CS 414 – Multimedia Systems Design

Lecture 14 – H.264, H.265

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Spring 2014

Administrative

- MP1 – Demonstrations on February 21, Friday
  - Sign up for time slot at Piazza
- Homework 1
  - posted February 24 (Monday)
  - deadline March 1 (Monday)

Outline

- H.26x
- Reading:
  - Media Coding book, Section 7.7.2 – 7.7.5
  - http://en.wikipedia.org/wiki/H.264

H.261 – Video Coding for Video Conferencing

- H.261 – CCITT Recommendation of ITU-T Standard
  - Developed for interactive conferencing applications
  - Symmetric coder - real-time encoding and decoding
  - Rates of p x 64 Kbps for ISDN networks
  - **Only I and P frames**

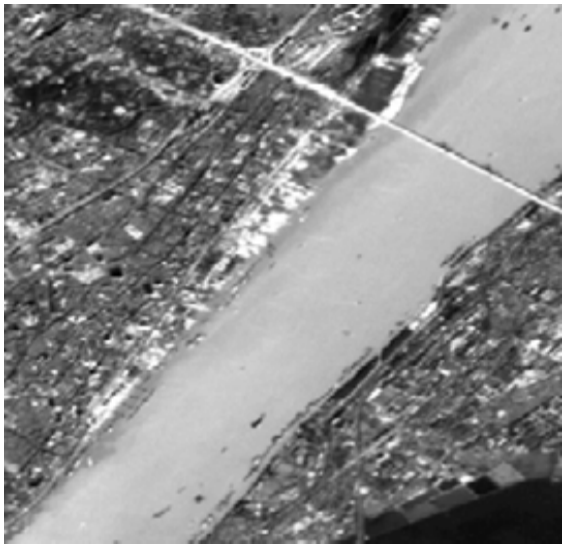
H.261 Design

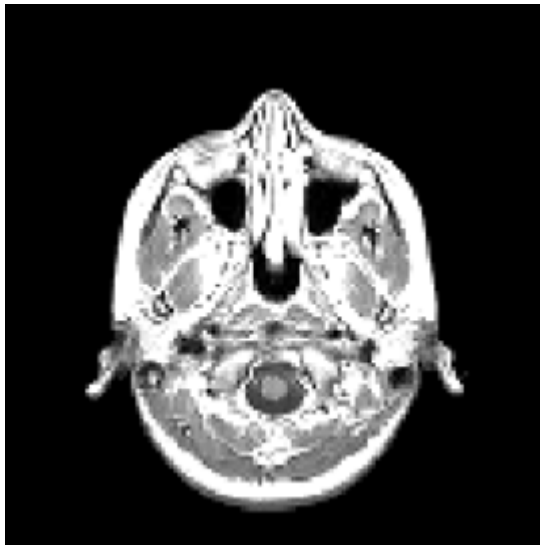
- ITU-T Video Coding Experts Group (VCEG) Standard – 1988
  - Bit rates between 40 kbps-2 Mbps
  - Video frame sizes
    - CIF (352x288 luma, 176x144 chroma)
    - QCIF (176x144 luma, 88x72 croma) using 4:2:0 sampling scheme

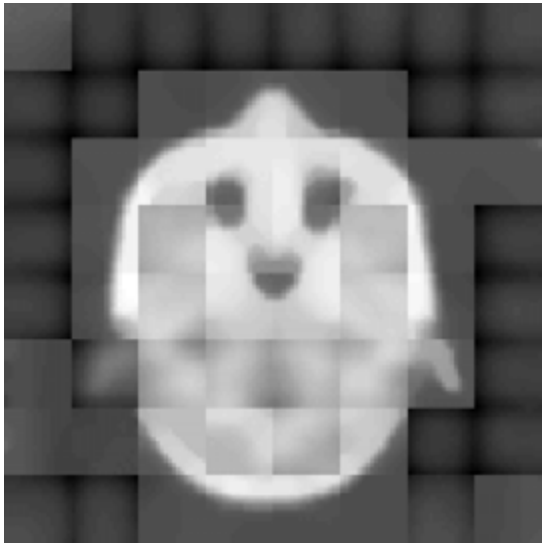
H.261 Design

- Basic processing unit – macroblock
- Macroblock consists of
  - **16x16 luma samples**
  - two corresponding **8x8 chroma** samples,
  - 4:2:0 sampling and **YCbCr color space**
- **DCT transform coding** is used to reduce spatial redundancy
- **Scalar quantization** and Zig-zag scanning
- **Entropy coding** with RLE

