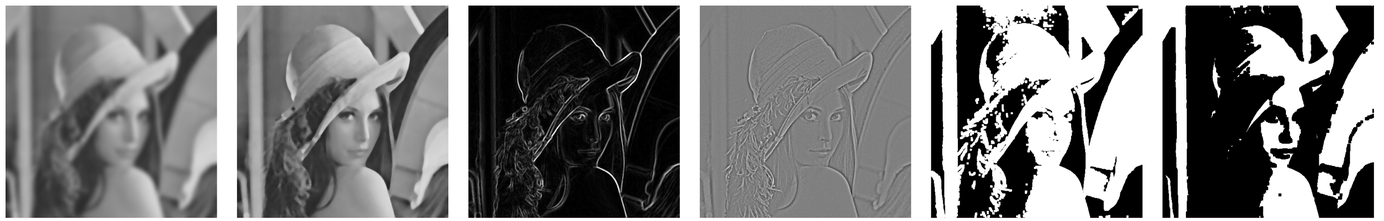
THE UNIVERSITY OF BRITISH COLUMBIA

CPSC 425: Computer Vision



Lecture 3: Image Filtering

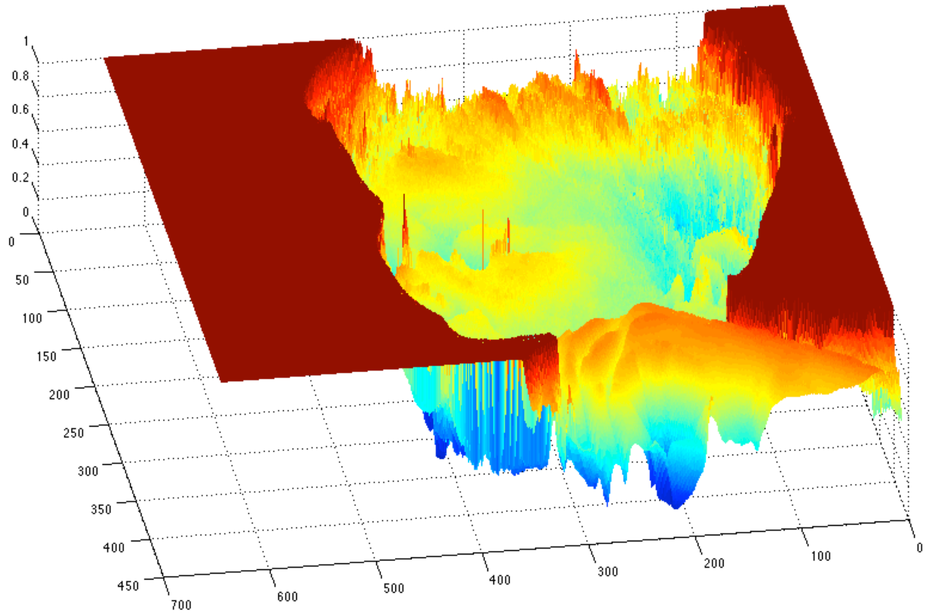
(unless otherwise stated slides are taken or adopted from **Bob Woodham, Jim Little** and **Fred Tung**)

Image as a **2D Function**

A (grayscale) image is a 2D function

grayscale image

$I(X,Y)$



What is the **range** of the image function?

$$I(X,Y) \in [0,255] \in \mathbb{Z}$$

domain: $(X,Y) \in ([1,width],[1,hight])$

Slide Credit: Ioannis (Yannis) Gkioulekas (CMU)

Adding two Images

Since images are functions, we can perform operations on them, e.g., **average**

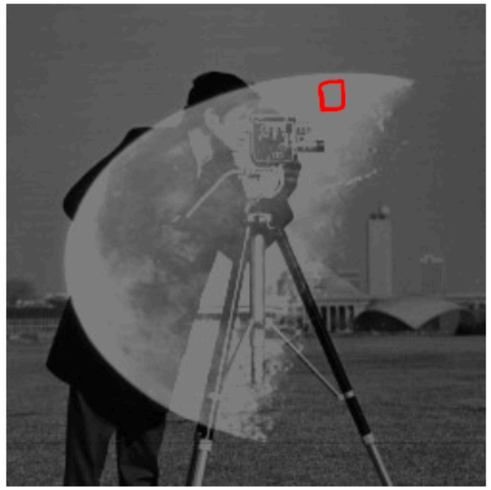
$I(X,Y)$

$G(X,Y)$

$$\frac{I(X,Y)}{2} + \frac{G(X,Y)}{2}$$

Adding two Images

$$a = \frac{I(X,Y)}{2} + \frac{G(X,Y)}{2}$$



$$b = \frac{I(X,Y) + G(X,Y)}{2}$$

Question:

