

# **Graphic Interchange Format: *GIF***

## **Goal:**

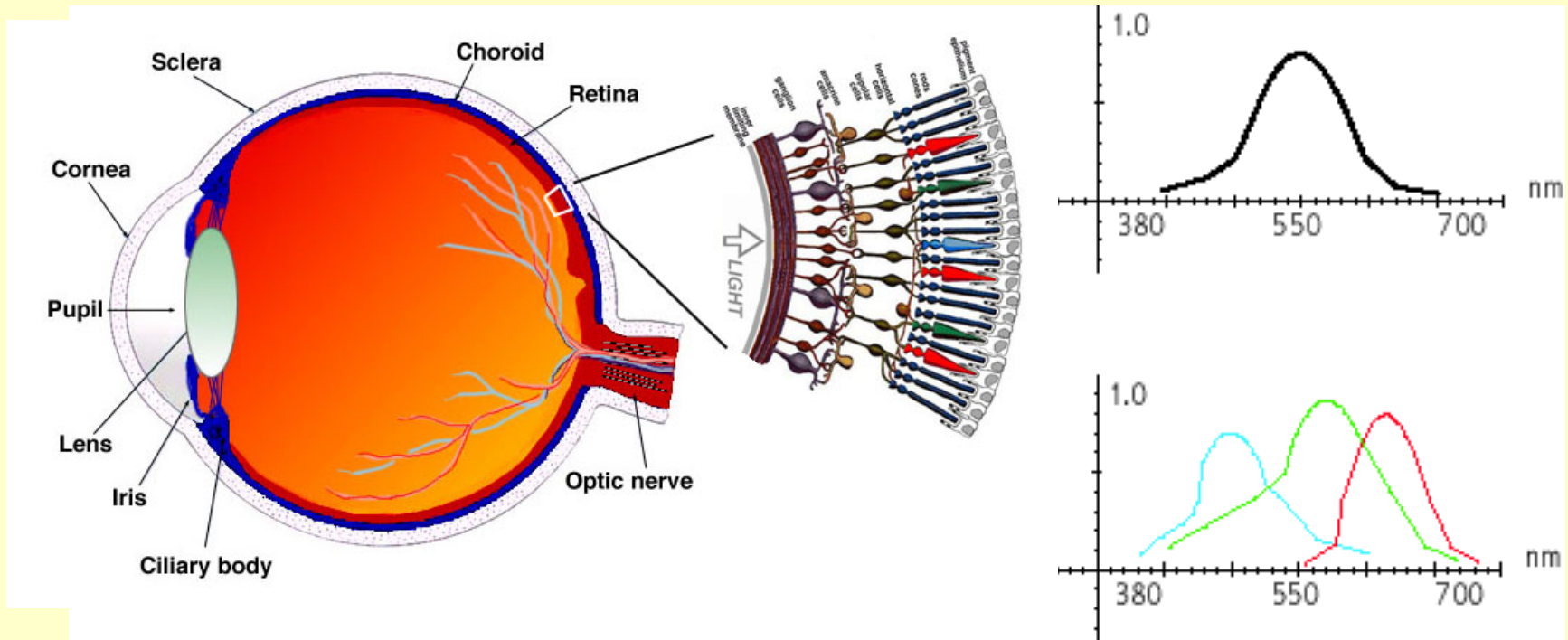
- *Graphics rather than photographs*
- *Lossless compression iff the image contains less than 256 different tones.*

## **Algorithms**

- *Quantize continuous tone by 256 colors*
- *Best match the image histogram*
- *Predictive Differential encoding*
- *Run Length encoding*
- *LZW*

