Multimedia
Lecture 10

Dr. Mona M.Soliman

Faculty of Computers and Artificial Intelligence

Cairo University

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Predictive Coding

Differential Pulse Code Modulation DPCM

- Encode the changes between consecutive samples
- The value of the differences between samples are much smaller than those of the original samples. Less bits are used to encode the data
- The difference is added to the previous sample to obtain the value of the current sample.
- In DPCM, the number of bits per sample needs to accommodate the largest value changes between samples, both in positive and negative direction.

Differential Pulse Code Modulation
DPCM

Example (Temperature)

Data: 30, 33, 34, 37, 40, 40, 40 , 38, 38, 37, 35, 34, 33 (6 bits)

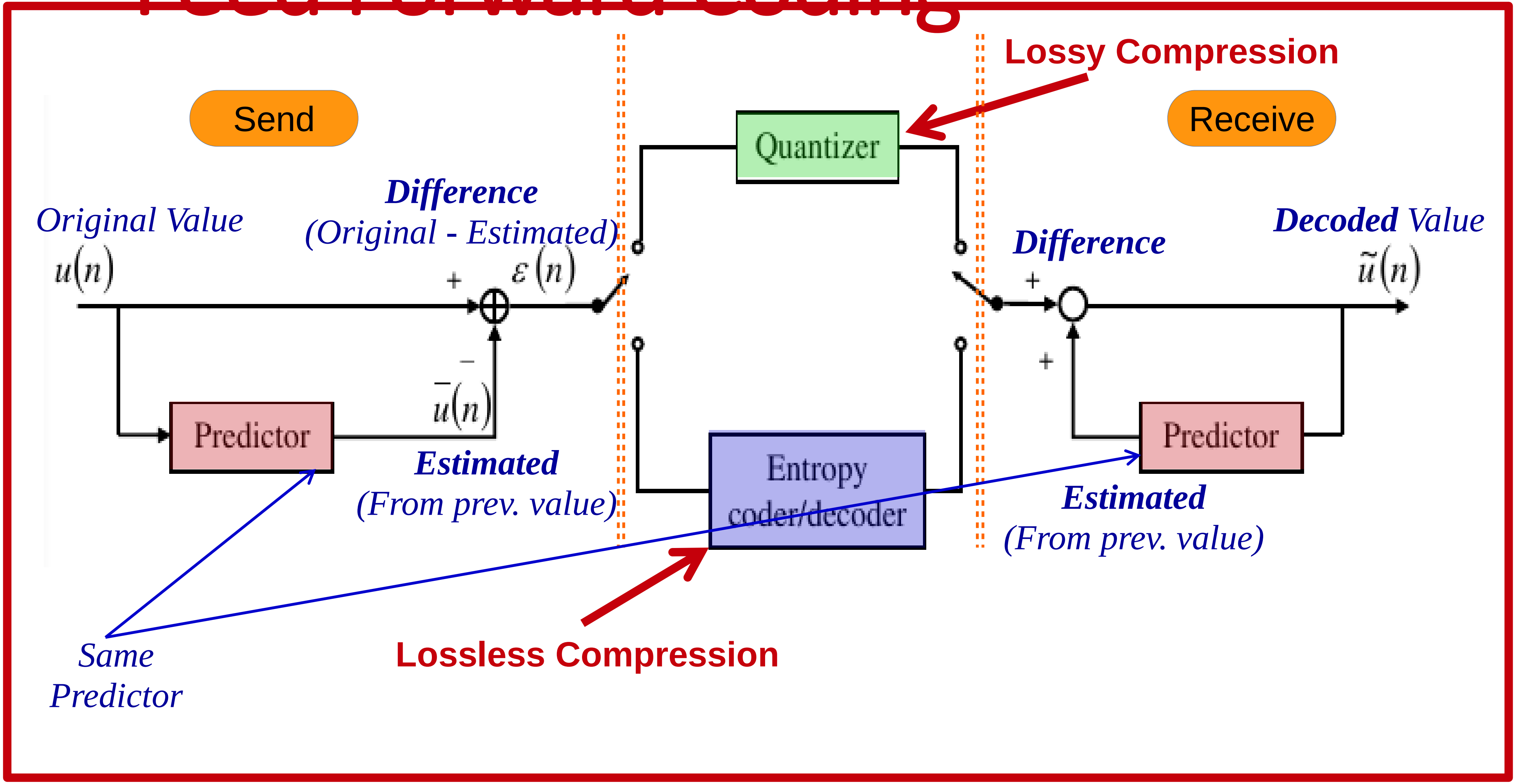
Difference 3, 1,3,3,0,0,-2,0,-1,-2,-1,-1 (3 bits including sign)

