

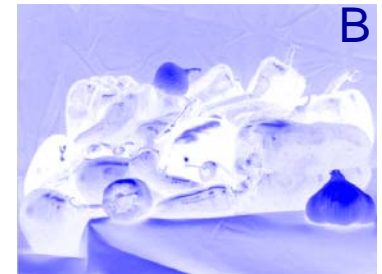
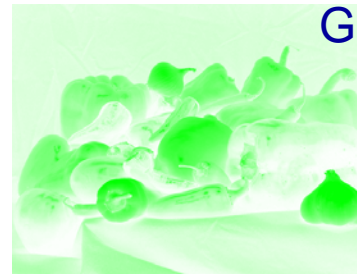
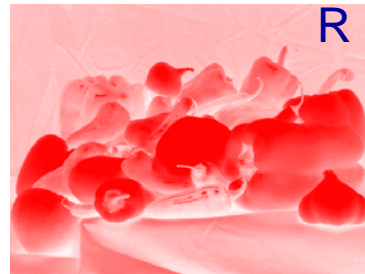
JPEG Modes of Operation

Nimrod Peleg
Dec. 2005

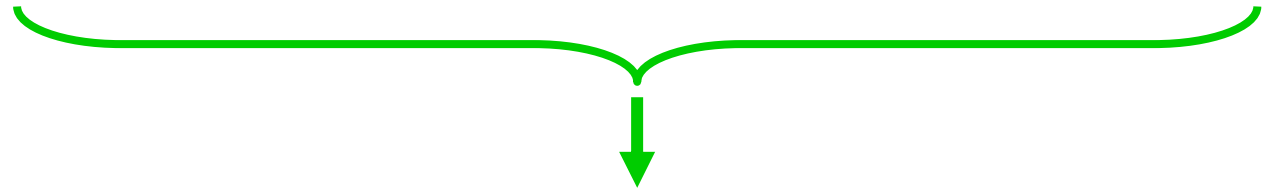
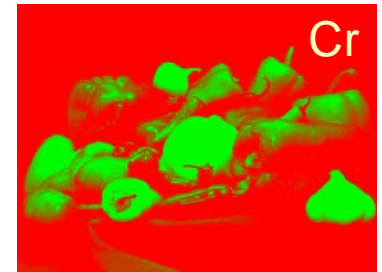
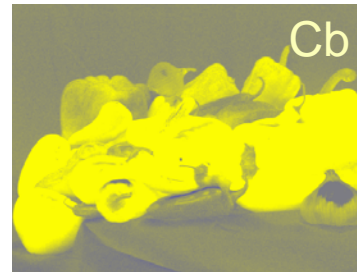
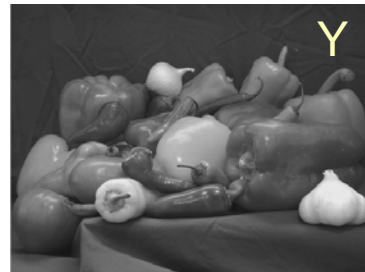


Color Space Conversion

- Example:



=



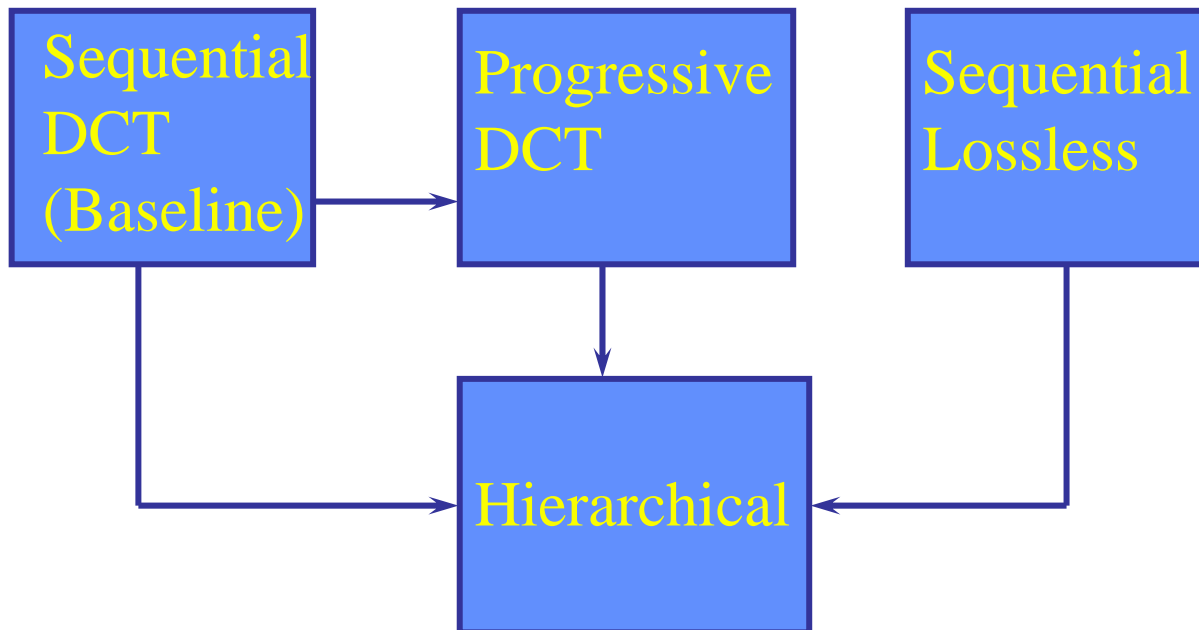
Remember: all JPEG process is operating on **YCbCr** color space !

