

.....

18-796



Multimedia Communications:
Coding, Systems, and Networking

Prof. Tsuhan Chen
tsuhan@ece.cmu.edu

.....

H.261



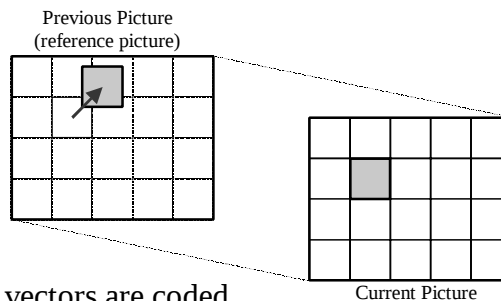
H.261

- ITU-T Study Group 15, 1984-1990
- Videophone and video conferencing
 - Low bit rates and low delay
 - Originally for $m \times 384$ kbits/s ($m=1\dots5$), changed to $p \times 64$ kbits/s ($p = 1\dots30$) in 1988. Also called “**p×64**”
 - 40 kbits/s to 2 Mbits/s
- A “hybrid” coding algorithm
 - Block-based motion-compensated DCT coding
 - Basic framework of most video coding standards

18-796/Spring 1999/Chen

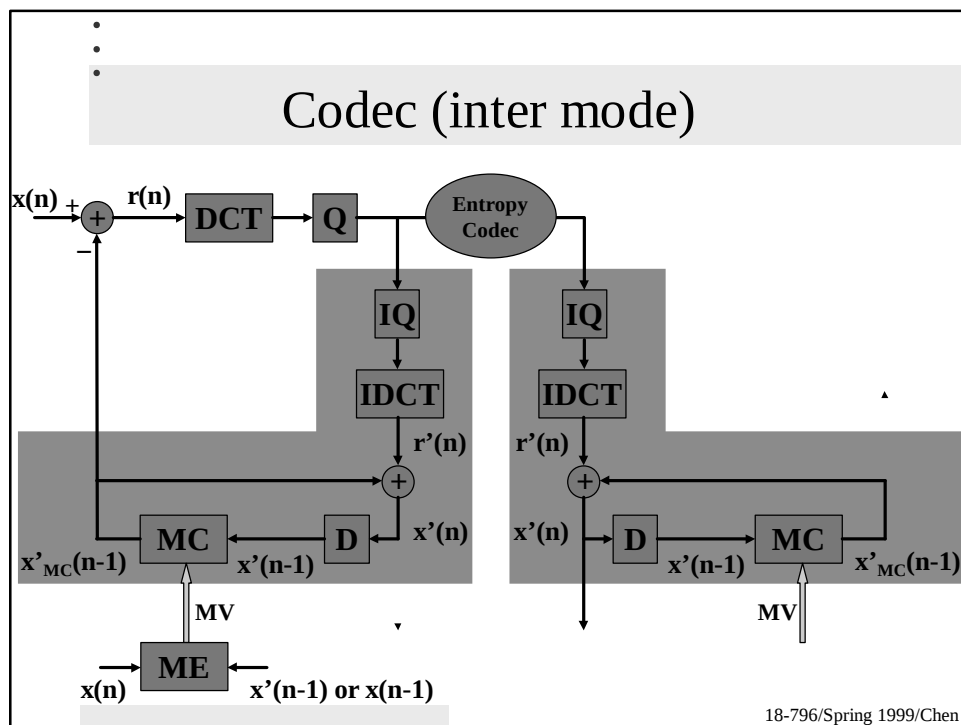
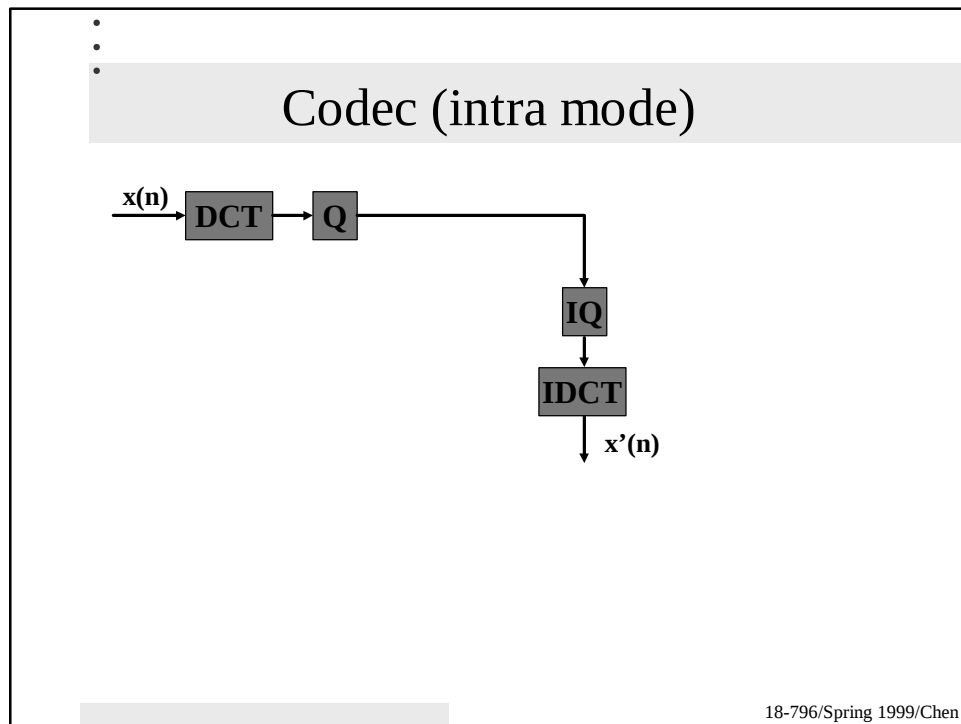
Inter and Intra