Blocking Problem in Compressed Images







How Blocking Effect Happens

- At low bit rates, the quantization step size is large
- Larger step sizes can force many DCT coefficients to zero
- If only DC and few AC coefficients remain, reconstructed picture **appears blocky**

H.261 Design

- Uses post-processing technique called
  - Deblocking filtering (loop filter)
  - Key element of H.261 (started here)
- **Deblocking filtering**
  - Reduces appearance of block-shaped artifacts caused by block-based motion compensation and spatial transform parts of design

Deblocking Filter

- Applied for **low bit rate video** 64kbps and 128 kbps
- Blockiness degradations appear as staircase noise
  - Mosquito noise
- Artifacts are reduced by using deblocking filter
  - low pass filter removing high frequency and block boundary distortions

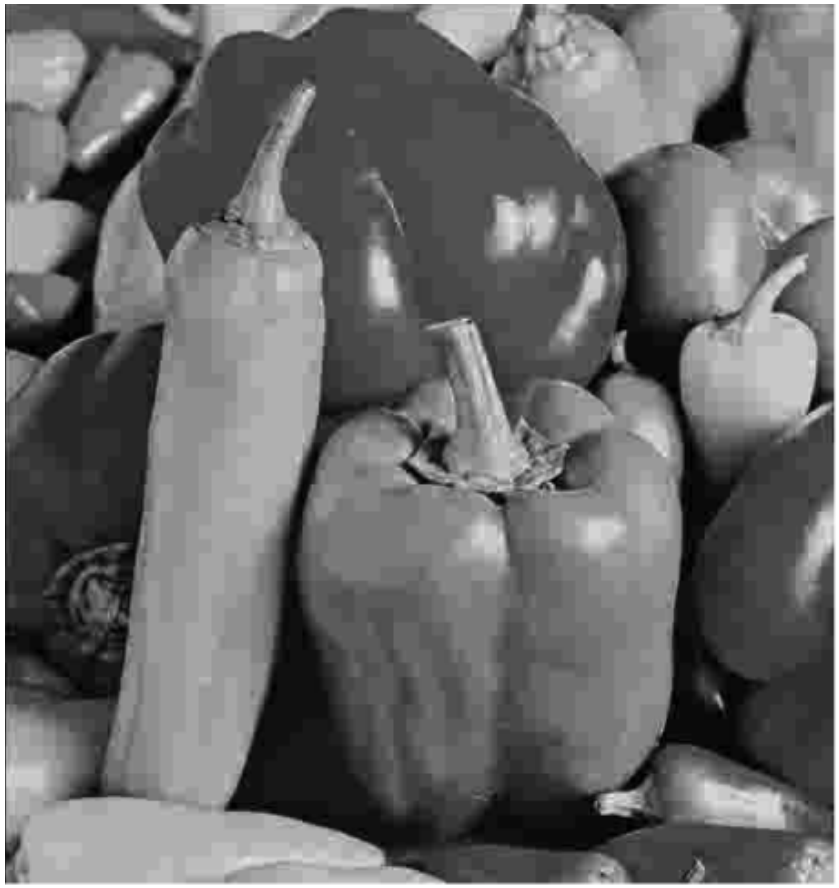
Deblocking Filter

Without filter

With filter

http://live.ece.utexas.edu/publications/2011/cy_tip_jan11.pdf

Deblocking filter



Without filter

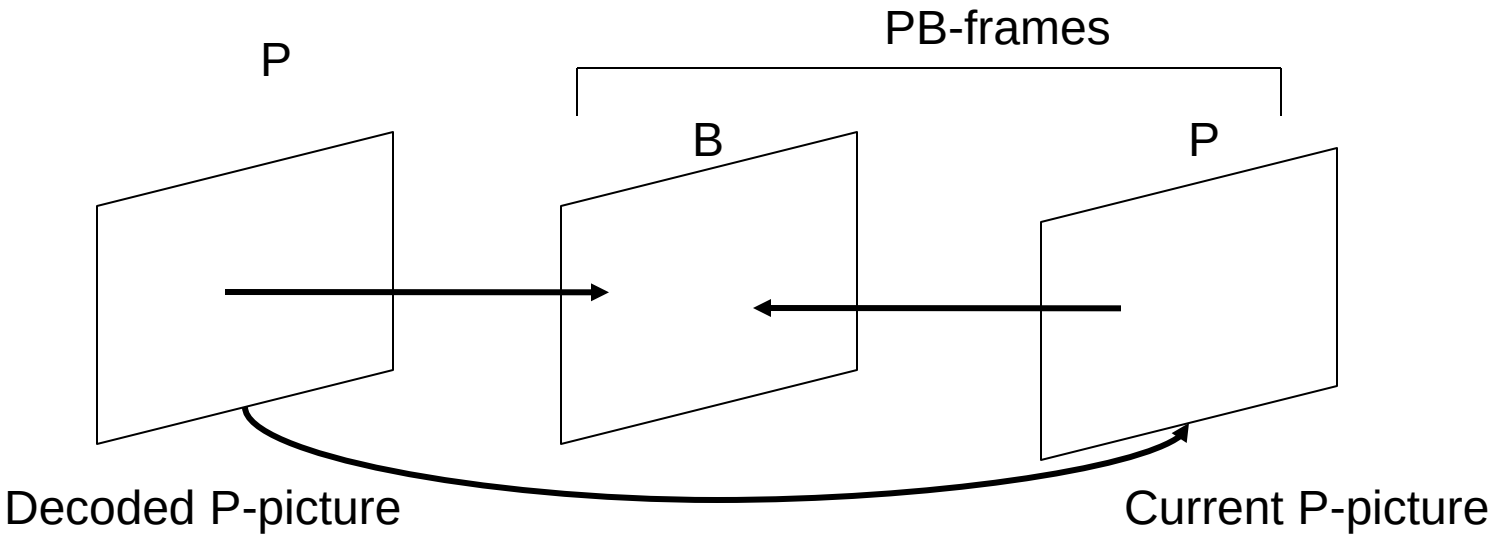
With filter

H.263 – video coding for low bit rate communications

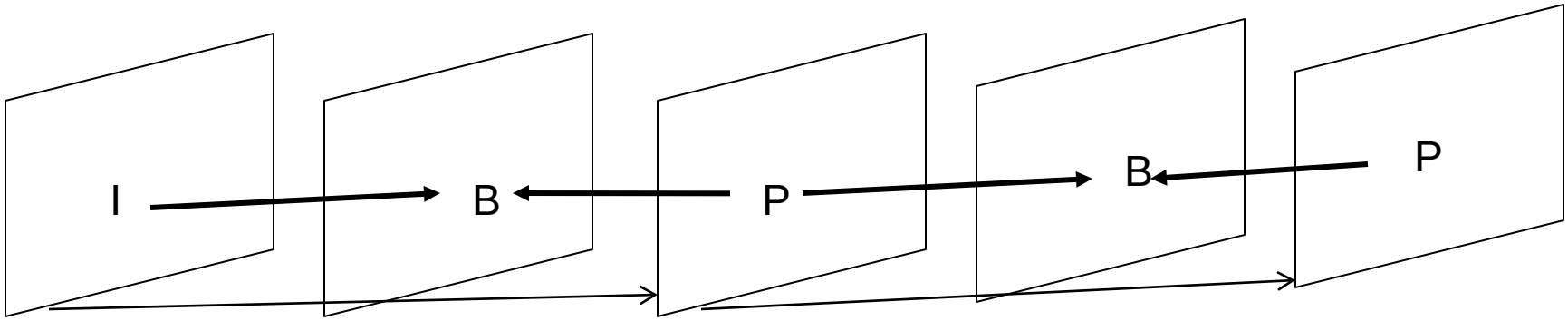
- H.263 – established 1996
  - Used for **low bit rate transmission**
  - Improvements of error correction and performance
  - Takes in PB-frames mode
  - Temporal, Spatial and SNR scalability

H.263 – PB-Frames Mode

- A PB-frames consist of two pictures encoded as one unit.
- PB-frame consists of
  - One P-picture which is predicted from last decoded P-picture
  - One B-picture which is predicted from last decoded P-picture and the P-picture currently being decoded.