Example: (Increase in Brightness)

Data: 150, 155, 160, 167,170,173, 180, 190, 205, 210 (8 bits)

Difference 5, 5, 7,3,3,7,10,15,5 (4 Bits)

Feed Forward Coding



Samples of DPCM Compressed Images

DPCM Compression

1 Bits / Pixel (2 Levels Quantizer)

2 Bits / Pixel (4 Levels Quantizer)

3 Bits / Pixel (8 Levels Quantizer)

Feed Forward DPCM

Data	Difference	Quantization		De-quantization	Decoded	error^2
15					15	---
16	1	0		4	19	3^2
24	8	1		12	31	7^2
33	9	1		12	43	10^2
44	11	1		12	55	11^2
68	24	3		28	83	15^2

Uniform Quantizer
2 bits, Step=8

Code	Range	Q^{-1}
0	0 → 7	4
1	8 → 15	12
2	16 → 23	20
3	24 → 30	28

Compressed Date= 15,0,1, 1, 1, 3

MSE= 1/5 [9+49+100+121+225]=100.8

Feed Backward DPCM

Data	Difference	Quantization		De-quantization	Decoded	$error^2$
15					15	---
16	16-15=1	0		4	19	3^2
24	24 - 19 =5	0		4	23	1^2
33	33-23=10	1		12	35	2^2
44	44 - 35=9	1		12	47	3^2
68	68-47=21	2		20	67	1^2

Uniform Quantizer
2 bits, Step=8

Code	Range	Q^{-1}
0	0 → 7	4
1	8 → 15	12
2	16 → 23	20
3	24 → 30	28

Compressed Date= 15,0,0,1,1,2

MSE= 1/5 [9+1+4+9+1]=24/5=4.8

Linear Predictor (LP)

- In DPCM, the value of the current sample is guessed based on the previous sample.
- we can use the previous two samples to predict the current one.
- LP is more general than DPCM. It exploit the correlation between multiple consecutive samples

Linear Predictor (LP)

For the following sequence

3, 7, 11,15, ?   (what will be the next number ?) It is 19

? = 15 + (15-11) {it is the same as previous number + same difference between previous number and it predecessor)

In general

If there is a sequence U_{n-2} , U_{n-1} , U_n, U_{n+1} , ……

Then $\boldsymbol{U_{n+1} = U_n + (U_n - U_{n-1})}$

Linear Predictor

Data	Prediction	Diff	Q		Q^{-1}	Decoded	error^2
45						45	---
49						49	---
54	49 + (49-45) = 53	1	0		1	49 + (49-45) +1 = 54	0
59	54+ (54 – 49) = 59	0	0		1	54 + (54 – 49) +1=60	1
75	60 + (60 – 54)= 66	9	3		10	60+(60 – 54)+10= 76	1
94	76 + (76 - 60)=92	2	0		1	76+(76-60)+1=93	1
112	93 + (93 -76)=110	2	0		1	93 +(93-76)+1=111	1

Compressed Date= 45, 49, 0, 0, 3, 0, 0

MSE= 1/5 [1+1+1+1] = 4/5

2 bits Uniform Quantizer

Code	Range	Q^{-1}
0	0 → 2	1
1	3 → 5	4
2	6 → 8	7
3	9 → 11	10

2-D Predictive Coding

2-D Predictors

B	C	D
A	?	

Adaptive 2-D Predictor

$$? = \begin{cases} \text{Max (A,C)} & \text{if b<=Min(A,C)} \\ \text{Min (A,C)} & \text{if B >= Max(A,C)} \\ \text{A+C-B} & \text{otherwise} \end{cases}$$

[1] ? = (A+C) / 2

[2] ? = (A+ C - B)

[3] ? = 0.75 A+ 0.75 C – 0.5 B)

2-D Predictive Coding

Original Image			
5	7	8	10
6	6	9	11
7	8	11	13
9	10	11	14

Predicted			
---	---	---	---
---	7	7	10
---	7	9	12
---	9	11	13

Difference			
---	---	---	---
---	-1	2	-1
---	1	2	1
---	1	0	1

Qunatized Difference			
---	----	---	----
---	1	2	1
---	2	2	2
---	2	1	2

De-Quantized Diff			
---	----	---	---
---	-1	2	-1
---	2	2	2
---	2	-1	2

Decoded Image			
5	7	8	10
6	6	9	11
7	9	11	14
9	11	10	15

Error $^{-2}$			
--	--	---	---
--	0	0	0
--	1	0	1
--	1	1	1

Quantizer		
0	$-5 \rightarrow -3$	-4
1	$-2 \rightarrow 0$	-1
2	$1 \rightarrow 3$	2
3	$4 \rightarrow 6$	5