- Intra coding: 8×8 DCT (similar to JPEG)
- Inter coding:
 - Block matching for motion estimation (16×16)

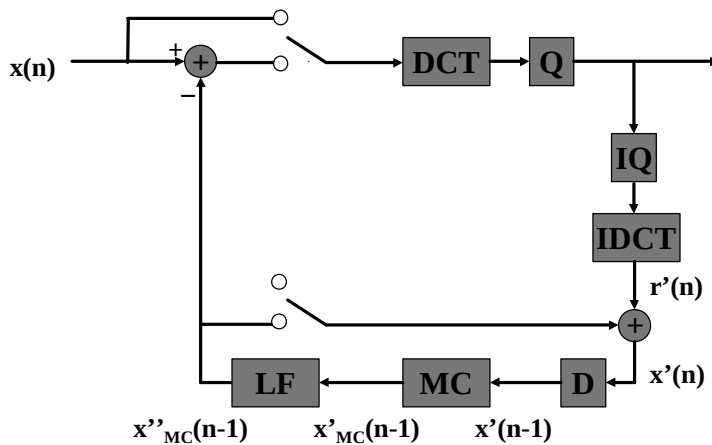


- Motion vectors are coded
- Residue is DCT coded (as in Intra)

18-796/Spring 1999/Chen



Inter/Intra Switching and Loop Filter

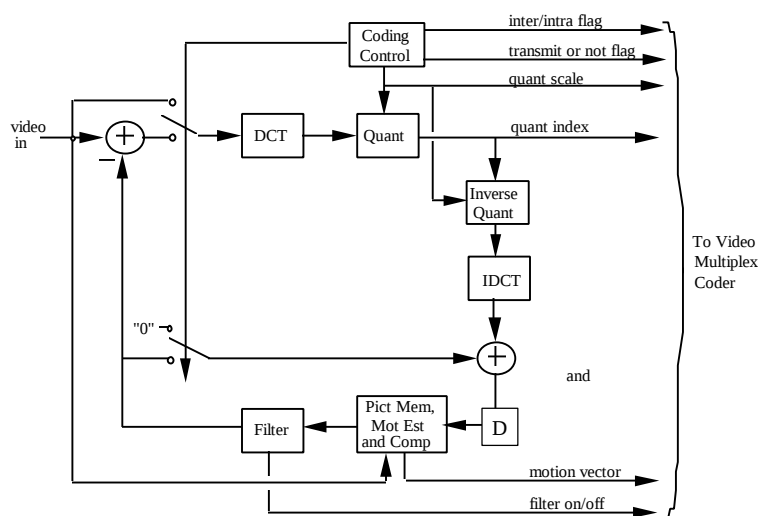


Loop Filter (LF): Low pass filter with $[1/4, 1/2, 1/4]$

Q: Switching at decoder?

