

Video Coding (Part-2)

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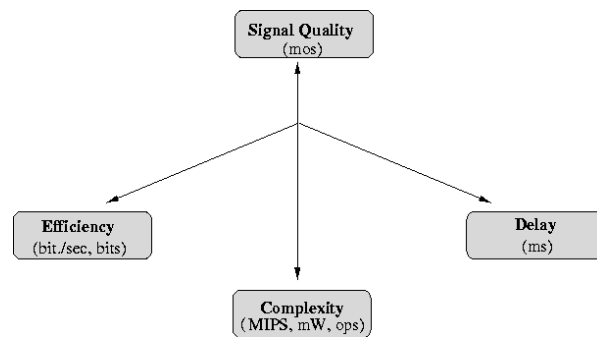


Last Time

- Motion estimation
 - Improve block-matching
 - Pixel-based motion estimation using O.F.E.
- Hybrid video coding
 - Transform coding plus motion estimation/compensation
- MPEG-1 standard
- Today
 - Standards evolved from or similar to MPEG-1
 - ♦ MPEG-2, H.26x
 - Intro. to model and object-based video coding
 - ♦ MPEG-4



Performance Tradeoff of Video Coding



From R.Liu's Handbook Fig.1.2:

"mos" – 5-pt mean opinion scale of bad, poor, fair, good, excellent



Structure of Block-based Hybrid Video Coding

- Sequence: entire video sequence
- Group of Pictures: basic unit allowing for random access
- Picture: primary coding unit with three color components and different picture formats progressive or interlaced scanning modes
- Slice or Group of Blocks: basic unit for resynchronization refresh and error recovery
- Macroblock: motion compensation unit
- Block: transform and compression unit

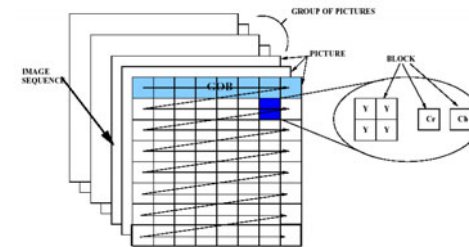


Figure 2.3: Sequence of pictures and picture formats.

(From Liu's Handbook Fig.2.3)

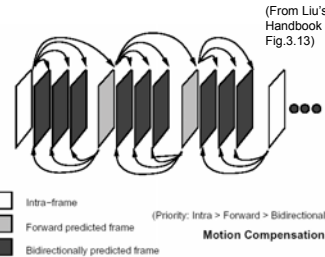


MPEG-1 Video Coding Standard

- Standard only specifies decoders' capabilities
 - Leave flexibility and competition in implementing encoder
- Block-based hybrid coding (DCT + M.C.)
 - 8x8 block size as basic coding unit
 - 16x16 “macroblock” size for motion estimation/compensation
- 3-Type frame structures: I/P/B
- Group-of-Pictures (GOP)

– Frame order
 $I_1 BBB P_1 BBB P_2 BBB I_2 \dots$

– Coding order
 $I_1 P_1 BBB P_2 BBB I_2 BBB \dots$



Quantization for I-frame (I-block) & M.C. Residues

- Quantizer for I-frame (I-block)
 - Different step size for different freq. band (similar to JPEG)
 - Scale the table for different compression-quality
- Quantizer for residues in predictive block
 - Noise-like residue ~ similar variance in each freq. band
 - Assign same quantization step size for each freq. Band

8	16	19	22	26	27	29	34
16	16	22	24	27	29	34	37
19	22	26	27	29	34	34	38
22	22	26	27	29	34	37	40
22	26	27	29	32	35	40	48
26	27	29	32	35	40	48	58
26	27	29	34	38	46	56	69
27	29	35	38	46	56	69	83

(a) quantization table for intra coding.

16	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16

(b) quantization table for non-intra coding.



