Image Coding Standards

- International Standardization of Image Coding
- JPEG
- •JPEG-2000

Thomas Wiegand: Digital Image Communication

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 build 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)

Thomas Wiegand: Digital Image Communication

Image Coding Standards 3

JPEG 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 guantization 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 Thomas Wiegand: Digital Image Communication Image Coding Standards 4

JPEG

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

Thomas Wiegand: Digital Image Communication

Image Coding Standards 5

JPEG: Baseline Algorithm Weighting / Image Block wise Entropy uniform coding in 8x8 DCT quantization Table specifications (transmitted as side information) Block wise Image Inverse Entropy inverse out weighting decoding 8x8 DCT

Thomas Wiegand: Digital Image Communication

JPEG: Quantizer Step Size

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

Luminance

Chrominance

. 1								
	16	11	10	16	24	40	51	61
	12	12	14	19	26	58	60	55
	14	13	16	24	40	57	69	56
	14	17	22	29	51	87	80	62
	18	22	37	56	68	109	103	77
	24	35	55	64	81	104	113	92
	49	64	78	87	103	121	120	101
	72	92	95	98	112	100	103	99

17	18	24	47	99	99	99	99	
18	21	26	66	99	99	99	99	
24	26	56	99	99	99	99	99	
47	66	99	99	99	99	99	99	
99	99	99	99	99	99	99	99	
99	99	99	99	99	99	99	99	
99	99	99	99	99	99	99	99	
99	99	99	99	99	99	99	99	

Thomas Wiegand: Digital Image Communication

Image Coding Standards 7

Quantization of DCT Coefficients

- Differential coding of DC coefficient: DPCM using previous quantized DC coefficient as predictor
- Zig-zag scan of AC coefficients



Thomas Wiegand: Digital Image Communication

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 (twopass system)
- Arithmetic coding
 - Binary coder
 - Default conditioning table
 - Adaptive to actual symbol statistics

Thomas Wiegand: Digital Image Communication

Image Coding Standards 9

JPEG 2000

- Improved R-D performance at low and medium bitrates
- Covers low bit-rate lossy coding up to lossless coding
- Progressive Transmission Capability (resolution & SNR)
- Region of interest (ROI) representation and editing
- Error Resilience

Approach:

Wavelet Transformation + EBCOT* + Adaptive **Arithmetic Coding**

*Embedded Block Coding with Optimized Truncation

JPEG-2000 Options



Flexibility and Applications

- Medical Imaging
 - Lossless coding, ROI
- Digital cameras
 - Limited storage capacity
 - Limited transmission bit-rate (mobile devices)
- Archiving
 - Encode and store on server
 - Decode to match application display requirements (mobile display, CRT, LCD)
- •WWW
 - Progressive decoding
 - User interaction: ROI

Thomas Wiegand: Digital Image Communication



Wavelet Transform

- Dyadic Partition
- Irreversible (9/7)
- reversible (5/3)
- Other partitions in Part 2
- Irreversible case: Scalar Quantization with dead zone (separate approach for every sub-band possible)



Scalability

- Embedded codes permit decoding with reduced quality with parts of the complete code
- Resolution scalability
 - Straight forward (DWT property)
 - Sort bits from lowest to highest sub-band

SNR scalability

- Embedded quantization
- Transmit sequence of quantizers



Image Coding Standards 15

Thomas Wiegand: Digital Image Communication





Thomas Wiegand: Digital Image Communication

JPEG: Hotel @ 0,145 bpp



Thomas Wiegand: Digital Image Communication

Image Coding Standards 17

JPEG-2000: Hotel @ 0,145 bpp





Thomas Wiegand: Digital Image Communication

Objective Comparison: Lossy Coding



JPEG2000: The Next Generation Still Image Compression Standard

Thomas Wiegand: Digital Image Communication

Image Coding Standards 19

Objective Comparison: Lossless Coding



From: M. D. Adams, H. Man, F. Kossentini, T. Ebrahimi, JPEG2000: The Next Generation Still Image Compression Standard

Thomas Wiegand: Digital Image Communication

Resolution Scalability: Level 1 of 5



Thomas Wiegand: Digital Image Communication

Resolution Scalability: Level 3 of 5





Thomas Wiegand: Digital Image Communication

Image Coding Standards 23

Resolution Scalability: Level 4 of 5



Thomas Wiegand: Digital Image Communication

Resolution Scalability: Level 5 of 5



SNR Scalability: Level 1 of 6, 0.0625 bpp





Thomas Wiegand: Digital Image Communication

SNR Scalability: Level 2 of 6, 0.125 bpp



Thomas Wiegand: Digital Image Communication

Image Coding Standards 27

SNR Scalability: Level 3 of 6, 0.25 bpp





Thomas Wiegand: Digital Image Communication

SNR Scalability: Level 4 of 6, 0.5 bpp



Thomas Wiegand: Digital Image Communication

Image Coding Standards 29

SNR Scalability: Level 5 of 6, 1.0 bpp





Thomas Wiegand: Digital Image Communication

SNR Scalability: Level 6 of 6, 2.0 bpp



Thomas Wiegand: Digital Image Communication

Image Coding Standards 31

ROI, Area: Circle, 0.0625 bpp



Thomas Wiegand: Digital Image Communication

ROI, Area: Circle, 0.125 bpp



Thomas Wiegand: Digital Image Communication

Image Coding Standards 33

ROI, Area: Circle, 0.25 bpp





Thomas Wiegand: Digital Image Communication

ROI, Area: Circle, 0.5 bpp



Thomas Wiegand: Digital Image Communication

Image Coding Standards 35

ROI, Area: Circle, 1.0 bpp





Thomas Wiegand: Digital Image Communication

ROI, Area: Circle, 2.0 bpp



Thomas Wiegand: Digital Image Communication

Image Coding Standards 37

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
- JPEG-2000 mostly provides improved performance at for low and high bit-rates
- JPEG-2000 yields a useful set of functionalities