18-796/Spring 1999/Chen

Information to be Sent



18-796/Spring 1999/Chen

Picture Formats

- Only two picture formats are allowed
 - CIF (Common Intermediate Format) (~CGA)
 - QCIF (Quarter-CIF)

	Pels/line	Lines	Uncompressed Bit Rate
QCIF	176	144	9.12 Mbits/s
CIF	352	288	36.5 Mbits/s

- Color components
 - YUV (or $Y C_B C_R$) by ITU-R 601 (CCIR 601)

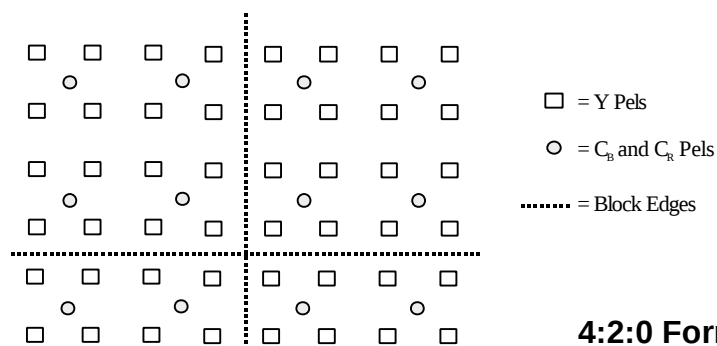
$$\begin{matrix} 16 \cdots 235 \rightarrow [Y] \\ 16 \cdots 240 \rightarrow [C_B] \\ 16 \cdots 240 \rightarrow [C_R] \end{matrix} = \begin{bmatrix} 0.257 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix}$$

Q: $Y C_B C_R$ to RGB?

18-796/Spring 1999/Chen

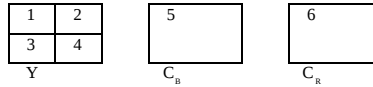
Positions of Samples

- Luminance (Y) and chrominance (C_B , C_R)



18-796/Spring 1999/Chen

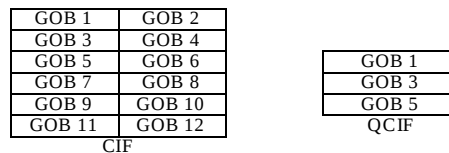
Blocks, Macroblocks and Groups of Blocks



A macroblock

1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	20	21	22
23	24	25	26	27	28	29	30	31	32	33

A group of blocks (GOB)

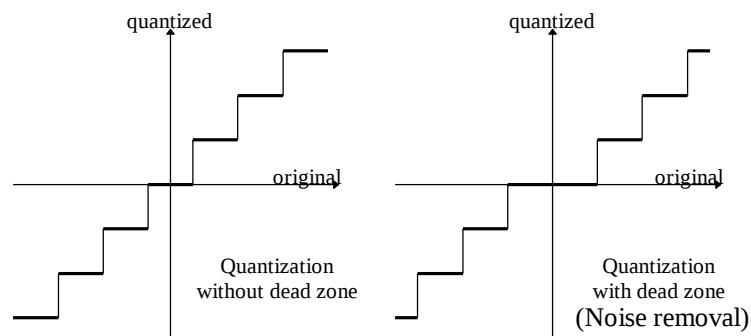


GOB structures in a picture

18-796/Spring 1999/Chen

Quantization

- No quantization tables (cf. JPEG)
- Intra DC: Uniform quantization with step size 8
- All others: Uniform quantization with dead-zone



18-796/Spring 1999/Chen

Quantization (cont.)

- Step size may change at every MB or GOB
 - Step size = $\text{QUANT} \times 2$; $\text{QUANT}=1\dots31$
- Threshold can be used at the encoder
 - Adaptive threshold (e.g., RM8) to increase the run of zeros, e.g.,

Coefficients	50	0	0	0	33	34	0	40	33	34	10	32	...
Threshold	32	32	33	34	35	36	37	38	32	32	32	33	...
New coeff.	50	0	0	0	0	0	0	40	33	34	0	0	...

