



Upcoming

- Short Paper Due Monday 10/2
- HW Due Tuesday 10/3

- Quiz now scheduled Thursday 10/5

- Midterm on Thursday 10/12
 - 1 side of 1 page of notes

Image Chain Link 5: Processing

- Create the Image from the "Data"
 - from the changes in the physical parameters
- Emulsion: chemical processing to convert to silver atoms
- CCD: electrical processing to read out the numbers of electrons

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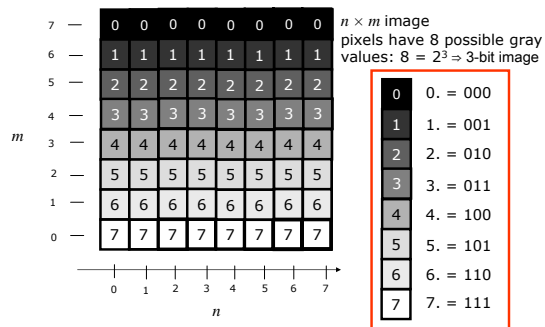
Digital Image Processing

- Capability formerly limited to "high-end" computers and skill levels
 - Cheap software now available
- Computer processing of image data to "modify" the values
- Mathematical algorithms to enhance or attenuate certain "features" of image
 - Enhanced or Locate "Edges"
 - Locate Specific Shapes (e.g., letters)
 - Remove or Attenuate "Random Noise"

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Digital Image Format $f[n,m]$

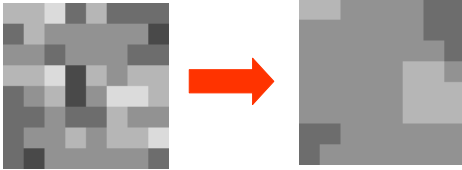


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Calculations Produce "New" Image

- Input Image = $f[n,m]$
- Output Image = $g[n,m]$



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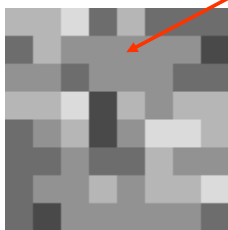
Noise Reduction/Removal

- "Noise" = Distribution of gray values due to statistical fluctuations in "something"
 - variation in sensitivity of pixels
 - random fluctuations

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3-Bit Image with Noise



Average Value = 4
"Variation" = 1

5	5	6	3	5	3	3	3
3	5	4	4	4	4	4	2
4	4	3	4	4	4	3	3
5	5	6	2	5	4	5	5
3	4	5	2	4	6	6	5
3	3	4	3	3	5	4	4
3	4	4	5	4	5	5	6
3	2	4	4	4	4	4	3

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Reduce Noise by "Local Average"

- Replace each pixel by average of 9 neighbors centered on that pixel

5	5	6	3	5	3	3	3
3	5	4	4	4	4	4	2
4	4	3	4	4	4	3	3
5	5	6	2	5	4	5	5
3	4	5	2	4	6	6	5
3	3	4	3	3	5	4	4
3	4	4	5	4	5	5	6
3	2	4	4	4	4	4	3

Replace "2" in red box by average of values of pixels in blue box

$$\frac{3+4+4+6+2+5+5+2+4}{9} = \frac{35}{9} = 3\frac{8}{9} \approx 3.89$$

Round average to nearest integer

$$3\frac{8}{9} \rightarrow 4$$

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Round Average Values for Display

Before Rounding

4.6	4.7	4.4	4.2	3.9	3.8	3.2	3.4
4.3	4.3	4.2	4.1	3.9	3.8	3.2	3.1
4.4	4.3	4.1	4.0	3.9	4.1	3.8	3.4
4.2	4.3	3.9	3.9	4.6	4.6	4.3	
3.9	4.2	3.8	3.8	3.8	4.7	4.9	4.6
3.6	3.7	3.8	3.8	4.1	4.7	5.1	4.9
5.1	3.3	3.7	3.9	4.1	4.2	4.4	4.1
3.3	3.7	4.1	4.2	4.1	4.0	4.2	4.0

Mean Value = 4.04
Variation = 0.44

After Rounding

5	5	4	4	4	4	3	3
4	4	4	4	4	4	3	3
4	4	4	4	4	4	4	3
4	4	4	4	4	5	5	4
4	4	4	4	4	5	5	5
4	4	4	4	4	5	5	5
3	3	4	4	4	4	4	4
3	4	4	4	4	4	4	4

Mean Value = 4.03
Variation = 0.53

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3-bit Noise Image After Averaging



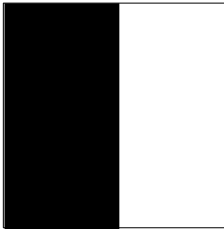
5	5	4	4	4	4	3	3
4	4	4	4	4	4	3	3
4	4	4	4	4	4	4	3
4	4	4	4	4	5	5	4
4	4	4	4	4	5	5	5
4	4	4	4	4	5	5	5
3	3	4	4	4	4	4	4
3	4	4	4	4	4	4	4

Mean Value = 4
Variation = 1/3

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Section of 3-bit Image of Edge



0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7

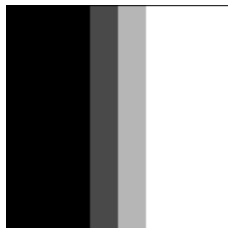
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Section of 3-bit Image of Edge

Result of Average

0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0
0.0	0.0	0.0	2.3	4.7	7.0	7.0	7.0



After Rounding

0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7

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Effect of Local Average on Edge

Input image has "Sharp" Edge

0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7



Output has "Fuzzy" Edge

0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7
0	0	0	2	5	7	7	7



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Lesson of Local Averaging

- Local Averaging Reduces the Variation in Gray Value
 - "Pushes Values Towards the Mean Value"
- Effective for Decreasing Visibility of Noise
- Also "Blurs" Edges of Image Features

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Edge Detector

- Observation: Local Averager Makes Edge "Blurry" and More Difficult to See
- How to "Detect" an Edge?
 - Can't use Local "Average"
 - Try a Local "Difference"

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Local Difference

- Compute difference of gray values of adjacent pixels

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"Local Difference" at Edge

0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7

Replace "0" in red box by difference of gray value in blue - red

$$7 - 0 = 7$$

Replace "7" in yellow box by of gray value in yellow - green

$$7 - 7 = 0$$

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Result of "Local Difference" at Edge

0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7
0	0	0	0	7	7	7	7

Input Image $f[n,m]$

0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0
0	0	0	0	7	0	0	0

Output Image $g[n,m]$

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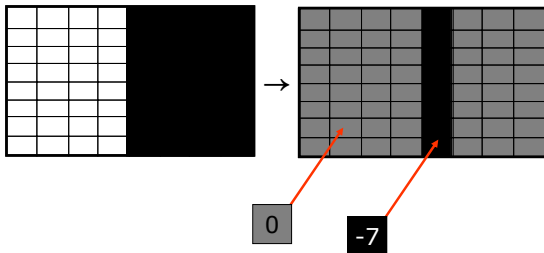
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Produces "More" Gray Values

$$7 - 0 = +7$$

$$0 - 7 = -7$$

Range of Output values is $-7 \leq g \leq +7$
from 8 levels on input to 15 levels in output



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