Down-Sampling

- Another optional action is down-sampling the chrominance components (Cb, Cr):
 - 4:2:2 : Down-sample 2:1 horizontally
 - 4:1:1 : Down-sample 2:1 horizontally and 2:1 vertically
- Input data is shifted so it is distributed about zero
 - An 8-bit input sample in the range [0 255] is shifted to the range [-128 127] by subtracting 128

JPEG 4 Modes

- Sequential DCT based (Lossy)
- Progressive DCT based (Lossy)
- Sequential **lossless**, DPCM based
- Hierarchical



Sequential DCT-Based Mode

- Image components are compressed either individually or in groups (by interleaving).
- One pass operation.
- **“Baseline System”**: A restricted mode, that must be included in any decoder.
- Color Components **Interleaving** is done to save buffer size.

Baseline Results

(After Pennabaker & Mitchell)

<u>Image</u>	<u>Fixed H.</u>	<u>Custom H.</u>	<u>Diff.</u>
Boats	40854	38955	4.9%
Board	35853	33233	7.9%
Hotel	49406	48267	2.4%

<u>Image</u>	<u>Arith.</u>	<u>vs. Custom Huffman</u>
Boats	35497	9.7%
Board	30528	8.9%
Hotel	45398	6.3%

- Results in Bytes
- Fixed Huffman: JPEG CD tables
- Average difference over 9 images: 4.6%
- Original is YCbCr (Y:720x576, Cb,Cr:367x576 meaning about 830K original size), 16bit Ave.

3 Different Bitrates of Baseline

- DC Q value unchanged - AC Q values changed (see in transparencies).
- The Scale factor determines compression ratio and quality.

