ELEN627 Lecture 3

- Review of last class
- JPEG

JPEG Goals

- JPEG = Joint Photographic Experts Group
- Encoder should be parameterizable
  - Applications can tune compression level
- To be applicable to any continuous tone digital image
- Should have tractable computational complexity
- Should be possible to implement in hardware
JPEG Goals

- Should have the following modes of operation
  - Sequential Encoding
    - Encode image in multiple scans
    - Allow image to be built from coarse to fine quality
    - Allows easier transmission
  - Lossless encoding
    - Should allow lossless encoding if desired
  - Hierarchical Encoding
    - Encode at multiple resolutions
    - Lower resolution image available without decompressing to full resolution

JPEG Goals

- Compression scheme should be independent of data format
  - PAL/NTSC etc. shouldn’t change things
  - Independent of picture size, colors, aspect ratio
- Each picture consists of many components
  - Components can be YUV, RGB, YIQ etc.
- Components can be of different sizes
  - Allows subsampling - compression is independent
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

Data preparation

- Convert each component into 8x8 data blocks
  - Component size and number of components may vary
**Forward DCT**

- Apply DCT to generate 64 new samples
- DC coefficient normally has most of the information
  - An 8x8 block of one color will only have DC coefficient
- Changes are smooth
  - Low frequency components more likely
- Sharp black line on a white background
  - Produces high frequency components
- Encode non-zero values

**Quantization**

- $F^Q(u, v) = \text{IntegerRound}F(u, v)/Q(u, v)$
- DC coefficient treated separately
  - Strong correlation of DC component between data blocks
    - Encode it based on differential techniques
- Non-DC components sorted in zig-zag order
  - Lower frequency components come first
- Do entropy coding on non-DC components
  - JPEG allows Huffman encoding, Arithmetic encoding
    - Codebooks can be application dependent
Interleaving multiple components

- When image has multiple components
  - May want to interleave encoding of components
  - Progressive display of the image at the receiver

- Notion of Minimum Coded Unit (MCU)
  - JPEG allows up to 4 components in one MCU
  - Up to 10 blocks in one MCU
  - Application can decide how to do this

Progressive Encoding

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

- Image initially will be blurred
  - Sharpness improves with higher frequency components

- Receiver gets a feel for the image at progressive quality

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

- Again Image is progressively better
Hierarchical Encoding

- Also called Pyramidal Encoding
- Subsample the original image
  - Multiples of 2 in X and Y dimensions
- Code the subsampled image as a first stream
- Decode the subsampled image
- Upsample the decoded image
- Subtract from the original image
- Encode the difference as a second stream
- Can vary the number of layers

Hierarchical Encoding

- Greater Storage demands at the encoder
  - Need multiple versions of image
- A form of progressive encoding
  - Progression in spatial resolution
- Can increase data rate up to 33%
  - $N^2(1 + 1/4 + 1/16 + ...) \leq 4N^2/3$
- Hierarchical mode better at low bit rates than other techniques
- Downsampling filter is not specified in JPEG
- Upsampling filter
  - Interpolated value = truncated average of two lower resolution pixels