18-796/Spring 1999/Chen

Zigzag Scan and Entropy Coding

- Zigzag scan: Same as in JPEG
- Entropy coding
 - DC: Differential coding, same as in JPEG
 - AC: Run-level coding

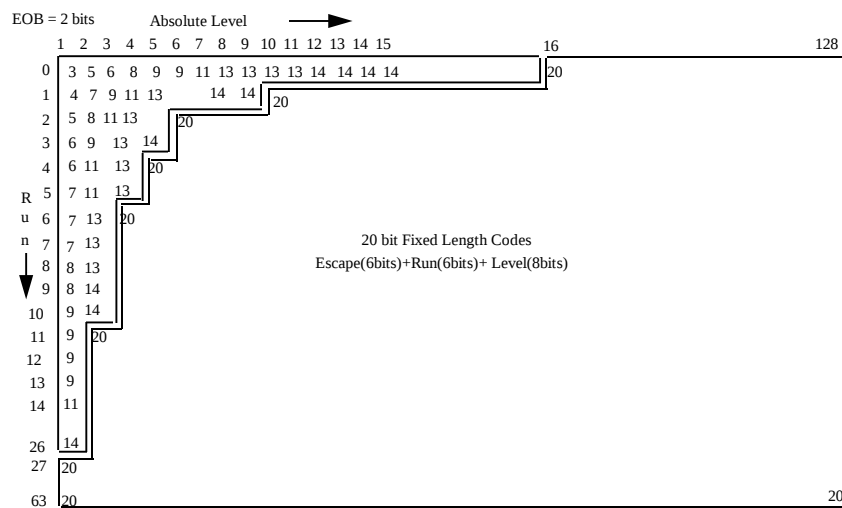
18-796/Spring 1999/Chen

AC Coding

- **Run-level symbols**
 - **run**: Length of the zero run
 - **level**: Amplitude of the nonzero coefficient
- **Huffman coding**
 - Short codes for frequent symbols
 - 2D table of variable length codes (VLC)

18-796/Spring 1999/Chen

Length of VLC



18-796/Spring 1999/Chen

An Example...

Run	Level	Code
EOB		10
0	1	1s If first coefficient in block
0	1	11s Not first coefficient in block
0	2	0100 s
0	3	0010 1s
0	4	0000 110s
0	5	0010 0110 s
0	6	0010 0001 s
0	7	0000 0010 10s
0	8	0000 0001 1101 s
0	9	0000 0001 1000 s
0	10	0000 0001 0011 s
0	11	0000 0001 0000 s
0	12	0000 0000 1101 0s
0	13	0000 0000 1100 1s
0	14	0000 0000 1100 0s
0	15	0000 0000 1011 1s
1	1	011s
1	2	0001 10s
1	3	0010 0101 s
1	4	0000 0011 00s
1	5	0000 0001 1011 s
1	6	0000 0000 1011 0s
1	7	0000 0000 1010 1s
2	1	0101 s
2	2	0000 100s
2	3	0000 0010 11s
2	4	0000 0001 0100 s
2	5	0000 0000 1010 0s
3	1	0011 1s
...	...	...

0 0 0 -1 6 0 3 EOB



001111 001000010 001001010 10

18-796/Spring 1999/Chen

Coding of Motion Vectors

- MVs have integer values in [-15,15]
- Differential coding in each direction
 - VLC for MV difference

MVD	Code
...	...
-7 & 25	0000 0111
-6 & 26	0000 1001
-5 & 27	0000 1011
-4 & 28	0000 111
-3 & 29	0001 1
-2 & 30	0011
-1	011
0	1
1	010
2 & -30	0010
3 & -29	0001 0
4 & -28	0000 110
5 & -27	0000 1010
6 & -26	0000 1000
7 & -25	0000 0110
...	...

Example:

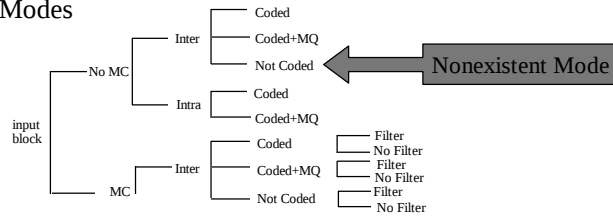
15 14 -13 12 ...
-1 -27 25 ...

011 00001010 00000111...