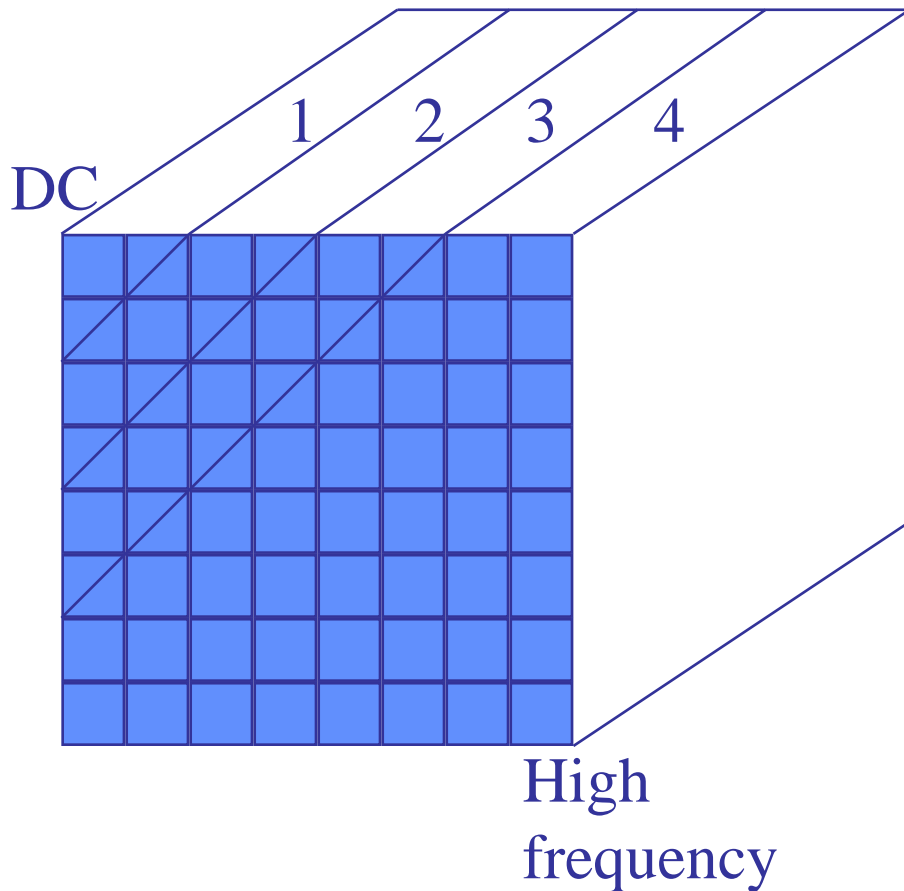


Progressive DCT-Based mode

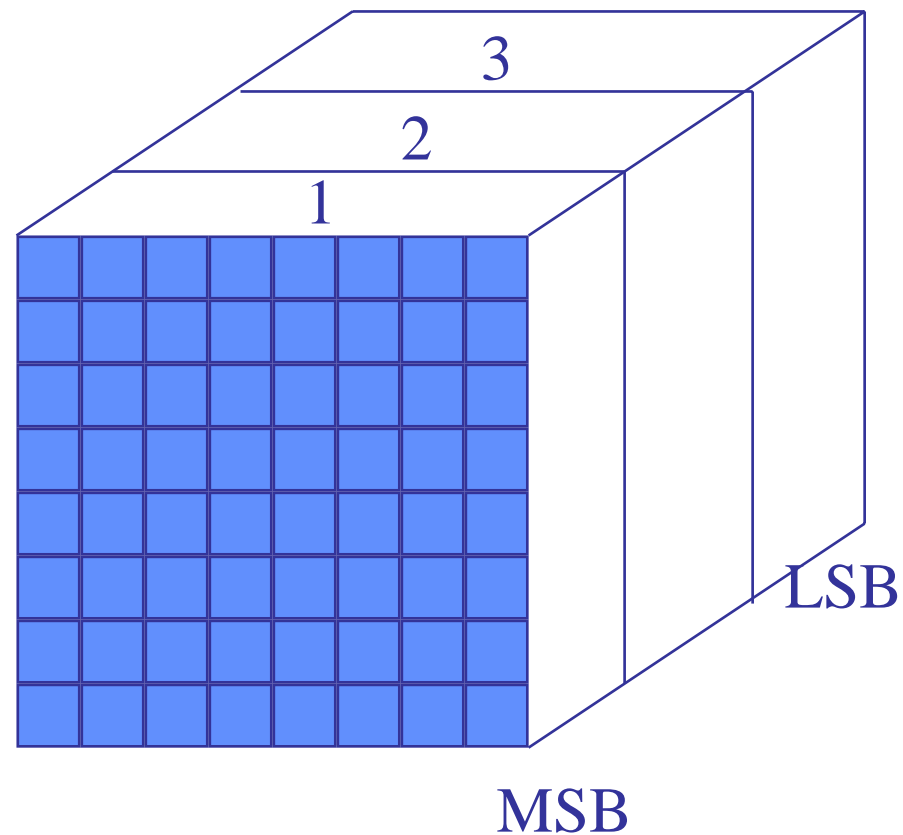
- A sequence of “scans”, each codes a part of the quantized DCT coefficients data.
- Two ways of doing this:
 - Spectral selection: coeff. are grouped into spectral bands, and lower-frequency bands sent first.
 - Successive Approximation: data is first sent with lower precision and then refined.
- Gives better quality for lower bit-rates !
- A mixture of the two is also possible !

Progressive: 2 ways of selection

Spectral Selection



Successive Approximation



Progressive DCT Results, Arithmetic coding

<u>Image</u>	<u>S.S.</u>	<u>S.A.</u>	<u>Mixed</u>
Boats	36291	35020	35587
Board	31609	29967	30512
Hotel	46392	44223	44999

Sequential Lossless mode

- Reconstructed neighbors (a, b, c) are used to predict current sample x .
- Prediction equation selected from 8 options:

none, a , b , c , $a+b-c$, $a-(b-c)/2$, $b-(a-c)/2$, $(a+b)/2$

		c	b		
		a	x		

5 Progressive Mode Slides



- Spectral selection, DC Only
- Spectral selection, DC + 2 AC Coeff.
- Spectral selection, DC + 5 AC Coeff.