# ***Human Perception***

***Minimize bandwidth, down to the perception level of the human eye and ear.***



***Exploit the low sensitivity of the human eye to high (and low) frequencies, in colors, space JPEG, and time MPEG.***

# ***JPEG Images***

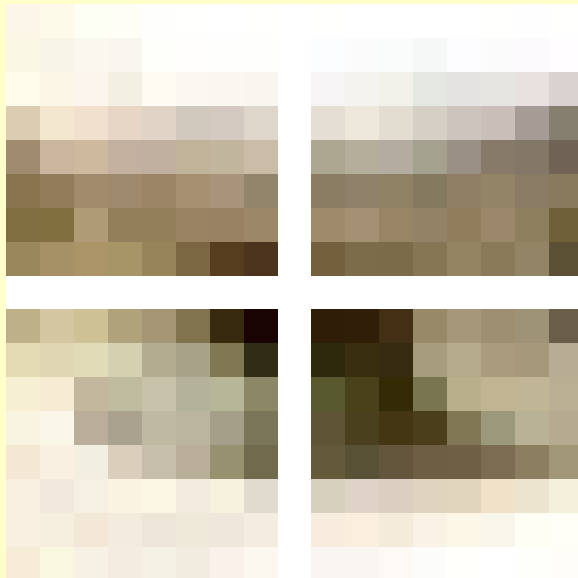
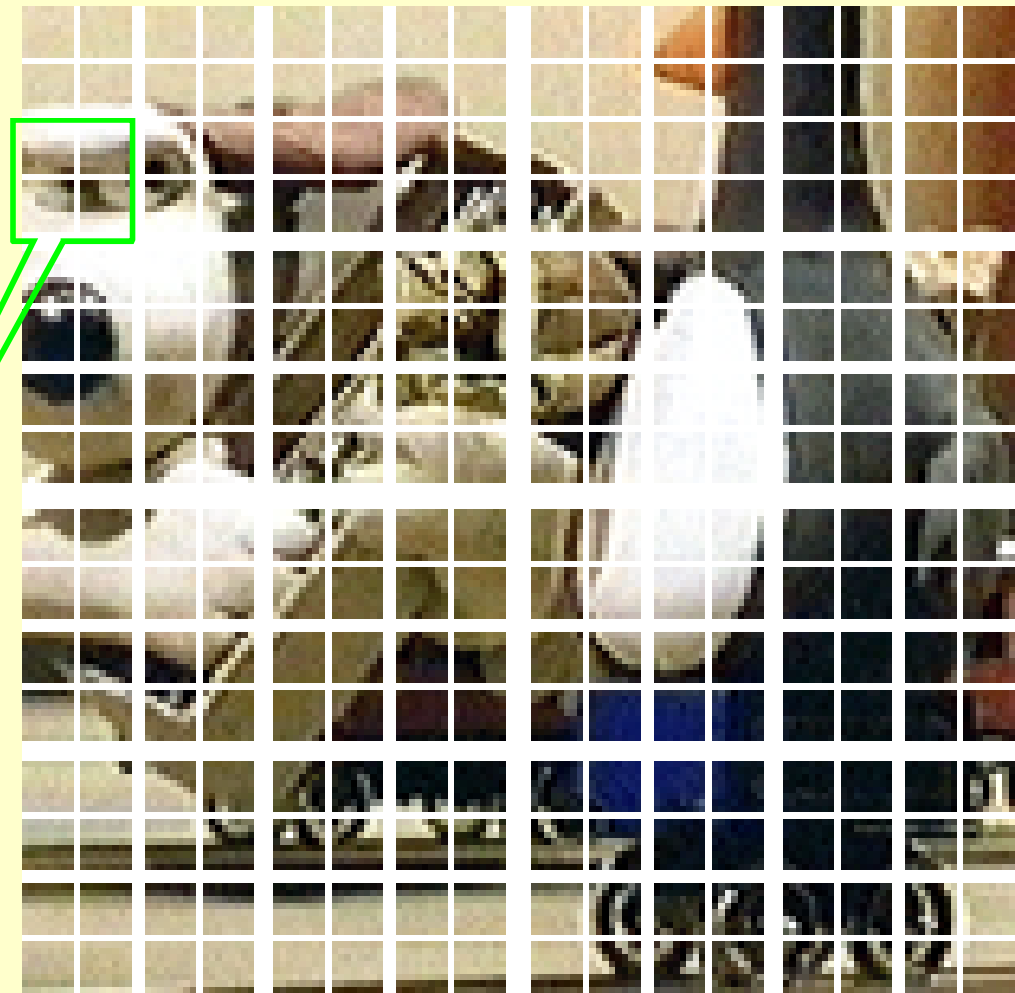
**Goal: from 0.2 to 2 bit/pixel**

- ***Photos, video***
- ***Acceptable for text and graphics***
- ***Just noticeable distortion (by the human eye)***
- ***Standard with MANY options*** (Color/BW, x+y Size, loss-y/less, Q-tables, H-tables, Huffman/Arithmetic code, Block Scan/Progressive, ...)

