COL783: Digital Image Processing

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Recap

Arithmetic Coding

Dictionary based methods

- LZ77
- LZW

Run Length Coding

Predictive Coding

Recap: Image Compression

Predictive Coding

Basic premise: Current pixel is similar to the previous pixel (coherence)

Differential Coding

$$d(x,y) = I(x,y) - I(x-1,y)$$

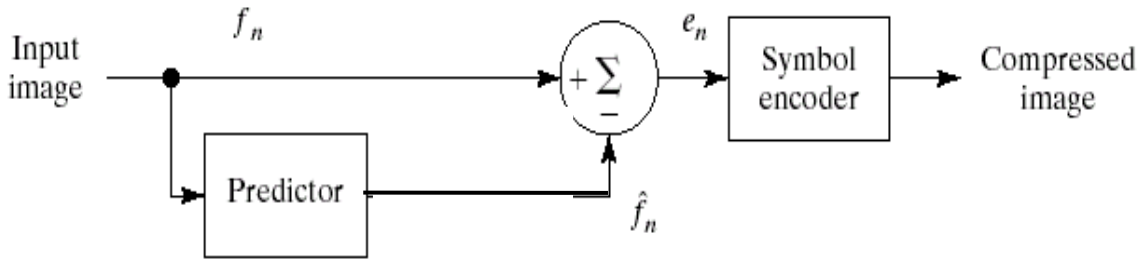
d(x,y) prediction error which is to be encoded.

Recap: Image Compression

Predictive Coding

Compression

$$e_n = f_n - \hat{f}_n,$$

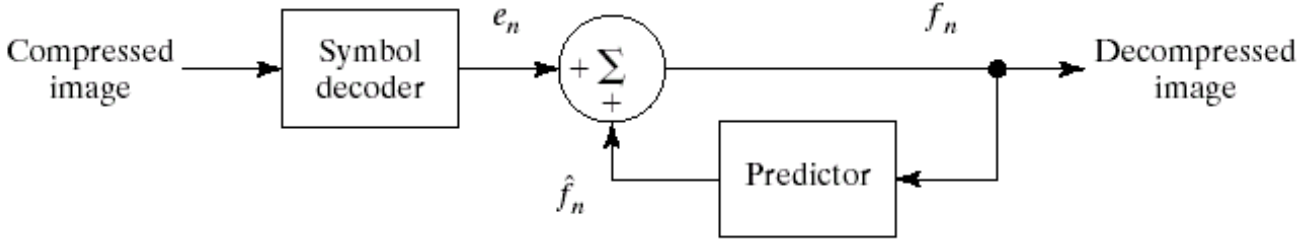


Source: Digital Image Processing, Gonzalez and Woods.

Recap: Image Compression

Predictive Coding

Decompression



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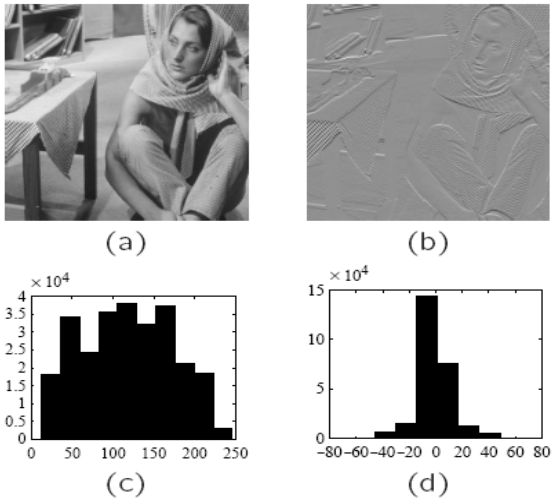
Predictive Coding



Distributions for Original versus Derivative Images. (a,b): Original gray-level image and its partial derivative image; (c,d): Histograms for original and derivative images.