- Successive Approximation, AC coeff. divided by 4
- Successive Approximation, AC coeff. divided by 2

S.A gives better results for low bitrates !

Sequential Lossless results

- for selector 7 (predictor: $(a+b)/2$)

<u>Image</u>	<u>Arithmetic (Custom)</u>	<u>bits/pixel</u>
Boats	369084	7.2
Board	355650	6.9
Hotel	422420	8.1

- Custom condition for Arith. achieves ~1% better results

- Selector 7 is usually the best (on average):

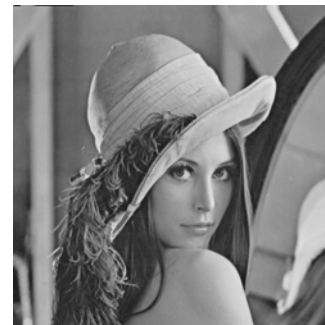
<u>Selector</u>	<u>Predictor</u>	<u>Diff. from selector 7</u>
1	a	6.9%
2	b	1.5%
2	c	11.6%
6	$b-(a-c)/2$	1.8%

Hierarchical Mode

- Progressive coding **with increasing spatial resolution** between stages.
- First stage (lowest resolution) is coded using sequential or progressive modes.
- Output of each stage is **up-sampled** (if necessary) and becomes the prediction for the next stage.
- Image quality at extremely low bit-rates is much better than all other modes, **but at cost of higher bit-rate** (~30%) at completion.

Hierarchical Mode (Cont'd)

- Useful for multi-resolution requirements :

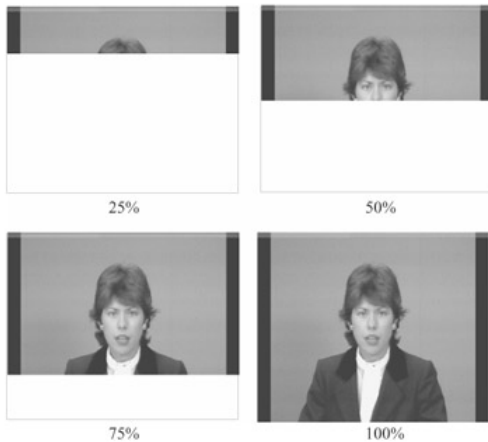


Should be
Expanded
by N:1 !

JPEG Modes

- Three “lossy” modes of operation:

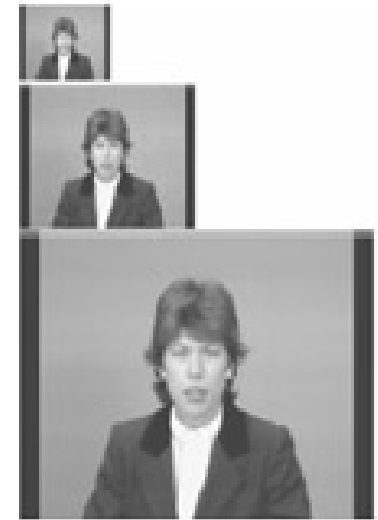
Baseline Sequential



Progressive



Hierarchical



This is the most common mode and the only one we're going to talk about

JPEG Modes: Summary

<u>Baseline</u>	<u>Extended</u>	<u>Lossless</u>	<u>Hierarchical</u>
DCT Based	DCT based	Predictive	DCT/Lossless
Sequential	Seq. / Prog.	Sequential	
8 bpp	8 - 12 bpp	2 - 16 bpp	
Huffman coding	Huff./Arith.	Huff./Arith.	
2 AC, 2 DC tab.	4 AC, 4 DC	4 DC Tables	
Non /Interleaved	- same -	- same -	- same -
			Multiple frames (Non/differential)

Motion JPEG (M-JPEG)

- A real-time h/w implementation, 30 fps, each frame is compressed independently
- Using JPEG syntax but not supported in the T.81 recommendation



JPEG File formats

- **JFIF**: JPEG File Interchange Format
 - A minimal format to allow bitstream exchange between different platforms
- **TIFF™** (Tag Image File Format)
 - version 6.0 and above, from Aldus Corp.
- **JTIP**
 - JPEG Tiled, Pyramid Format)
- **SPIFF**
 - Still Picture Interchange File Format, JPEG Part 3)
- **FlashPix**
 - Developed by Kodak, Hewlett- Packard, Microsoft (1996)
 - Widely used in digital still cameras
- **EPS, PDF** etc.