18-796/Spring 1999/Chen

Microblock Type (MTYPE)

• MTYPE Modes

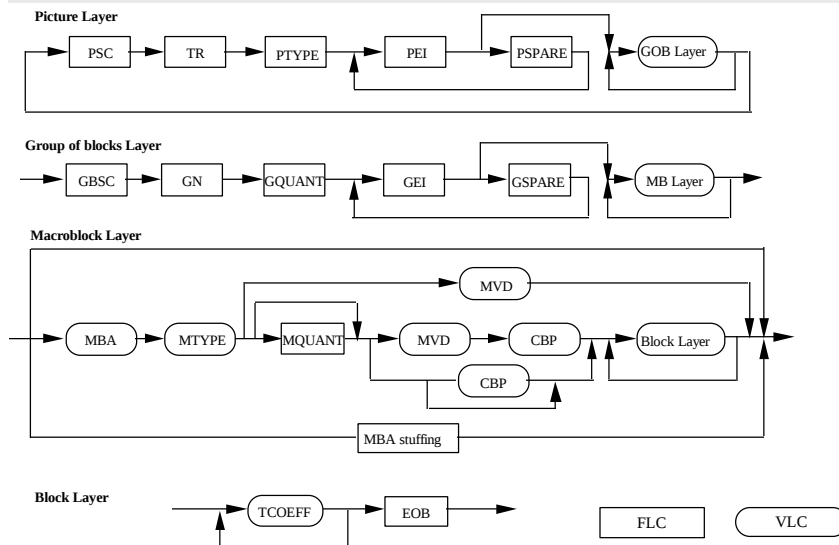


• VLC Table for MTYPE Modes

Prediction	MQANT	MVD	CBP	TCOEFF	VLC
Intra				y	0001
Intra	y			y	0000.001
Inter			y	y	1
Inter	y		y	y	0000.1
Inter + MC		y			0000.0000.1
Inter + MC		y	y	y	0000.0001
Inter + MC	y	y	y	y	0000.0000.01
Inter + MC +FIL		y			001
Inter + MC +FIL		y	y	y	01
Inter + MC +FIL	y	y	y	y	0000.01

18-796/Spring 1999/Chen

Syntax Diagram



18-796/Spring 1999/Chen

Syntax Diagram (cont.)

- Picture layer
 - PSC (20 bits): Picture Start Code
 - TR (5 bits): Temporal Reference
 - PTYPE (6 bits): CIF or QCIF, etc.
 - If PEI = 1, PSPARE: spare bits for future
- GOB layer
 - GBSC (16 bits): GOB Start Code
 - GN (4 bits): Group Number
 - GQUANT: Group quantizer, 1...31
 - If GEI = 1, GSPARE: spare bits
- MB layer
 - MBA: MB Address
 - MQAUNT: MB quantizer, 1...31
 - MVD: MV Data
 - CBP: Coded Block Pattern

18-796/Spring 1999/Chen

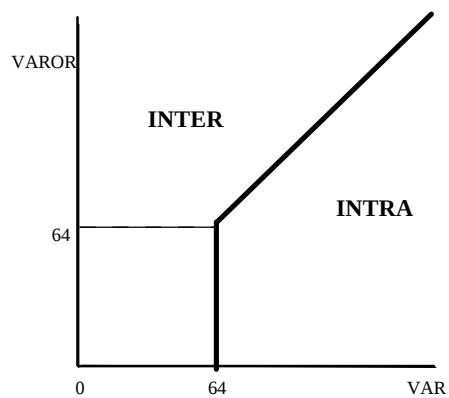
Reference Model (RM) 8

- Encoder specification
 - Motion estimation: 3-step search
 - Quantization
 - Inter/intra decision
 - MC/No MC decision
 - Buffer and rate control
 - Loop filter on/off