Recap: Image Compression

Predictive Coding

$$E\{e_n^2\} = E\left\{\left[f_n - \sum_{i=1}^{m} \alpha_i f_{n-i}\right]^2\right\}.$$

$$\boldsymbol{\alpha} = \mathbf{R}^{-1}\mathbf{r}$$

where $\mathbf{R}^{-1}$ is the inverse of the $m \times m$ autocorrelation matrix

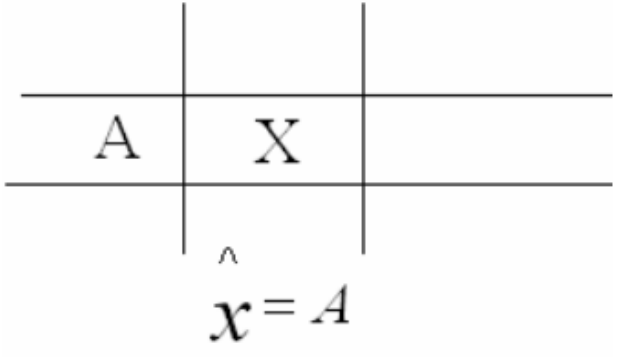
$$\mathbf{R} = \begin{bmatrix} E\{f_{n-1}f_{n-1}\} & E\{f_{n-1}f_{n-2}\} & \cdots & E\{f_{n-1}f_{n-m}\} \\ E\{f_{n-2}f_{n-1}\} & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & & & \\ E\{f_{n-m}f_{n-1}\} & E\{f_{n-m}f_{n-2}\} & \cdots & E\{f_{n-m}f_{n-m}\} \end{bmatrix}$$

and $\mathbf{r}$ and $\boldsymbol{\alpha}$ are the m-element vectors

$$\mathbf{r} = \begin{bmatrix} E\{f_n f_{n-1}\} \\ E\{f_n f_{n-2}\} \\ \vdots \\ E\{f_n f_{n-m}\} \end{bmatrix} \quad \text{and} \quad \boldsymbol{\alpha} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_m \end{bmatrix}.$$

Recap: Image Compression

Predictive Coding



91	99 (+7)	96 (-3)
93	101 (+8)	97 (-4)
101	103 (+2)	104 (+1)

Recap: Image Compression

Predictive Coding

B	C	D
A	X	

$$\hat{x} = k_1 A + k_2 B + k_3 C + K_4 D$$

Image Compression

Lossy

- Psychovisual redundancy
- Keep more important information
- Trade off between loss (degradation) and compression

Original

Compression Ratio: 7.7

Compression Ratio: 12.3

Compression Ratio: 33.9

Image Compression

Lossy

Original

Image Compression

Lossy

Compression Ratio 7.7

Image Compression

Lossy

Compression Ratio 33.9

Image Compression

Lossy

- Recall Quantization

  Discrete value to represent range of values

  Irreversible operation

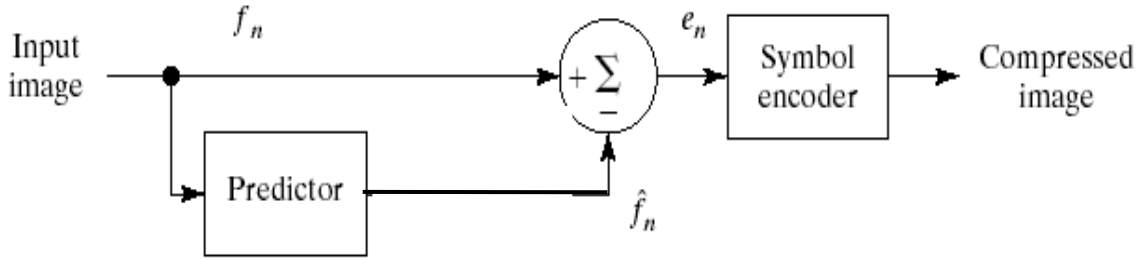
  Information loss !