Comment on Temporal Scalability



- Temporal scalability is achieved using B-pictures
- These B pictures differ from B-picture in PB-frames
  - they are not syntactically intermixed with subsequent P-picture
- H.263 is used for low frame rate apps (e.g., mobile), hence in base layer there is one B-picture between I and P pictures.

H.264/MPEG-4 AVC Part 10

- Joint effort between
  - ITU- Video Coding Experts Group (VCEG) and
  - ISO/IEC Moving Picture Experts Group (MPEG)
  - 2003 completed
- H.264 – codec
  - Standard for Blu-ray Discs
  - Streaming internet standard for videos on YouTube and iTunes Store
  - web software Adobe Flash Player and Microsoft Silverlight support H.264
  - Broadcast services – direct broadcast satellite television services; cable television services

H.264 Characteristics

- Sampling structure
  - YCbCr 4:2:2 and YCbCr 4:4:4
- Scalable Video Coding (SVC) allows
  - Construction of bit-streams that contain sub-bit-streams that also conform to standard
  - Temporal bit-stream scalability, spatial and quality bit-stream scalability
  - Complete in 2007

Scalable Video Coding

- Encoding of high-quality video stream that contains one or more subset of bitstreams
  - Allows for sending video over lower bandwidth networks
    - Reduced bandwidth requires
      - Temporal scalability - Lower spatial resolution (smaller screen)
      - Spatial scalability - Lower temporal resolution (lower frame rate)
      - SNR/Quality/Fidelity scalability - Lower quality video signal
  - Subset bitstream can be derived by dropping packets from larger video

H.264 Characteristics

- Multi-view Video Coding (MVC)
  - Construction of bit-streams that represent more than one video of a video scene
    - Example: stereoscopic (two-view) video
    - Example: free viewpoint television
    - Example: multi-view 3D television
  - Two profiles in MVC:
    - Multi-view High Profile (arbitrary number of views);
    - Stereo High Profile (two-view stereoscopic video);
  - Complete in 2009

MVC

- Contains large amount of inter-view statistical dependencies
  - Cameras capture same scene from different viewpoints
- Combined temporal and inter-view prediction
  - Key for efficient MVC encoding
  - Frame from certain camera can be predicted not only from temporally related frames from same camera, but also from neighboring cameras

H.264 Characteristics

- Multi-picture inter-picture prediction
  - Use previously-encoded pictures as references in more flexible way than in past standards
  - Allow up to 16 reference frames to be used in some cases
    - Contrast to H.263 where typically one or in some cases conventional “B-pictures”, two.
  - Use variable block size from 16x16 to 4x4
  - Use multiple motion vectors per macro-block (one or two per partition where partition can be a block of 4x4)