## **Algorithms**

- ***Color Coding: 3->2 color/pixel***
- ***2D-DCT: 8->13 bit/pel***
- ***Quantization: L-Table, & C-Table***
- ***Entropy Coding : DC + Run Length + Huffman/Arithmetic***

# **JPEG:** **8x8 Blocks**



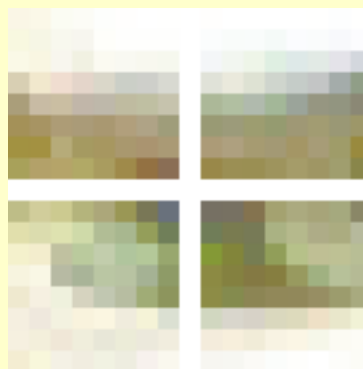
JPEG Code = Header + Image Code

Input = Raster Scan RGB: 24b/pel

Output = Block Scan RGB: 24b/pel

Requires memory: 16 lines + 3 pel.

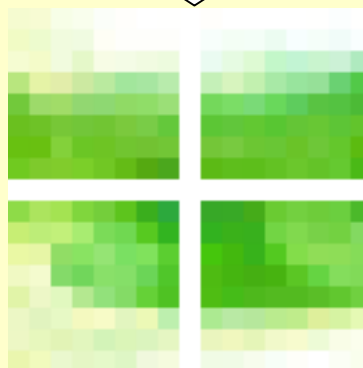
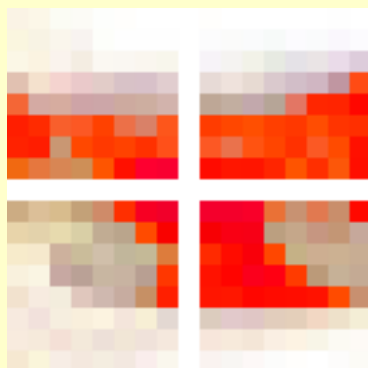
# JPEG: Color Conversion



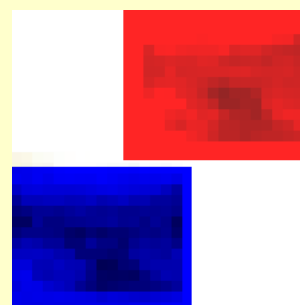
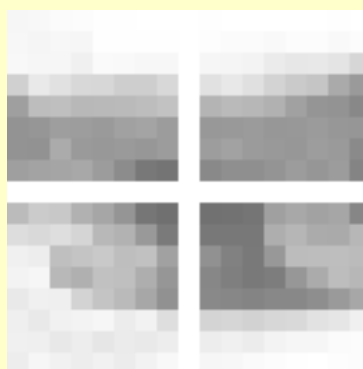
RGB = 24  
bit/pixel



3x(8 bit/pel)



- 3x3 linear transform:  
RGB  $\rightarrow$  CrYCb



- sub-sample CrCb

2x(8 bit/pel)

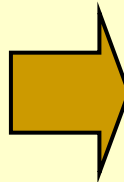
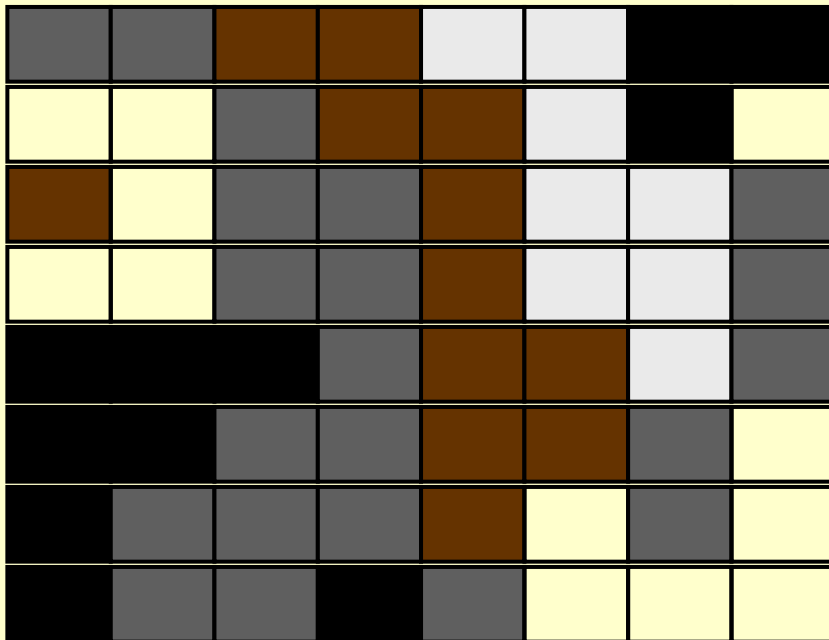
# Discrete Cosine Transform: DCT