- Predictive Coding
- Transform Coding

Image Compression

Predictive Coding: Loss-less (Revisit)

Compression



Decompression

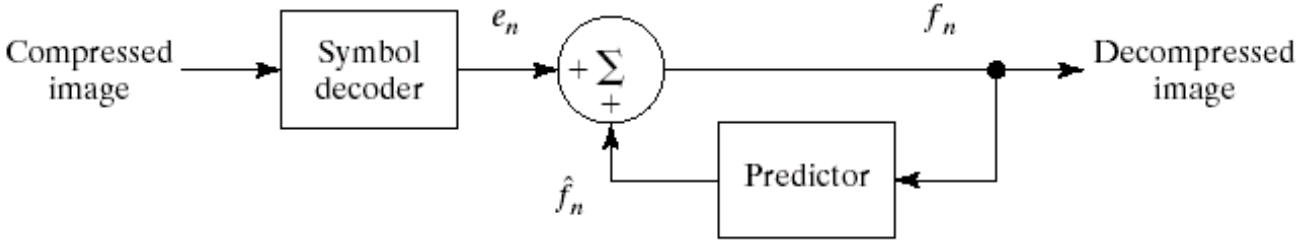
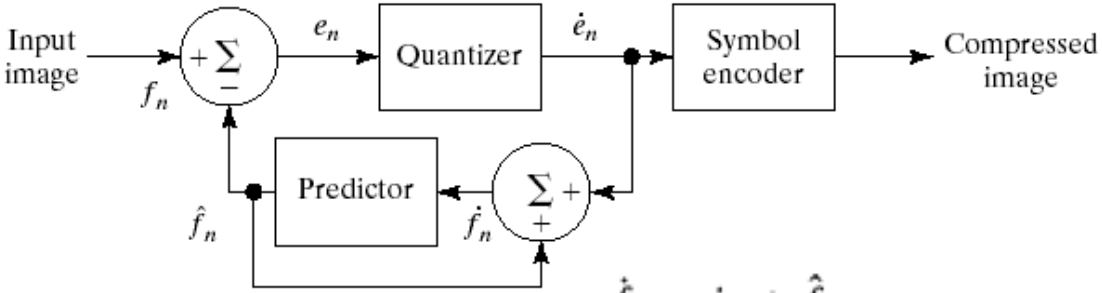


Image Compression

Predictive Coding: Lossy

Compression



$$\dot{f}_n = \dot{e}_n + \hat{f}_n$$

Decompression

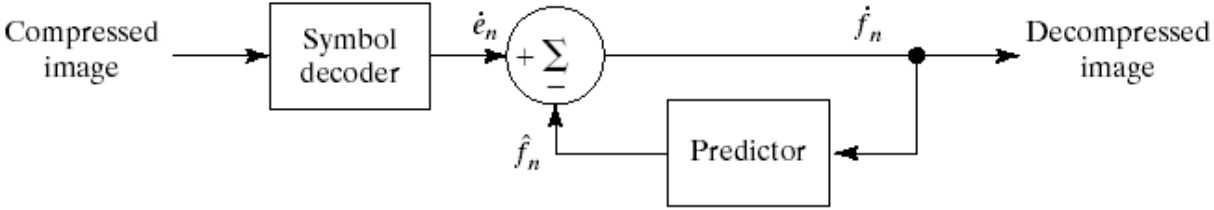


Image Compression

Predictive Coding: Lossy

Delta Modulation

Example:

$$\hat{f}_n = \alpha \dot{f}_{n-1}$$

$$\text{and } \dot{e}_n = \begin{cases} +\xi & e_n > 0 \\ -\xi & e_n < 0 \end{cases}$$

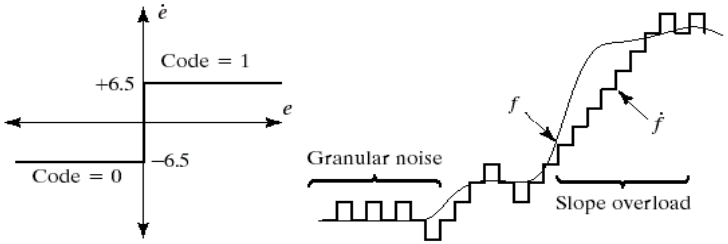
$0 < \alpha < 1$
prediction coefficient

$$\dot{f}_n = \dot{e}_n + \hat{f}_n$$

$$= \dot{e}_n + \alpha \dot{f}_{n-1}$$

Image Compression

Predictive Coding: Lossy



a b
c

FIGURE 8.22 An example of delta modulation.