H.264 Characteristics

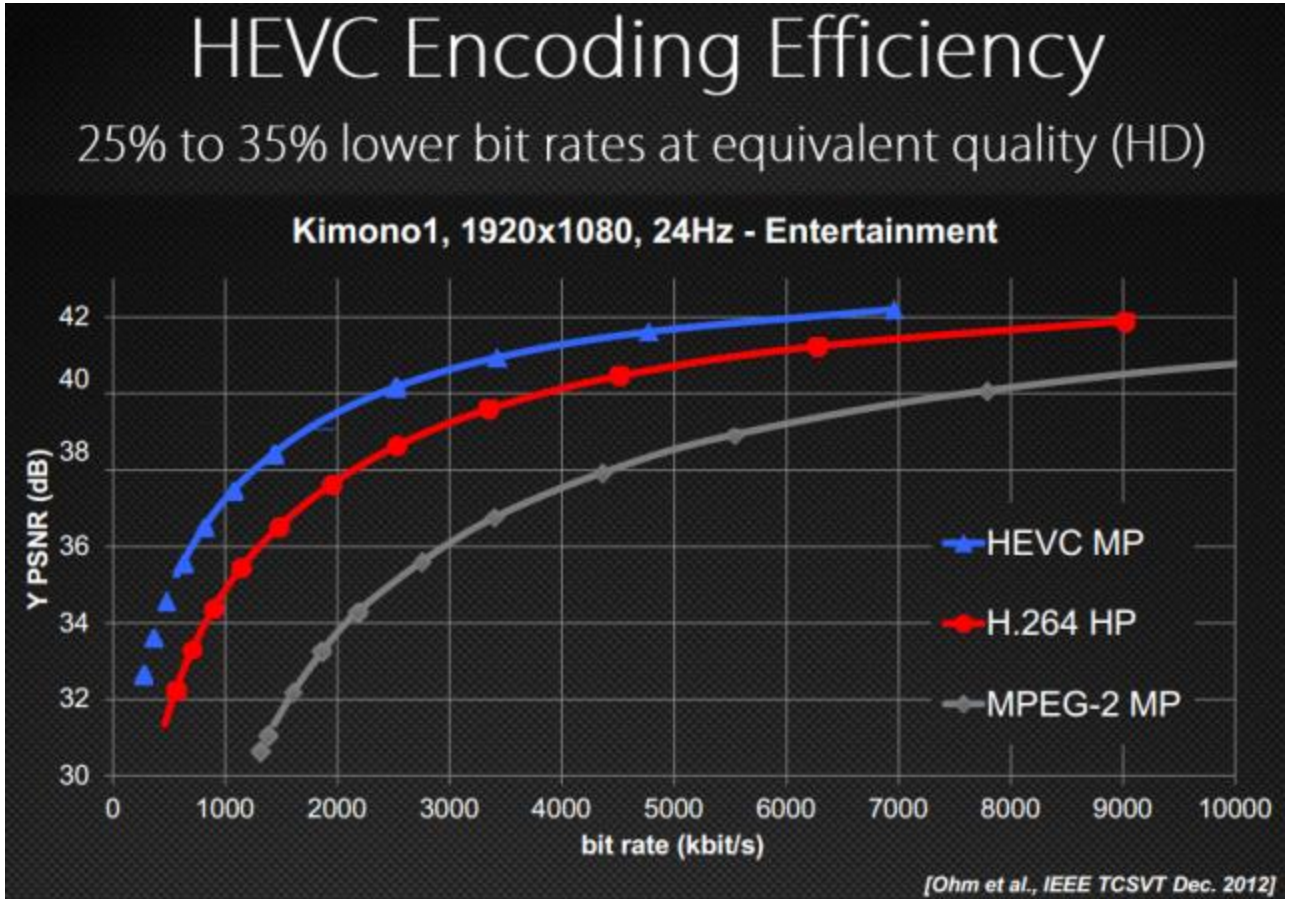
- New Transform design features
  - Similar to DCT, but simplified and made to provide exactly-specified decoding
- Quantization
  - Frequency-customized quantization scaling matrices
    - selected by encoder based on perception optimization
- Entropy Encoding
  - Context-adaptive variable-length coding
  - Context-adaptive binary arithmetic coding (CABAC)

H.265/HEVC/MPEG-H Part 2

- Main drivers
  - Get **Low bitrate target – target 2:1** over H.264
  - Cheat your eyes – how much can you cut bits and still see the same quality
  - Improve **resolutions (8K by 4K and 4K by 2K) and frame rates**
  - Launch **1080p50/60 services** to compete against BluRay
  - Expect <10x more computational complexity and 2x-3x (decode)

H.265 – High Efficience Video Coding (HEVC)

- Under development by ISO MPEG and ITU-T
  - Proposed in January 2013
  - Double the compression rate to H.264



Conclusion

- H.264 – major leap forward towards scalable coding and multi-view capabilities
  - Some controversy on patent licensing
    - Qualcomm owns patent on adaptive block size image compression and system
    - Qualcomm owns patent on interframe video encoding and decoding system
  - Controversies around H.264 stem primarily from its use within HTML5 Internet standard and its use of video and audio.
    - Fight between Theora and H.264 as the Internet video format
- **Theora** – free lossy video compression format
  - Developed by Xiph.Org Foundation
  - Distributed without licensing fees
  - Goes with Vorbis audio format and the Ogg container
  - Comparable in design and bitrate to MPEG-4 Part 2 (early version of Microsoft Media Video and RealVideo)

H.265

- Derived from H.264
  - More modes, tools and more interdependencies
  - More efficient search algorithms
  - More complex intra-prediction
  - Macroblocks vs Partitions

H.265

- AVC
- 16x16 macro-blocks
- 8x8 and 4x4 transform sizes

- HEVC
- Coding unit size 64x64 to 8x8
- 32x32, 16x16, 8x8 and 4x4 transformsizes