Deep Learning for Computer Vision

Image Representation

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Question

On Colour

If visible light spectrum is VIBGYOR, why RGB colour representation?

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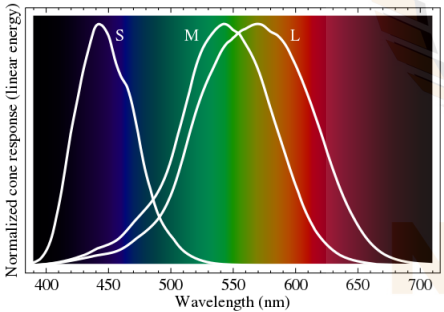
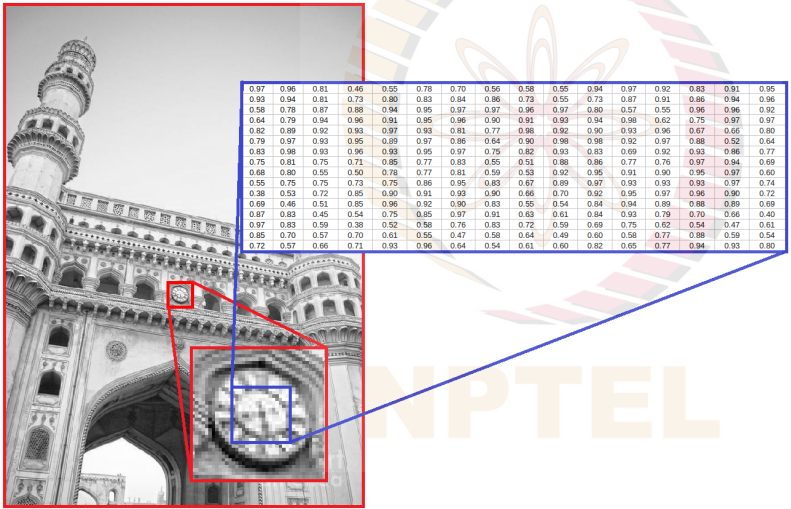


Credit: Derek Hoiem, UIUC

- Long (red), Medium (green), and Short (blue) cones, plus intensity rods
- Fun facts
  - "M" and "L" on the X-chromosome $\implies$ men are more likely to be colour blind!
  - Some animals have 1 (night animals), 2 (e.g., dogs), 4 (fish, birds), 5 (pigeons, some reptiles/amphibians), or even 12 (mantis shrimp) types of cones

https://en.wikipedia.org/wiki/Color_vision

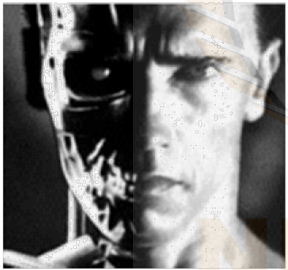
Image as a Matrix

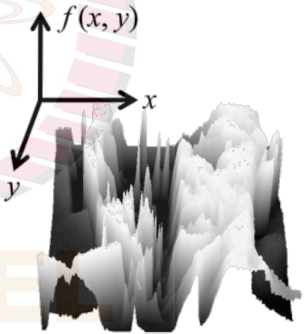


- Common to use one byte per value: 0 = black, 255 = white
- One such matrix for every channel in colour images

Image as a Function

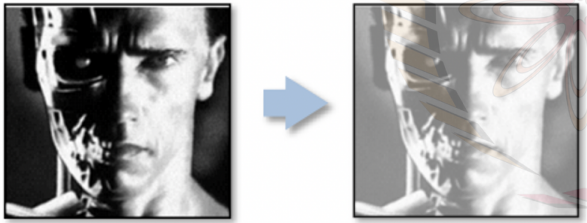
- We can think of a (grayscale) image as a function $f : \mathbb{R}^2 \to \mathbb{R}$, giving the intensity at position (x, y)
- A digital image is a discrete (sampled, quantized) version of this function





Credit: Noah Snavely, Cornell Univ

Image Transformations



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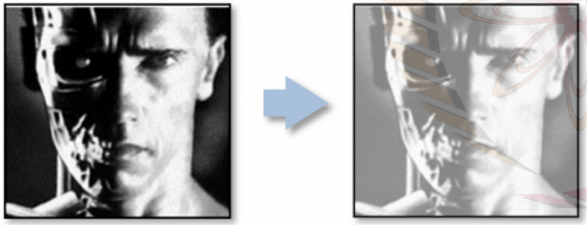

