Histogram Equalization and more Point Operations

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Point operations on images

- Point operations perform some operation on one pixel at a time (independent on the neighboring pixels)

  For each (x,y)

  $I_2(x,y) = f(I(x,y))$
- Contrast to image transforms (later in course) perform operations on the whole image

Common point operations

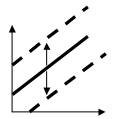
- Brightness adjustment
- Contrast adjustment
  - Dynamic range compression
  - Gray level slicing
- Histogram equalization
- Image (sequence) averaging
- Background subtraction

Linear brightness and contrast adjustment

- As seen on TV!
- Brightness

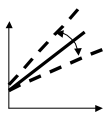
  For each (x,y)

  $I_2(x,y) = I(x,y)+const$

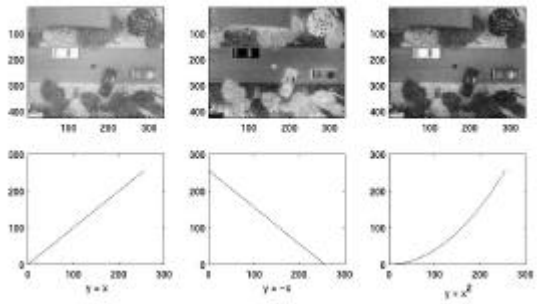


- Contrast

  $I_2(x,y) = const*I(x,y)$



Contrast adjustment example



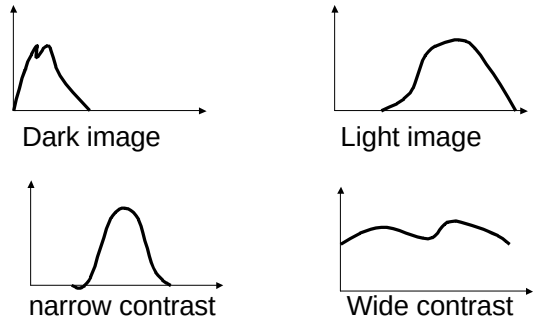
Special purpose contrast adjustments

- Dynamic range limitation
  $I_2(x,y) = \text{sqrt}(I(x,y))$
  $I_2(x,y) = \log(I(x,y))$
- Inverted image
  $I_2(x,y) = 1-I(x,y)$
- Gray level slicing

Image histogram

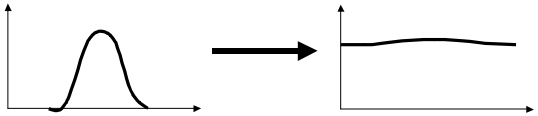
- For a discrete image quantized e.g. on [0..255]
  - Let n = total number of pixels
  - Let n_k = number of pixels with value k
  - Histogram: $p_k = n_k / n$
- Analogy: Consider the image a sample of a random variable. Then p_k is probability of a pixel having value k

Histogram examples



Histogram equalization

- Let p(k) = image histogram on k = [0..1]
- Goal: find a contrast stretching transform T(k) so that $I_2 = T(I)$ and $p_2 = 1$(uniform)



p(k) p_2

Histogram eq.

- Consider:

$$s = T(r) = \int_0^R p_r(w)dw; \quad r \in [0::1]$$

$$\frac{ds}{dr} = p_1(r)$$

- Then:

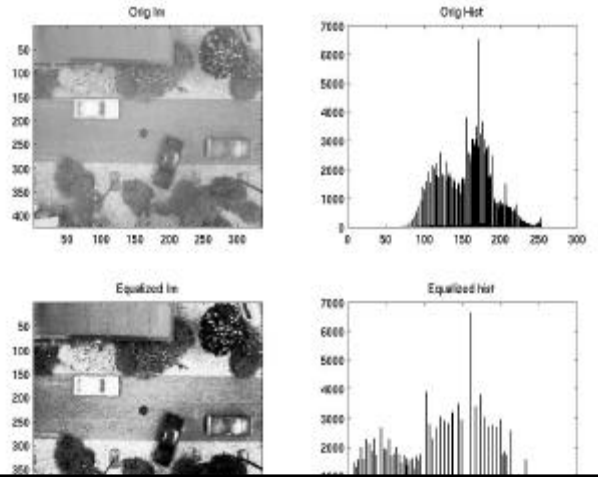
$$p_2(s) = p_1(r)\frac{dr}{ds} = p_1(r)\frac{1}{p_1(r)} = 1$$

Discrete histogram equalization

- Compute discrete histogram summing bins
- Compute cumulative sum
- Map image intensities through cumulative histogram

- Question: is discrete histogram uniform?

Discrete histogram equalization



Background subtraction

- Subtract out static background to capture changes

What process actually happened?

Image averaging

- Average several images of the same scene

  $I_s(x,y) = \text{sum}(I(x,y))/n$

- Can remove noise