Input		Encoder				Decoder		Error
n	f	$\hat{f}$	e	$\dot{e}$	$\dot{f}$	$\hat{f}$	$\dot{f}$	$[f-\dot{f}]$
0	14	—	—	—	14.0	—	14.0	0.0
1	15	14.0	1.0	6.5	20.5	14.0	20.5	–5.5
2	14	20.5	–6.5	–6.5	14.0	20.5	14.0	0.0
3	15	14.0	1.0	6.5	20.5	14.0	20.5	–5.5
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
14	29	20.5	8.5	6.5	27.0	20.5	27.0	2.0
15	37	27.0	10.0	6.5	33.5	27.0	33.5	3.5
16	47	33.5	13.5	6.5	40.0	33.5	40.0	7.0
17	62	40.0	22.0	6.5	46.5	40.0	46.5	15.5
18	75	46.5	28.5	6.5	53.0	46.5	53.0	22.0
19	77	53.0	24.0	6.5	59.6	53.0	59.6	17.5
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.

Image Compression

Predictive Coding: Lossy – Quantization

Uniform Quantization

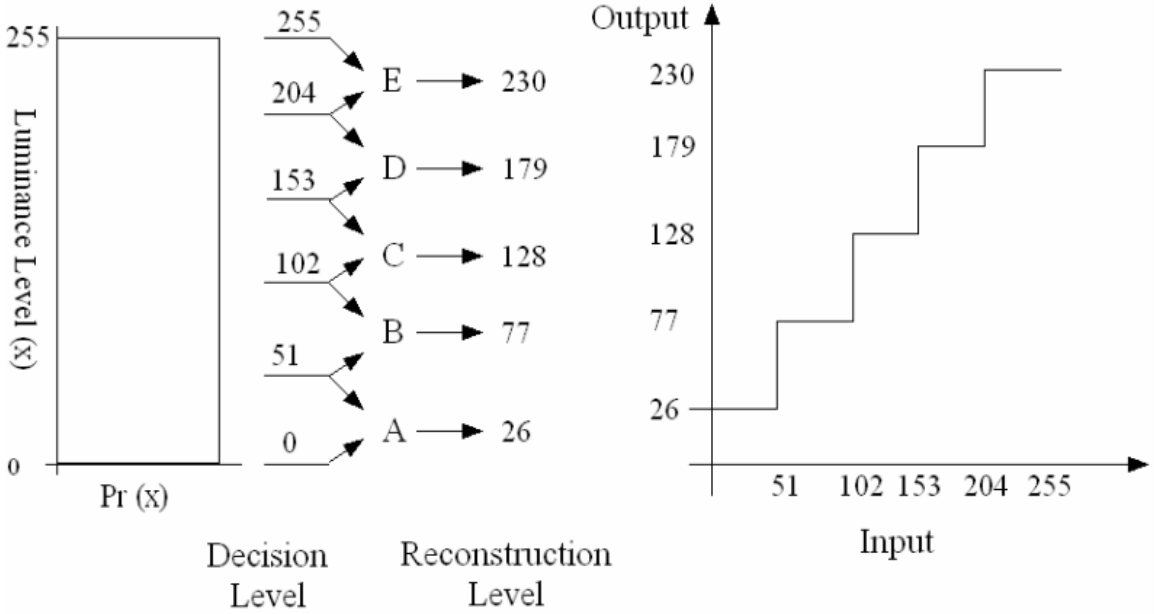


Image Compression

Predictive Coding: Lossy – Quantization

Uniform Quantization

Difference Image

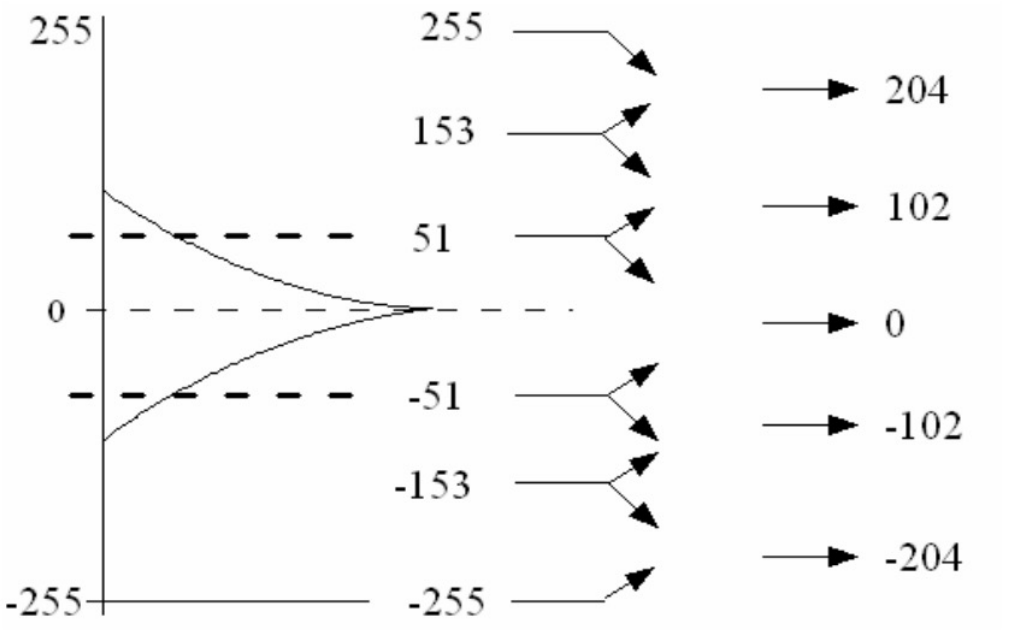


Image Compression

Predictive Coding: Lossy – Quantization

Non-Uniform Quantization

Difference Image

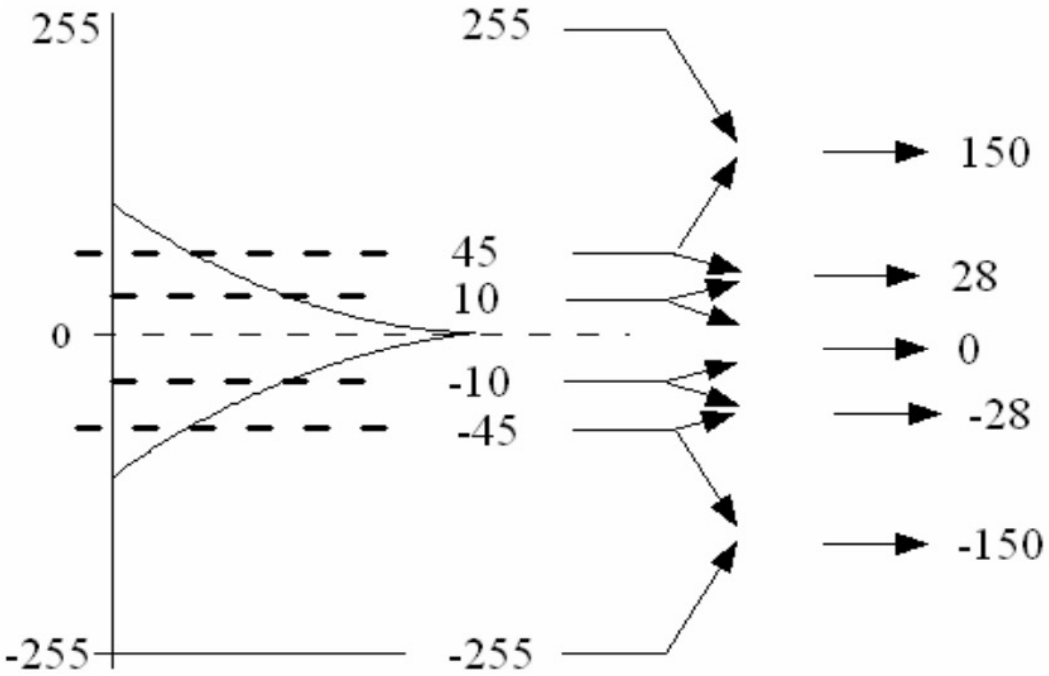


Image Compression

Predictive Coding: Lossy – Quantization

Non-Uniform Quantization