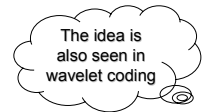
Adjusting Quantizer

- For smoothing out bit rate
 - Some applications prefer approx. constant bit rate video stream (CBR)
 - ♦ e.g., prescribe # bits per second
 - ♦ very-short-term bit-rate variations can be smoothed by a buffer
 - ♦ variations can't be too large on longer term ~ o.w. buffer overflow
 - Need to assign large step size for complex and high-motion frames
- For reducing bit rate by exploiting HVS temporal properties
 - Noise/distortion in a video frame would not be very much visible when there is a sharp temporal transition (scene change)
 - ♦ can compress a few frames right after scene change with less bits
- Alternative bit-rate adjustment tool ~ frame type
 - I I I I I ... lowest compression ratio (like motion-JPEG)
 - I P P ... P I P P ... moderate compression ratio
 - I B B P B B P B B I ... highest compression ratio

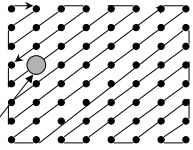
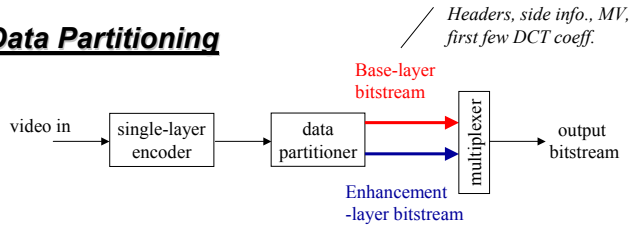


Scalability in Video Codecs

- Possible ways for achieving scalabilities
 - SNR Scalability ~ Multiple-quality video services
 - ♦ Basic vs. premium quality
 - Spatial Scalability ~ Multiple-dimension displays
 - ♦ Display on PDA vs. PC vs. Super-resolution display
 - Temporal Scalability ~ Multiple frame rates
 - Frequency Scalability ~ Blurred to sharp (also known as data partitioning)
- Data partitioning
 - Critical bitstreams for better channel and less critical data for poorer channel when two channels are available
 - Or allow the use of unequal error protection (UEP)
- Layered coding facilitates:
 - Unequal error protection
 - Customer satisfaction
 - Efficient use of resources
 - Multiple services



Data Partitioning

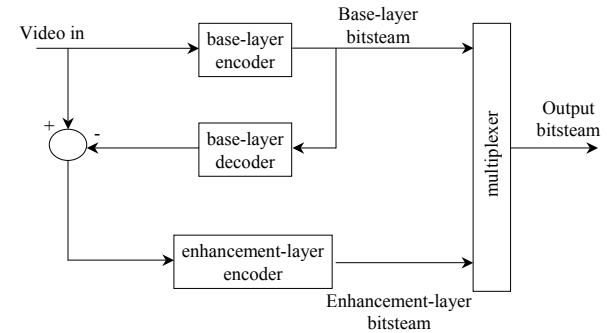


- A simple approach:
- No extra complexity over non-scalable coder
 - Suffers from picture drift
=> M.C. reference changes when enhancement part gets lost
 - Useful in low-loss networks
- Need M.C. to match the partition of ref. frame to avoid drift ~ complexity ↑