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$$\hat{I}(x,y) = I(-x,y)$$

Image Processing Operations

- Point Operations
  - Output value at (m_0, n_0) is dependent only on the input value at the same coordinate
  - *Complexity/pixel:* Constant
- Local Operations
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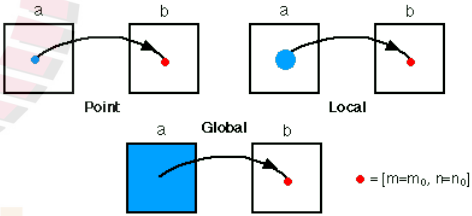
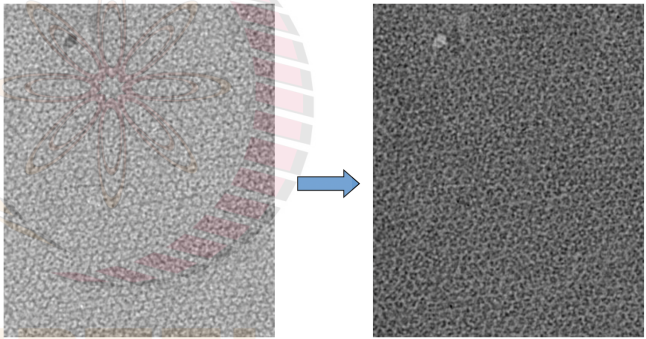


Point Operations: Example

- Image Enhancement:
  Reversing the contrast
- How?



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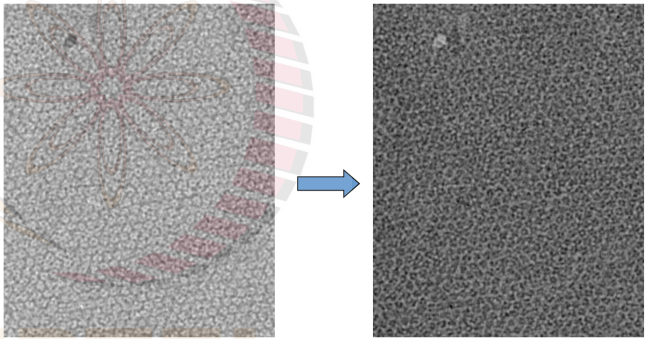
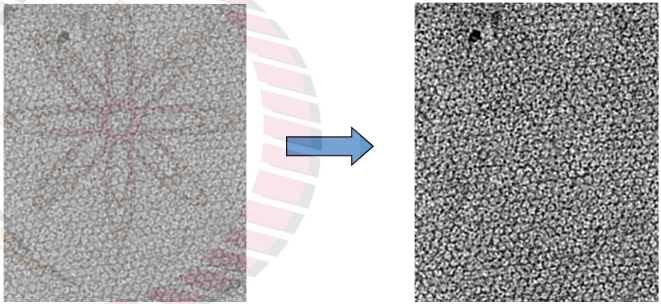


$$\hat{I}(m_0, n_0) = I_{MAX} - I(m_0, n_0) + I_{MIN}$$

Point Operations: Another Example

- Image Enhancement:
  Stretching the contrast
- How?



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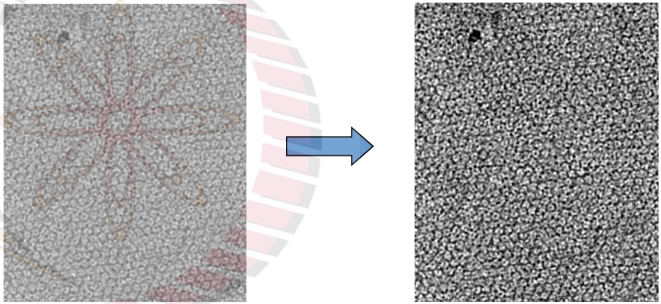

Linear Contrast Stretching

$$\hat{I}(m_0, n_0) = \left(I(m_0, n_0) - \min_{x,y} I(x, y)\right) * \left((I_{MAX} - I_{MIN})/(\max_{x,y} I(x, y) - \min_{x,y} I(x, y))\right) + I_{MIN}$$

Going Beyond Linear Stretching

Question

Heard about **Histogram Equalization**? Read about it, homework!

How Useful are Point Operations?

