ECE 438 Lecture — Wednesday 26 April 2023

- Office Hour today: 3:30p EDT
- Remember to complete course evaluation
- Exam 3 can be picked up in MSEE 330 with photo ID between 1p & 5p today

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Image Processing

Gray level histogram

$$h_f[b] = \frac{1}{MN} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} \delta[f[m,n] - b]$$

f ← image

Module 2.4.2

Gray scale transformation

$f[m,n]$ — 3 bits/pixel

2	2	3	3
2	3	3	4
3	3	4	4
3	4	4	5

0	0	2	2
0	2	2	6
2	2	6	6
2	6	6	7

We could have $0 \le f[m,n] \le 7$

b	$h_f[b]$
0	0
1	0
2	3/16
3	6/16
4	5/16

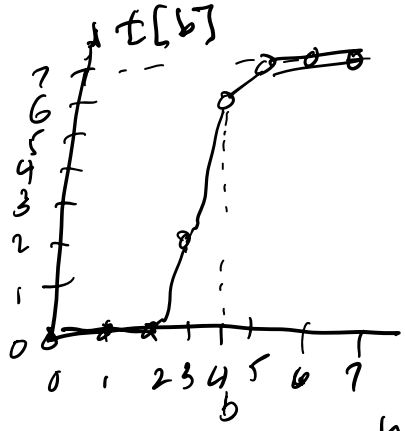
b	$h_s[b]$
0	3/16
1	0
2	7/16
3	0
4	0
5	0

b	$t[b]$
0	0
1	0
2	0
3	2
4	6
5	7

$g[m,n] = t[f[m,n]]$

have increased contrast in image

5	1/16	6	5/16	6	
6	0	7	1/16	7	7
7	0				



can also map histogram $h_f[b]$ to $h_g(b)$ by using this curve - see on-line notes

$$h_g[b] = \sum_{b'=t[b']} h_f[b']$$

Applications

1. Quantization
2. Calibration
3. Contrast modification
4. gamma mapping
5. feature selection (masking)
6. pseudo color
7. classification

end of Module 2.4.2

Module 2.4.3 - Spatial Filtering

- Linear filtering - each pixel in the output image is a weighted sum of pixels in the corresponding neighborhood of the input image

- This is basically 2D DS convolution

Applications

- sharpening
  - enhances edges & detail
  - boost energy at high frequencies
- smoothing
  - remove noise
- edge detection
  - widely used in image analysis, computer vision, and machine learning

Advantages of linear filtering

- rich theory
- ease of implementation

Disadvantages of linear filtering

- may blur edges
- outliers in input may exert large influence on output image (nonlinear filtering can avoid this)

Equations for linear filtering

(1) $g[m,n] = \sum_{k',l'} h[k',l'] f[m+k', n+l']$

let $k = -k'$, $l = -l'$ $\quad h[k,l] = h'[-k,-l]$

then we get:

(2) $g[m,n] = \sum_{k} \sum_{l} h[k,l] f[m-k, n-l]$ — 2D convolution

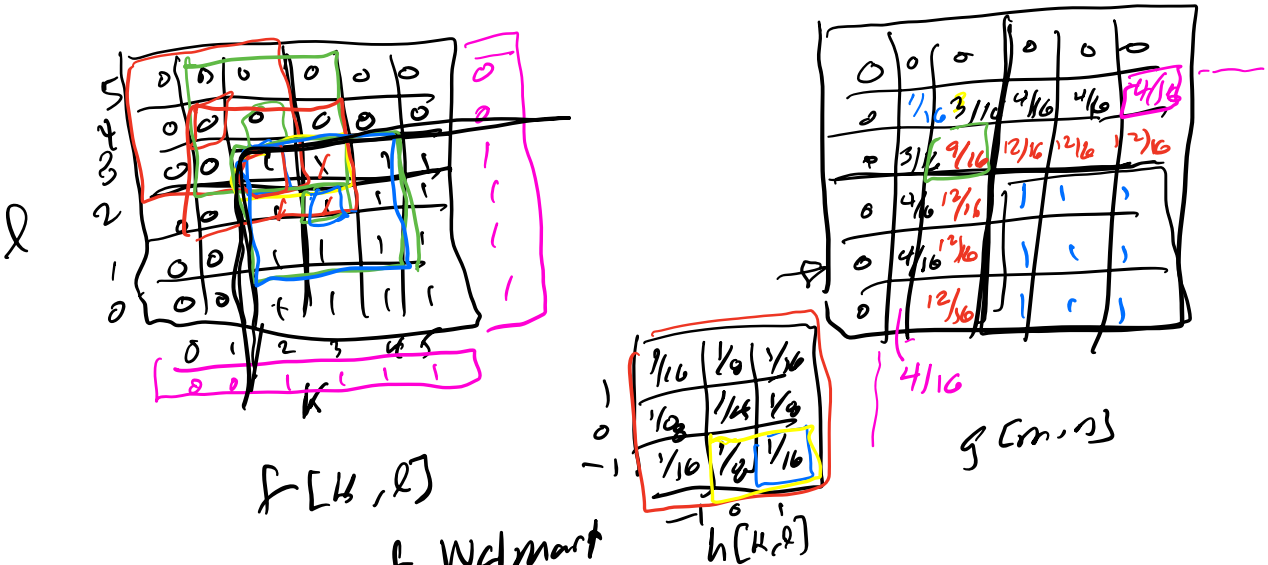
$= \sum_{k} \sum_{l} h[m-k, n-l] f[k,l]$

or $g[m,n] = \sum_k \sum_l$ [illegible]

$= \sum_k \sum_l h[-(k-m), -(l-n)]\, f[k,l]$ (filter)

$\sum_{k} \sum_{l}$

Example 2



aerial view of Walmart
0 – asphalt parking lot
1 – light gravel on roof

Boundary conditions for linear filtering

(1) Let missing pixels be zero

✓ (2) Extend boundary pixels

DC preserving?

$\sum_k \sum_l h[k,l] = 1$

See posted ppt. for "Intro to ECE" under Supplementary Material – (very short)

What did filter do for Example 2?

1. Preserved constant areas of image
2. Blurred edges