JPEG Image Coding Standard

- International Standardization of Image Coding
- JPEG
The Scope of Picture and Video Coding Standardization

- Only Restrictions on the *Bitstream, Syntax, and Decoder* are standardized:
  - Permits optimization beyond the obvious
  - Permits complexity reduction for implementability
  - Provides *no* guarantees of Quality
Why Do We Need Standards?

- Image (and video) coding standards provide *interoperability* between codecs built by different manufactures
  - Basis for most products in communication technology
  - Standards based products can be built with common software and hardware tools
  - Only syntax and decoder specified

- Standards provide state-of-the-art technology that is developed by a group of experts in the field
  - Actual performance depends on implementation of standard regarding error resilience, delay, display
  - Encoder is not standardized and its optimization is left to the manufacturer
Standardization of Image Coding

- ITU-R Radiocommunications (www.itu.int/ITU-R)
  SG 6 - Broadcasting Service (terrestrial and satellite)
  - Standards for digital high definition television
  - Objective picture quality parameters and associated measurement and monitoring methods for television images
- ITU-T Telecommunication Standardization (www.itu.int/ITU-T)
  SG 9 - Integrated broadband cable networks and television and sound transmission
  - Objective and subjective methods for evaluating conversational audiovisual quality in multimedia services
  - Digital transmission of television signals for contribution
- SG 16 – Multimedia services, systems and terminals
  - Video and data conferencing using Internet-supported services
  - Advanced video coding
- ISO/IEC JTC1 SC29 Coding of audio, picture, multimedia and hypermedia information (www.iso.ch/meme/JTC1SC29.html)
  WG 1 - Digital compression and coding of still pictures (JPEG)
  WG 11 - Generic coding of moving pictures and associated audio information (MPEG)
JPEG: Image Partitioning

8x8 Blocks

Padded Blocks
JPEG: Baseline Algorithm

Image in ➔ Block wise 8x8 DCT ➔ Weighting / uniform quantization ➔ Entropy coding ➔ Bitstream out

Table specifications (transmitted as side information)

Image out ➔ Block wise inverse 8x8 DCT ➔ Inverse weighting ➔ Entropy decoding ➔ Bitstream in
JPEG: Quantizer Step Size

- Different weighting matrices are standardized, adapted to human visual contrast sensitivity
- Example: Inverse weighting for ITU-R 601 images

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Quantization of DCT Coefficients

- Differential coding of DC coefficient: DPCM using previous quantized DC coefficient as predictor
- Zig-zag scan of AC coefficients
Features of the JPEG “baseline system”
- Represents a minimum of capabilities
- Compression of digital images with 8-bit representation
- Sequential processing of blocks, i.e. starting from upper left corner moving to right side
- Transform coding using 8x8 block DCT
- Scalar quantization of transform coefficients with weighting matrix
- Zig-zag scan and successive entropy coding with prefix-free codes

Extended DCT-based system
- Digital images with 8 and 12-bit representation
- Sequential as well as progressive block handling
- Prefix-free or arithmetic codes
**JPEG – Beyond Baseline**

- **Lossless mode**
  - DPCM-based (no DCT)
  - Compression of digital images with 2 – 16 bits representation
  - Sequential processing of blocks
  - Prefix-free codes

- **Hierarchical mode**
  - Multiple pictures encoded differentially as well as non-differentially
  - Employs extended DCT-based or lossless JPEG mode
Entropy Coding

- Two methods for entropy coding defined
  - Prefix-free coding
  - Arithmetic coding

- Two options for Prefix-free coding of run-level pairs
  - Predefined code tables (one-pass system)
  - Code tables optimized for individual image (two-pass system)

- Arithmetic coding
  - Binary coder
  - Default conditioning table
  - Adaptive to actual symbol statistics
Coding Results

Original                            Coded at rate 1:150
Coding Results: Detail

Original

Coded at rate 1:150
Summary

- International Standardization of Image Coding is conducted to achieve inter-operability and to provide state-of-the-art technology
- Only syntax and decoder are specified
- JPEG started in 1986 and is a well established image coding standard
- JPEG still provides competitive performance for the medium bit-rate range