\ 0 & 0 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 & 128 \end{pmatrix}$$

So we see that the white strips have all now changed to gray level midpoint between scale.

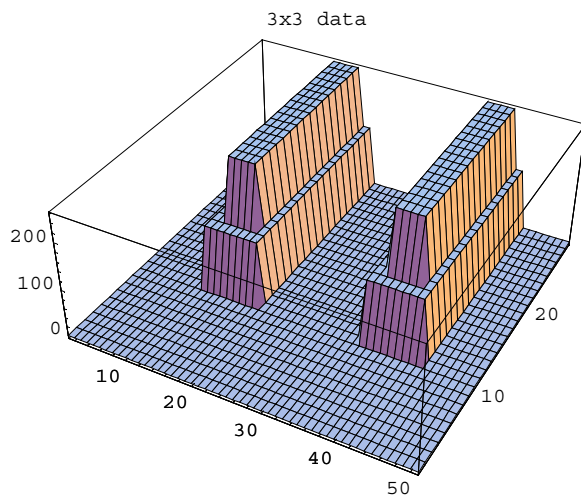
■ 3D plots

I'll now display the 3 images in 3D to better illustrate the filter result. I will only plot the region near the ends of the top of the first white strips.

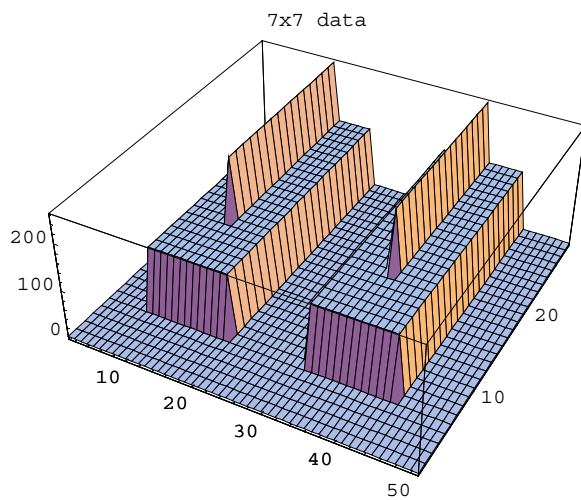
```
In[39]:= ListPlot3D[Take[data, {12, 40}, {15, 65}], PlotLabel → "original data"]
ListPlot3D[Take[nImage3, {12, 40}, {15, 65}], PlotLabel → "3x3 data"]
ListPlot3D[Take[nImage7, {12, 40}, {15, 65}], PlotLabel → "7x7 data"]
```



Out[39]= - SurfaceGraphics -



Out[40]= - SurfaceGraphics -



Out[41]= - SurfaceGraphics -