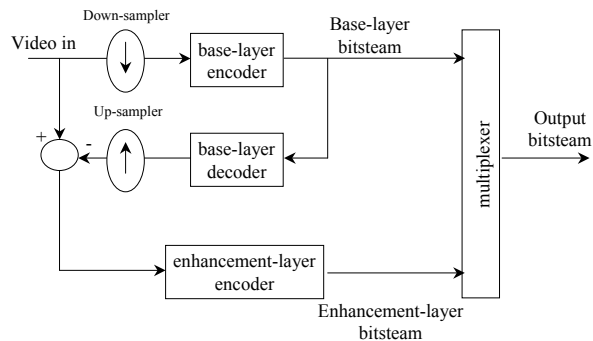
SNR Scalability

- Two layers with same spatio-temporal resolution but different qualities



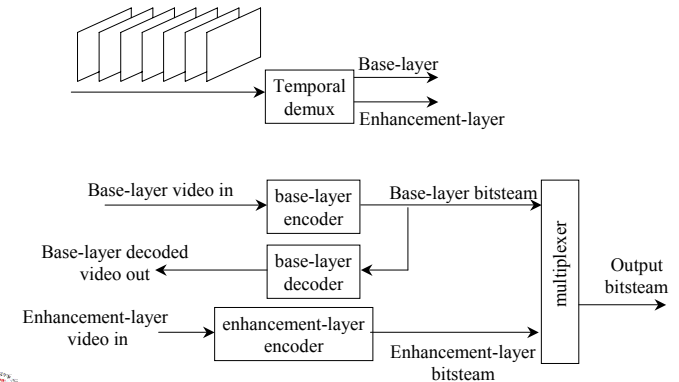
Spatial Scalability

- Two layers with different spatial resolution



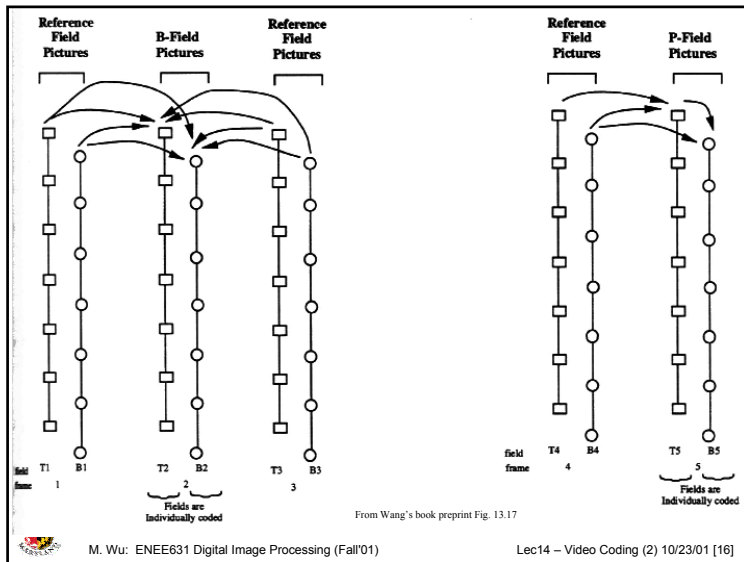
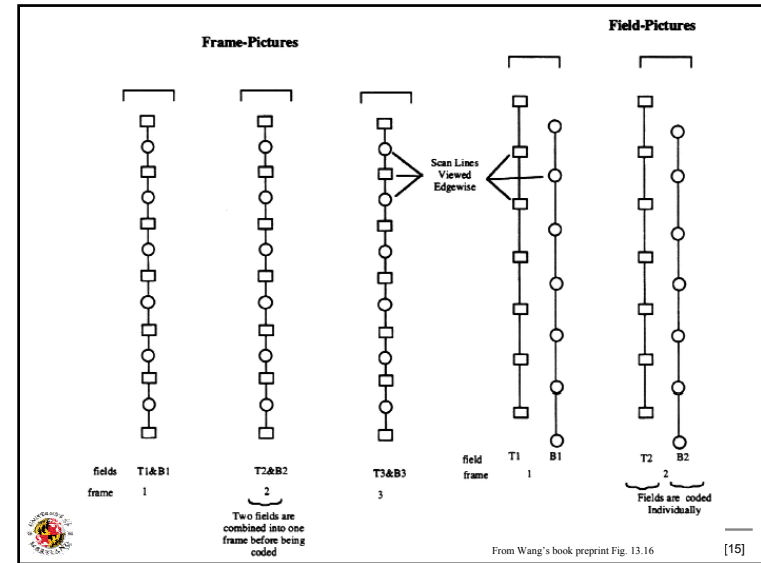
Temporal Scalability

- Enhancement layer carries additional frames at same spatial resolution



MPEG-2

- Extend from MPEG-1
- Target at high-resolution high-bit-rate applications
 - Digital video broadcasting, HDTV, ...
 - Also used for DVD
- Support scalability
- Support interlaced video
 - Frame pictures vs. Field pictures
 - New prediction modes for motion compensation related to interlaced video
 - ◆ Use previously encoded fields to do M.E.-M.C.