$$a = b$$

$$a > b$$

$$a < b$$

Adding two Images

Red pixel in camera man image = 98

Red pixel in moon image = 200

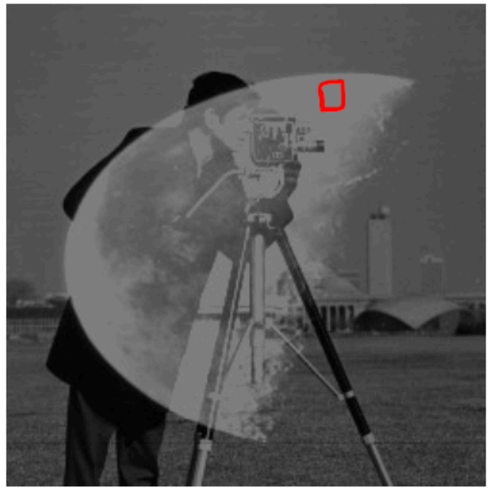
$$\frac{98}{2} + \frac{200}{2} = 49 + 100 = 149$$

Question:

$a = b$

$a > b$

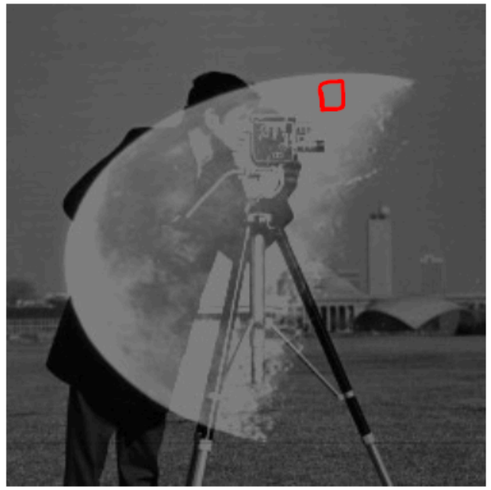
$a < b$



$$\frac{98 + 200}{2} = \frac{\lfloor 298 \rfloor}{2} = \frac{255}{2} = 127$$

Adding two Images

$$a = \frac{I(X,Y)}{2} + \frac{G(X,Y)}{2}$$



$$b = \frac{I(X,Y) + G(X,Y)}{2}$$

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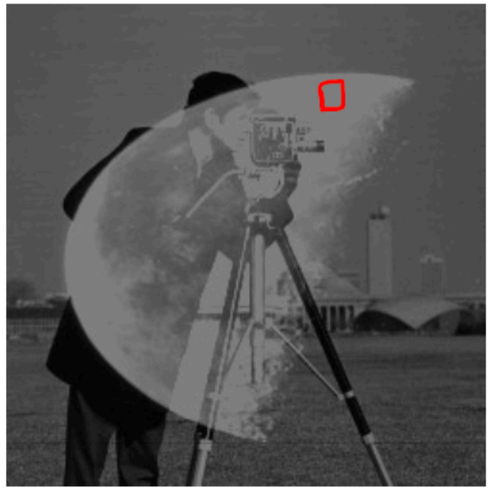
Adding two Images



It is often convenient to convert images to **doubles** when doing processing

In Python

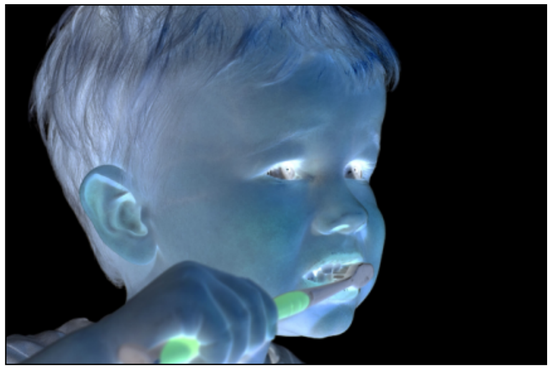
```
from PIL import Image
img = Image.open('cameraman.png')
import numpy as np
imgArr = np.asfarray(img)

# Or do this
import matplotlib.pyplot as plt
camera = plt.imread('cameraman.png');
```

What types of **transformations** can we do?

