Image Point Operations and Histogram Equalization

C306

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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
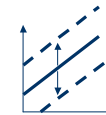
Common point operations

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

Linear brightness and contrast adjustment
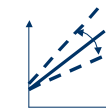
- As seen on TV!
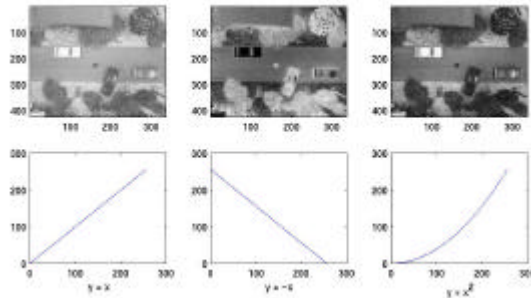- Brightness

    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
  - $I_2(x,y) = sqrt(I(x,y))$
  - $I_2(x,y) = log(I(x,y))$
- Inverted image
  - $I_2(x,y) = 1-I(x,y)$
- Gray level slicing

Contrast operations example

-
```
clf
a =
subsample(ppmunpack(readppm('../images/Tinytown.pgm')),1);
figure(1)
subplot(332)
b = 255:-1:1
show(b(a),1)
subplot(335)
plot(b)
xlabel(' y = -x')

subplot(333)
b = 255*((1:255)/255).^2
show(b(a),1)
subplot(336)
plot(b)
xlabel(' y = x^2')
```

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```
print -djpeg TinytownContr1.jpg
```
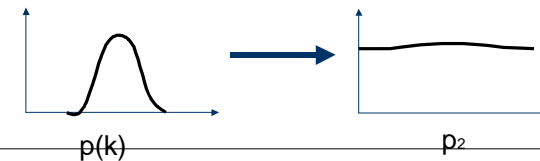
Image histogram

- 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

Dark image

Light image

narrow contrast

Wide contrast
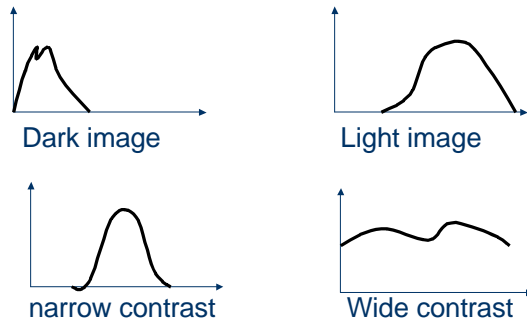
Histogram equalization

- 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:

$$s = T(r) = \int_0^r p_r(w)dw, \quad r \in [0..1]$$
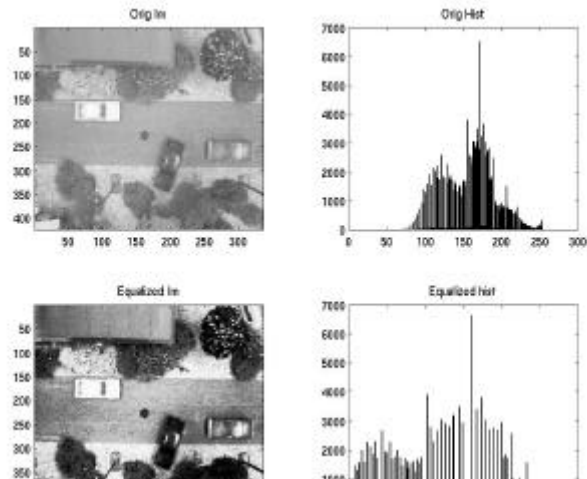
$$\frac{ds}{dr} = p_1(r)$$

- 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

  $I_s(x,y) = \quad I(x,y))/n$

- Can remove noise