ELEN627 Lecture 4

- Review of last class
- MPEG

JPEG Goals

- JPEG = Joint Photographic Experts Group
- Sequential Encoding
  - Encode image in multiple scans
  - Allow image to built from coarse to fine quality
- Lossless encoding
  - Should allow lossless encoding if desired
- Hierarchical Encoding
  - Encode at multiple resolutions
  - Lower resolution image available without decompressing to full resolution
JPEG Compression stages

- Preparation of Data blocks
  - Each component broken into a series of 8x8 data blocks
  - Component by component
  - From Top-left to Bottom-Right

- Source Encoding Step
  - Discrete Cosine Transform
  - Quantization

- Entropy Encoding Step
  - Run length coding
  - Huffman or Arithmetic coding

- Decompression reverses these steps

 Progressive Encoding

- Spectral Selection
  - Send lower frequency components first
  - Send higher frequency components later

- Successive Approximation
  - Send only MSBs of encoded values first
  - Send LSBs later

- Again Image is progressively better

- Spatial Resolution through pyramidal coding
JBIG

• Joint Bi-level Image Group
• Standard for bitonal images
  – Printed pages etc.
• Used for FAX transmission
• Lossless encoding
• Uses progressive/sequential encoding
• Can be used for Medical X-ray images

MJPEG

• Treat video as a sequence of frames
• Code each frame independently as a picture
• Use JPEG on each frame
  – Each frame can be independently decoded
MPEG

- Motion Pictures Experts Group
- Standard for encoding videos/movies/motion pictures
- Evolving set of standards
  - MPEG-1, MPEG-2, MPEG-4...

MPEG

- Successive frames may have significantly same data
- Can use delta encoding
  - Picture differencing
- Delta encoding leads to better compression
- MPEG exploits motion prediction
  - Image content changes due to motion
  - Camera movement, Object movement, Camera panning, etc
Motion Prediction

- Frame based prediction
  - Used in MPEG-1

- Field based prediction
  - Field = Half a scan of a frame
  - Allowed in MPEG-2

Basic MPEG encoding

- Preprocess data
- Use motion prediction
- Find errors of receiver’s prediction and actual values
- Encode the differences using DCT
- Quantization
- Apply variable-length entropy coding
Data preparation

- Similar to JPEG
- Subsample Chrominance signals
  - 4:2:0 subsampling in MPEG-2, 4:1:1 in MPEG-1
- Motion Prediction applied on macroblocks
- Macroblocks are 16x16 samples
  - Chrominance samples will be 8x8 samples
  - A macroblock results in 4 luminance 8x8 data blocks, 2 chrominance blocks

Motion Compensation/prediction

- Apply prediction at Macroblock level
- Motion prediction used to figure out where this macroblock may be in the next frame
  - Forward prediction
    - Prediction based on previous frames
  - Backward prediction
    - Prediction based on future frames
- Bidirectional prediction
  - Prediction based on both previous and future frames
IPB frames

- I Frames
  - Independently coded - no temporal prediction
  - Can start decoding once we have an I-frame

- P Frames
  - Forward predicted frames
  - Based on previous I or P frames

- B frames
  - Bidirectionally predicted frames

- Group of Pictures (GOP): Set of frames between two I frames

Bidirectional prediction

- Allows effective prediction of uncovered background
  - Areas of the picture that are visible in the future

- Improves interpolation to better than 1/2 pixel
  - 1/4 pixel prediction when two anchor frames differ by 1/2 pixel

- Reduces noise in the predictor

- Increases motion estimation complexity
  - Need larger motion tracking range between anchor frames

- If motion is 10 pixels per frame
  - Need 10M tracking distance, M = distance between anchor frames

- B frames not used in predicting other frames
  - Can be compressed heavily
**IPB frames**

- B frames require future frames for decoding
- Decoding of B frames requires future P frames
- Displaying and transmitting order may change
- MPEG decoders may have to buffer extra frames of data besides the frame being displayed

**Motion prediction**

- Field or Frame based prediction
- Horizontal motion makes frame based prediction difficult
  - Lot of high frequency components
  - Difficult to compress
  - Field based prediction easier
DCT
- Apply DCT on the 8x8 data blocks
- Apply Quantization on the frequency domain coefficients
- Favor low frequency components
- Code DC component differently using delta encoding
- Convert 2 dimensional symbols into 1 dimensional series
- Use zig-zag or vertical scans
- Apply run-length coding on the 1-dim series

Motion Estimation
- Constant velocity model
- Use subsampling to reduce spatial resolution
- Estimate motion based on Mean-Squared-Error
- Once the motion direction is predicted
- Use higher resolution images to improve prediction
- Reduces the complexity of motion prediction
- MPEG allows 1/2 pixel motion estimation
**Rate Control**

- MPEG compression generates a variable rate stream
- Should be able to send this over fixed rate channel
- Encoder has to consider decoder buffer
  - Make sure doesn’t overflow or underflow
- Requirements on decoder buffers can be reflected to the encoder
  - Encoder can work to ensure the stream reaches decoder properly

**Rate Control Strategies**

- When compression is not very high or data rates high
  - Encoder goes to coarser resolution
- First step: Change quantization steps
- Other options
  - Increase the number of skipped macroblocks
  - Decrease bits allocated to scenes with texture
MPEG System

- Video Coding
- Audio Coding
- System Coding
  - Multiplexing of different streams
  - System Timing and Synchronization
  - Presentation Time Stamps, Decoding Time Stamps, System Clock Reference