- A single point (or pixel)'s intensity is influenced by multiple factors, and may not tell us everything
  - Light source strength and direction
  - Surface geometry, material and nearby surfaces
  - Sensor capture properties
  - Image representation and colour
- Given a camera and a still scene, how do you reduce noise using point operations?

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- Given a camera and a still scene, how do you reduce noise using point operations?
- Take many images, and average them!
- You need local operations otherwise. What is the local operation?

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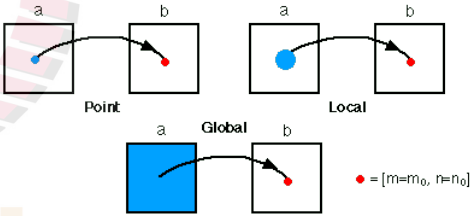
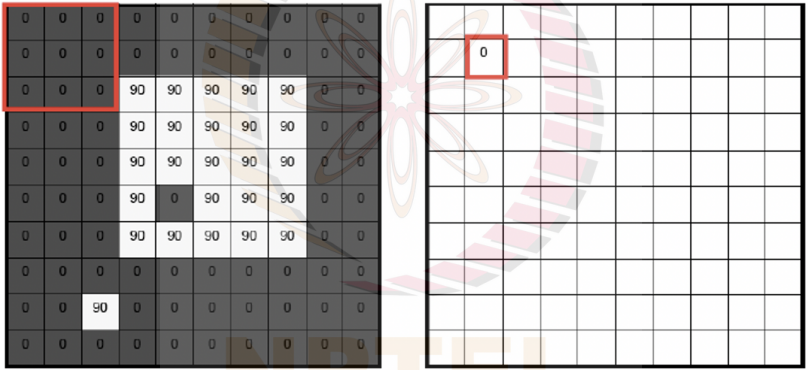


Local Operation Examples: Moving Average



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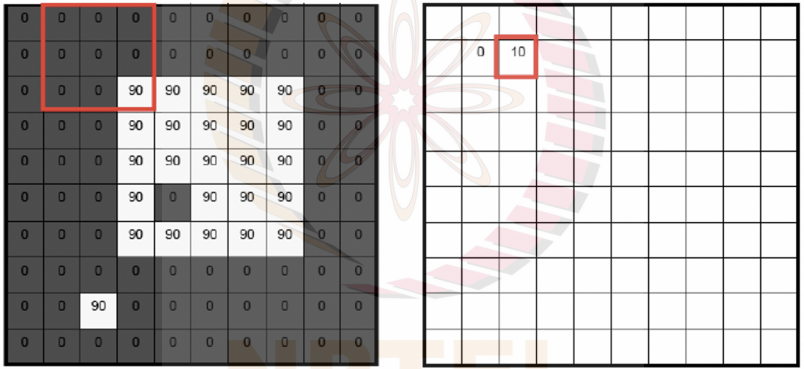

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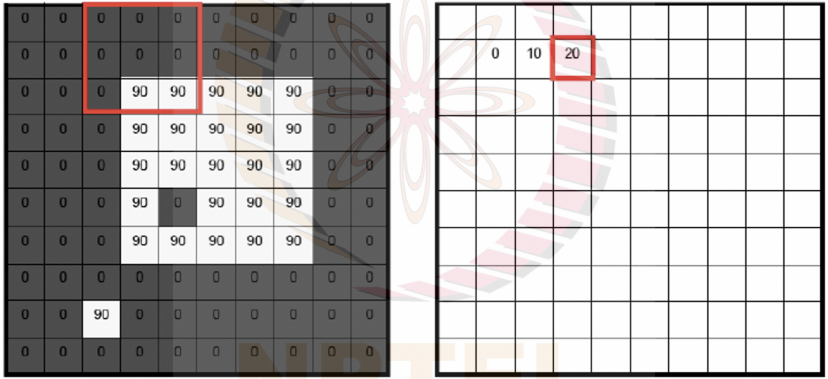