$I(X,Y)$

Filtering

$I'(X,Y)$

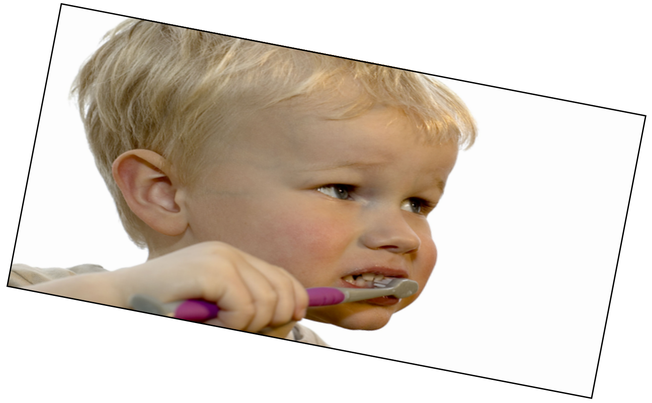


changes range of image function

$I(X,Y)$

Warping

$I'(X,Y)$

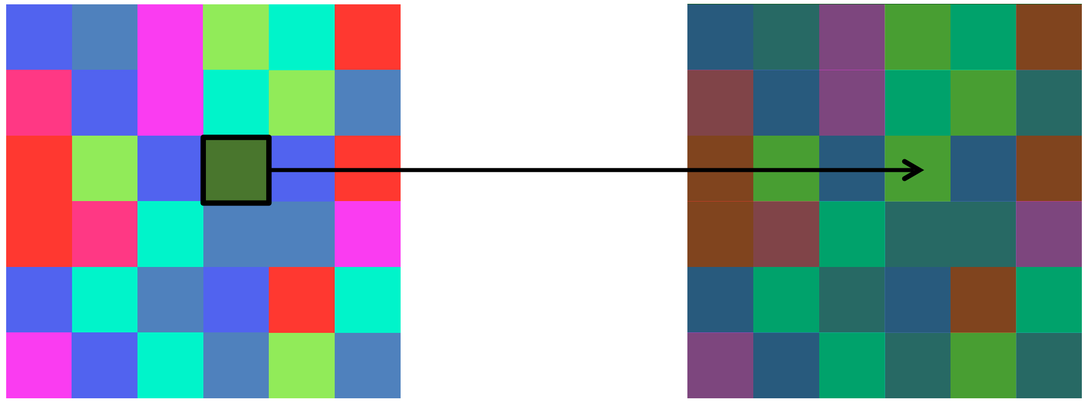


changes domain of image function

Slide Credit: Ioannis (Yannis) Gkioulekas (CMU)

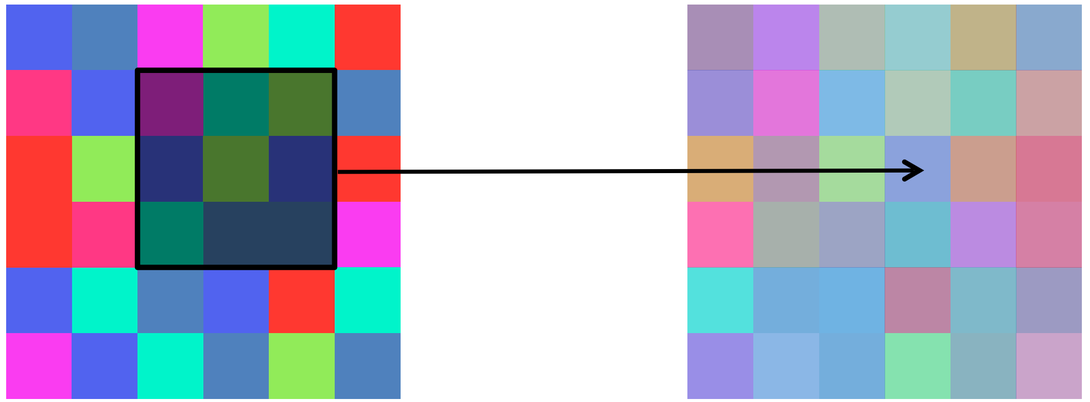
What types of **filtering** can we do?

Point Operation



point processing

Neighborhood Operation



“filtering”

Slide Credit: Ioannis (Yannis) Gkioulekas (CMU)

Examples of **Point Processing**

original

$I(X,Y)$

darken

$I(X,Y) - 128$

lower contrast

$\frac{I(X,Y)}{2}$

non-linear lower contrast

$\left(\frac{I(X,Y)}{255}\right)^{1/3} \times 255$

invert

$255 - I(X,Y)$

lighten

$I(X,Y) + 128$

raise contrast

$I(X,Y) \times 2$

non-linear raise contrast

$\left(\frac{I(X,Y)}{255}\right)^{2} \times 255$

Slide Credit: Ioannis (Yannis) Gkioulekas (CMU)

Examples of **Point Processing**

original

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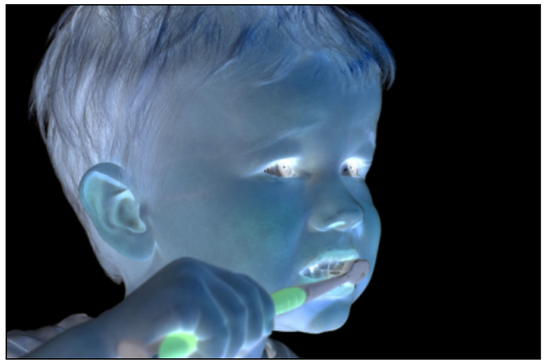

$255 - I(X,Y)$

lighten

$I(X,Y) + 128$

raise contrast

$I(X,Y) \times 2$

non-linear raise contrast

$\left(\frac{I(X,Y)}{255}\right)^{2} \times 255$

Slide Credit: Ioannis (Yannis) Gkioulekas (CMU)

Reminders

Redings:

— **Today's** Lecture: Forsyth & Ponce (2nd ed.) 1.1.1 — 1.1.3

— **Next** Lecture: Forsyth & Ponce (2nd ed.) 4.1, 4.5

Reminders:

— Complete **Assignment 0** (ungraded) by Wednsday, **September 12**

— **Assignment 1** will be out, **September 12**