University of Idaho
Department of Computer Science
Coeur d'Alene

Lecture #7

Image Smoothing and Blurring

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revised September 3, 2024

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Review

Convolution & Kernels

- Convolution explores overlap of two functions
- CS uses convolution to modify or filter input

Review
Convolution & Kernels
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Why Blur/Smooth an Image?

1. Pre-processing step for other operations
2. Reduces noise/pixel intensity variations
3. Often used in conjunction with grayscaling

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Types of Noise

From Wikipedia, Noise Reduction [1]

1. Salt and Pepper Noise

Figure: Salt and Pepper Noise [2]

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Types of Noise

From Wikipedia, Noise Reduction [1]

1. Salt and Pepper Noise
2. Gaussian Noise

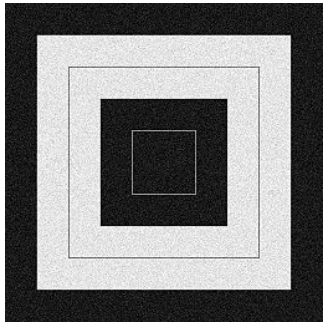

Figure: Gaussian Noise, [2]

Types of Noise
From Wikipedia, Noise Reduction [1]
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Privacy

Cows deserve privacy too…

Figure: Famous Cows, [3]

Privacy
Cows deserve privacy too…
Figure: Famous Cows, [3]

1. Google Street View's privacy protection protocol blurred out cow's face.

Smoothing Images Using Averages

$$K = 1/n^2 \begin{bmatrix} 1 & 1 & \dots & 1_{0n} \\ 1 & 1 & \dots & 1_{1n} \\ \dots & \dots & \dots & \dots \\ 1 & 1 & \dots & 1_{nn} \end{bmatrix}$$

Smoothing Images Using Averages
$K = 1/n^2 \begin{bmatrix} 1 & 1 & \dots & 1_{0n} \\ 1 & 1 & \dots & 1_{1n} \\ \dots & \dots & \dots & \dots \\ 1 & 1 & \dots & 1_{nn} \end{bmatrix}$

Smoothing Images Using Averages

For $n = 3\ldots$

$$K = \begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$$

Smoothing Images Using Averages
For $n = 3\ldots$
$K = \begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$

Smoothing Images Using Averages

For $n = 5\ldots$

$$K = \begin{bmatrix} 1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\ 1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\ 1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\ 1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\ 1/25 & 1/25 & 1/25 & 1/25 & 1/25 \end{bmatrix}$$

Smoothing Images Using Averages
For $n = 5\ldots$
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Notes on Blur

Larger kernel means…

1. More information from surrounding pixels
2. More blurry result

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Code Example

```python
img = cv.blur(img, (3,3))
```


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Gaussian Blurring

- Normal distribution
- Anchor pixel has greatest weight
- Common and popular method
- Standard deviation can be used to modify filter

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- Normal distribution
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Code Example

```python
blurred = cv.GaussianBlur(img, (3,3), 0)
```


Code Example
blurred = cv.GaussianBlur(img, (3,3), 0)

Median Blurring

- Kernel replaces pixel value with median value from input
- Lose detail quickly
- May be good for salt & pepper noise removal

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- Kernel replaces pixel value with median value from input
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Code Example

```python
blurred = cv.medianBlur(img, 3)
```


Code Example
blurred = cv.medianBlur(img, 3)

Bilateral Filtering

- Two Gaussian filters
- Attempts to blur while preserving edges
- Looks at pixels with similar intensity

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- Two Gaussian filters
- Attempts to blur while preserving edges
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Code Example

```python
blurred = cv.bilateralFilter(img, 11, 21, 7)
```


Code Example
blurred = cv.bilateralFilter(img, 11, 21, 7)

Denoising

Another synthetic CS/Image processing term…

- OpenCV has several ways to remove noise
- Average sections of image → replace noise
- Computationally expensive

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Denoising: Non-Local Means

Non-Local Means Algorithm

“Unlike "local mean" filters, which take the mean value of a group of pixels surrounding a target pixel to smooth the image, non-local means filtering takes a mean of all pixels in the image, weighted by how similar these pixels are to the target pixel.”

Wikipedia, Non-local Means [4]

Denoising: Non-Local Means
Non-Local Means Algorithm
“Unlike "local mean" filters, which take the mean value of a group of pixels surrounding a target pixel to smooth the image, non-local means filtering takes a mean of all pixels in the image, weighted by how similar these pixels are to the target pixel.”
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Denoising Options

1. `cv.fastNlMeansDenoising()`
   - works with single grayscale images

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1. `cv.fastNlMeansDenoising()`

2. `cv.fastNlMeansDenoisingColored()`
   - works with a color image

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Denoising Options

1. `cv.fastNlMeansDenoising()`
2. `cv.fastNlMeansDenoisingColored()`
3. `cv.fastNlMeansDenoisingMulti()`
   - works with image sequence (grayscale)

Denoising Options
1. cv.fastNlMeansDenoising()
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1. `cv.fastNlMeansDenoising()`
2. `cv.fastNlMeansDenoisingColored()`
3. `cv.fastNlMeansDenoisingMulti()`
4. `cv.fastNlMeansDenoisingColoredMulti()`
   - same as previous, but for color images

Denoising Options
1. cv.fastNlMeansDenoising()
2. cv.fastNlMeansDenoisingColored()
3. cv.fastNlMeansDenoisingMulti()
4. cv.fastNlMeansDenoisingColoredMulti()
   - same as previous, but for color images

Denoising Example

`cv.fastNlMeansDenoisingColored()`

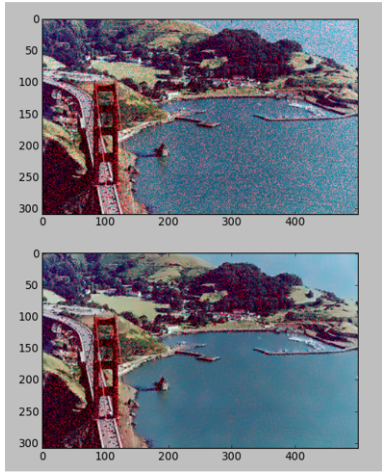

Figure: Bridge Denoise [2]

Denoising Example
cv.fastNlMeansDenoisingColored()
Figure: Bridge Denoise [2]

Q&A

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[3] C. Johnston, "Google Street View's beefed-up privacy blurs cow's face," *The GuardianTechnology*, Sep. 18, 2016, ISSN: 0261-3077. [Online]. Available: https://www.theguardian.com/technology/2016/sep/16/beefed-up-google-street-view-privacy-blurs-cows-face (visited on 08/30/2024).

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