18-796/Spring 1999/Chen

-
-
-

Inter/Intra Decision



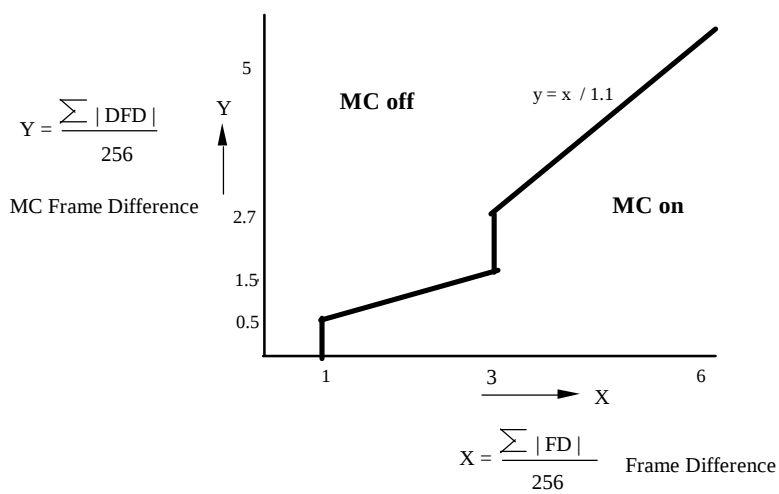
$$\text{VAR} = (\sum (\text{pel} - \text{mc_pel})^2) / 256$$

$$\text{VAROR} = (\sum (\text{pel} - \text{blk_avg})^2) / 256$$

18-796/Spring 1999/Chen

-
-
-

MC/No MC Decision



18-796/Spring 1999/Chen

-
-
-

Buffer Control

- Quantization step size varies from 2 to 62 with step 2
- Buffer size of $q \cdot 64$ kbits, q determines video bitrate
- Bitrate = $q \cdot 64$ kbits/s, frame rate = $30/k$ Hz ($k=1 \dots 4$)
- Mean bits/MB for CIF is $5 \cdot k \cdot q$ and for QCIF is $20 \cdot k \cdot q$
- $\text{step} = 2 \cdot \text{INT}(\text{buffer fullness} / [200 \cdot q]) + 2$

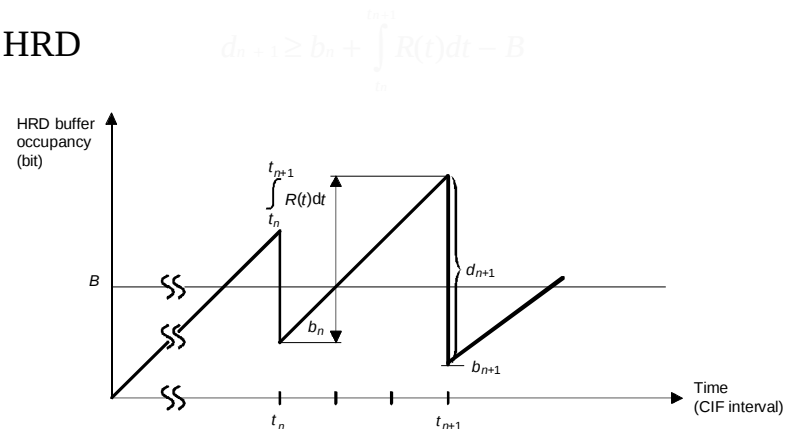
Buffer Fullness	Quantizer Step size
$< 200 \cdot q$	2
$< 400 \cdot q$	4
$< 600 \cdot q$	6
$< 800 \cdot q$	8
$< 6000 \cdot q$	60
$< 6200 \cdot q$	62

18-796/Spring 1999/Chen

-
-
-

Hypothetical Reference Decoder

- HRD



NOTE – Time $(t_{n+1} - t_n)$ is an integer number of CIF picture periods (1/29.97, 2/29.97, 3/29.97, ...).

18-796/Spring 1999/Chen

H.261 Quality vs. Bit Rates

	CIF	QCIF
20 kbits/sec	so so	poor
64 kbits/sec	fair	fair+
112 kbits/sec	good	good+
320 kbits/sec	good	excellent

18-796/Spring 1999/Chen

Multipoint Considerations

- Freeze picture request
 - causes decoder to freeze picture until release request or time-out
- Fast update request
 - causes encoder to encode next picture in INTRA mode
- Freeze release request
 - causes decoder to exit freeze picture mode and go in normal mode
- Used by Multipoint Control Unit (MCU)
 - Example...

18-796/Spring 1999/Chen

•
•
•

References

- Ming Liou, “Overview of the p×64 kbit/s video coding standard,” Comm. of the ACM, April 1991
- Arun N. Netravali, and Barry G. Haskell, Chapter 8, *Digital Pictures: Representation, Compression, and Standards*, 2nd Edition, Plenum Publishing Corp., New York, NY
- Joan L. Mitchell et al., Sec. 19.2, *MPEG Video: Compression Standard*, Chapman & Hall, New York, NY