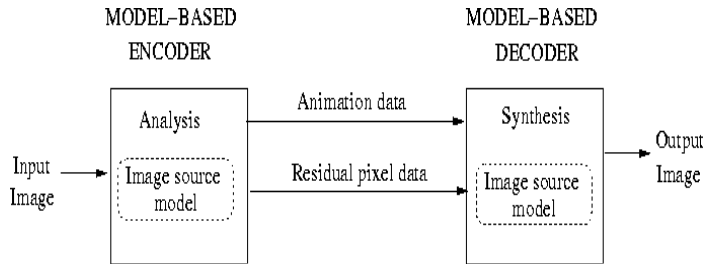


H.26x for Video Telephony

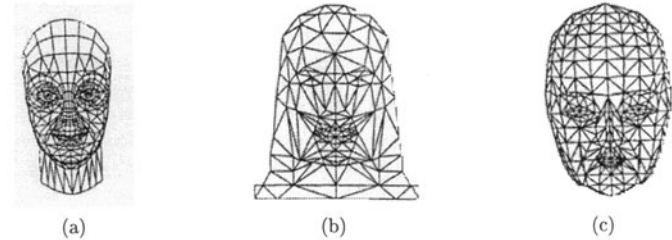
- Remote face-to-face communication: A dream for years
- H.26x – Video coding targeted low bit rate
 - Through ISDN or regular analog telephone line ~ on the order of 64kbps
 - Need roughly symmetric complexity on encoder and decoder
- H.261 (early 1990s)
 - Similar to simplified MPEG-1 ~ block-based DCT/MC hybrid coder
 - Integer-pel motion compensation with I/P frame only ~ no B frames
 - Restricted picture size/fps format and M.V. range
- H.263 (mid 1990s) and H.263+/H.263++ (late 1990s)
 - Support half-pel motion compensation
 - Many options for improved performance



Model-Based Video Coding



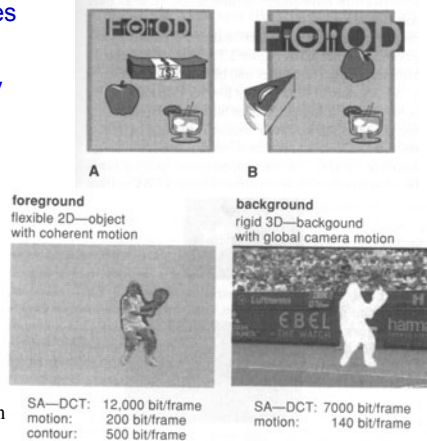
Some Coding Models



Object-based Coding in MPEG-4

Revised from R.Liu Seminar Course @ UMCP

- Interactive functionalities
- Higher compression efficiency by separately handling
 - Moving objects
 - Unchanged background
 - New regions
 - M.C.-failure regions
- Object segmentation needed
 - Based on color, motion, edge, texture, etc.
 - Popular statistical approach



Object-based Coding in MPEG-4 (cont'd)

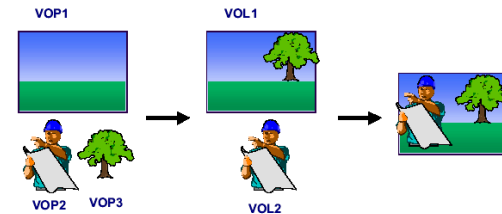


Figure 13.30. Object-based coding requires the decoder to compose different VideoObjectPlanes (VOP) into a scene. VideoObjectLayers (VOL) enable content-based scalability.



Summary

- More details on MPEG-1
- Scalable coding
- Standards evolved from or similar to MPEG-1
 - MPEG-2, H.26x
- Brief intro. on model-based coding
 - Object-based video coding & MPEG-4
- Additional MPEG-4 activities
 - Error resilience → Next semester
 - Intellectual property management/protection → Next semester
- What is after MPEG-4?
 - MPEG-7 for facilitating image/video search and indexing → Next time



Assignment

- Readings
 - Wang's book Chapt.13, Sec.11.1, Sec.10.5
 - [Electronic Handout] R.Liu's Handbook Chapt.1-3
- Proj. Building-Block 2 ~ Image Coding
 - Due on Monday 10/29/2001 noon 12pm ... no more extension
- Project Building-Block 3 ~ Motion estimation & compensation
 - To be assigned on Thursday
 - Team work ... submit team info. in Thursday class
- 1st Exam & comments will be handed back on Thursday



Grading

- Homework/Labs 18%
 - 2 Regular Hw/Lab [8% + 10%]
- Project 48%
 - 3 Building blocks [8% + 12% + 8%] ~ 28% total
 - Proposal ~ 2%
 - Presentation + Peer review ~ 6%
 - Implementation ~ 6%
 - Report and overall ~ 6%
- Two in-class exams 30%
 - 2 Exams [15% + 15%]
- Class participation 4%