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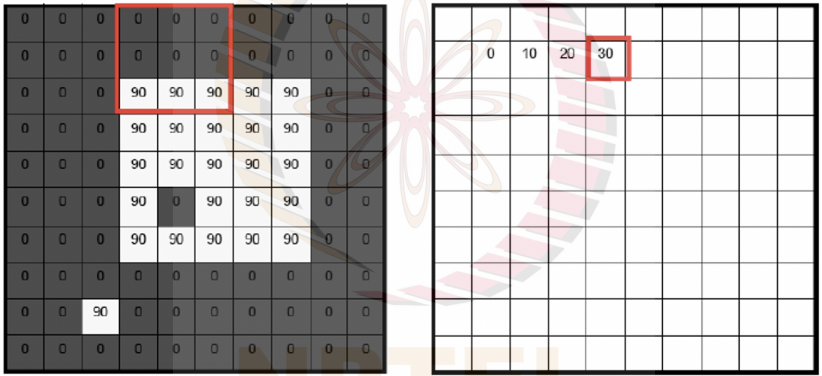

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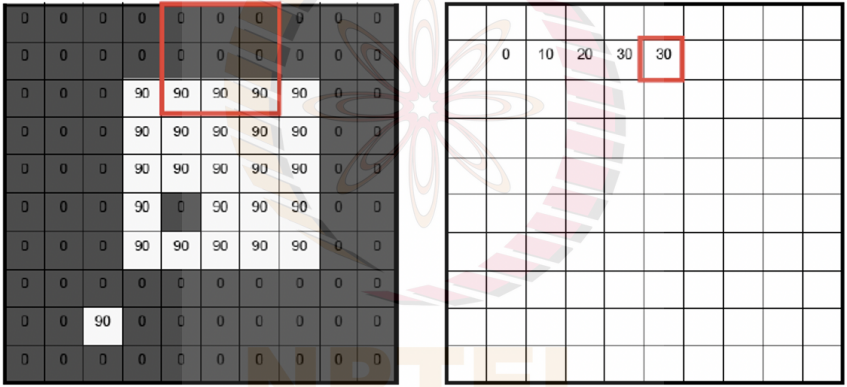

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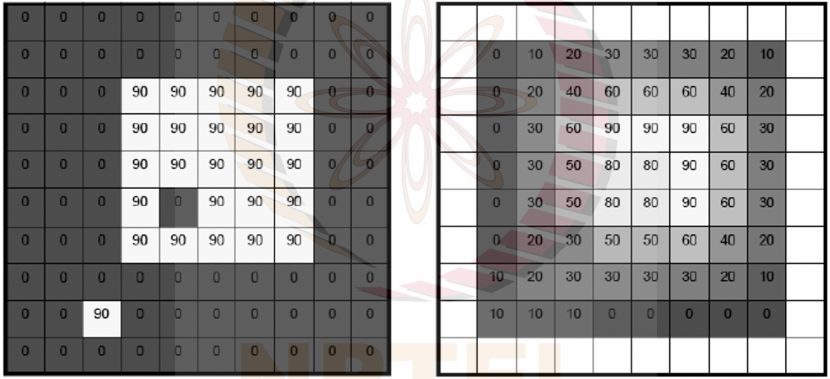

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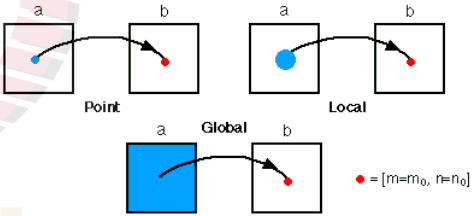
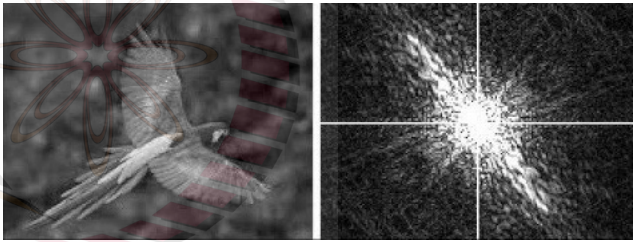


Global Operations: Examples

- Image coordinate transformations, e.g. Fourier transform
- We will see more of this later



Credit: Mathworks MATLAB Toolbox

Homework

Readings

- Chapter 3.1, Szeliski, *Computer Vision: Algorithms and Applications*

Questions to Answer

- What is histogram equalization, and how do you derive its formula?

References

Richard Szeliski. *Computer Vision: Algorithms and Applications*. Texts in Computer Science. London: Springer-Verlag, 2011.

Hoiem, Derek, CS 543 - Computer Vision (Spring 2011). URL: https://courses.engr.illinois.edu/cs543/sp2017/ (visited on 04/25/2020).