$$F_{u,v} = \frac{2\alpha_u\alpha_v}{N} \sum_{n=0}^{N-1} \sum_{m=0}^{N-1} p_{n,m} c_{n,u} c_{m,v}$$

$$p_{n,m} = \frac{2}{N} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} \alpha_u \alpha_v F_{u,v} c_{n,u} c_{m,v}$$

$$\alpha_0 = \frac{1}{\sqrt{2}} \quad \alpha_{N+1} = 1$$

$$c_{i,j} = \cos \frac{(2i+1)j\pi}{2N}$$



619	-29	24	2	1	-3	0	1
22	-6	-5	0	2	1	-2	3
11	0	5	-4	0	7	0	0
47	-11	-1	-2	1	2	3	1
4	0	-3	1	0	3	0	-2
-8	-2	0	2	-1	-4	-2	-1
1	0	-2	1	3	1	-1	0
-3	-1	-1	-4	1	0	1	-3

# Fast DCT

## 2D 8x8

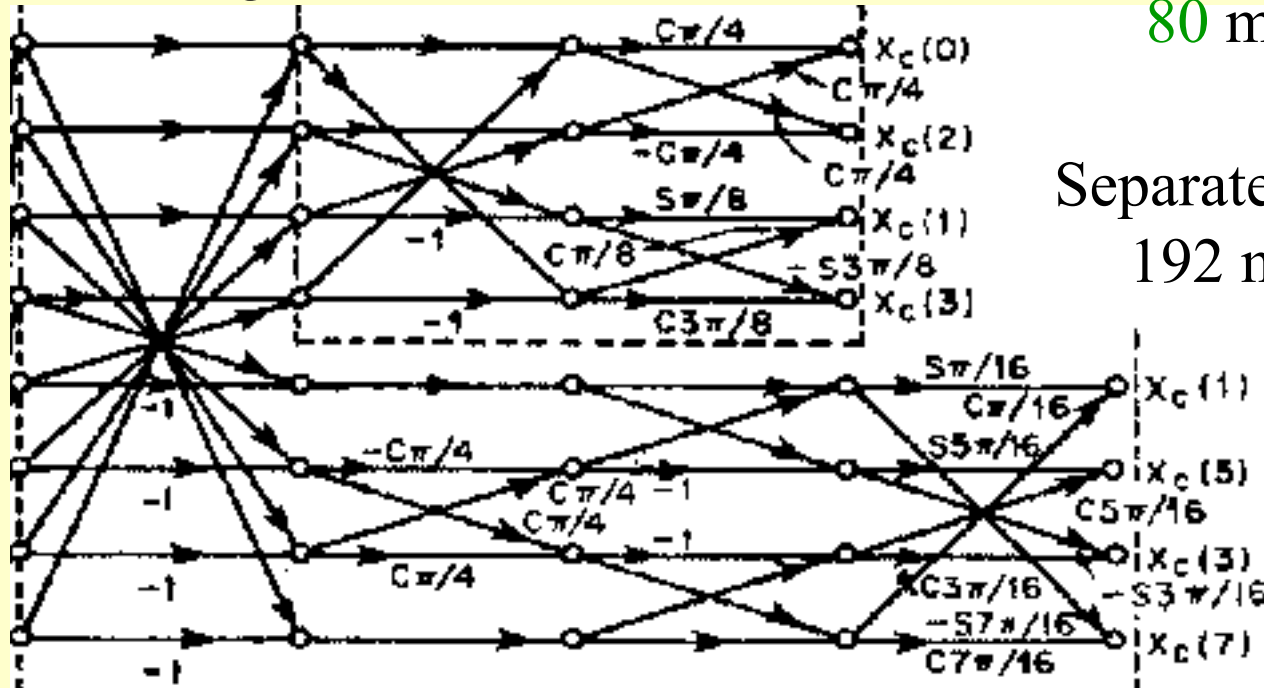
Naïve: 4096 mul & 4032 add

Separated: 1024 mul & 896 add

Fast 2D DCT: 96 mul & 466 add

Fast 2D DCT + post-condition:

32 mul & 466 add



$$F = CpC$$

$$p = C^t F C^t$$

$$F^t = C[Cp]^t$$

AAN + post-condition:

80 mul & 464 add

Separated Fast 1D DCT:

192 mul & 464 add

# ***JPEG: Quantization Matrices***

Human Eye is insensitive to high spacial frequencies

Luminance

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	106

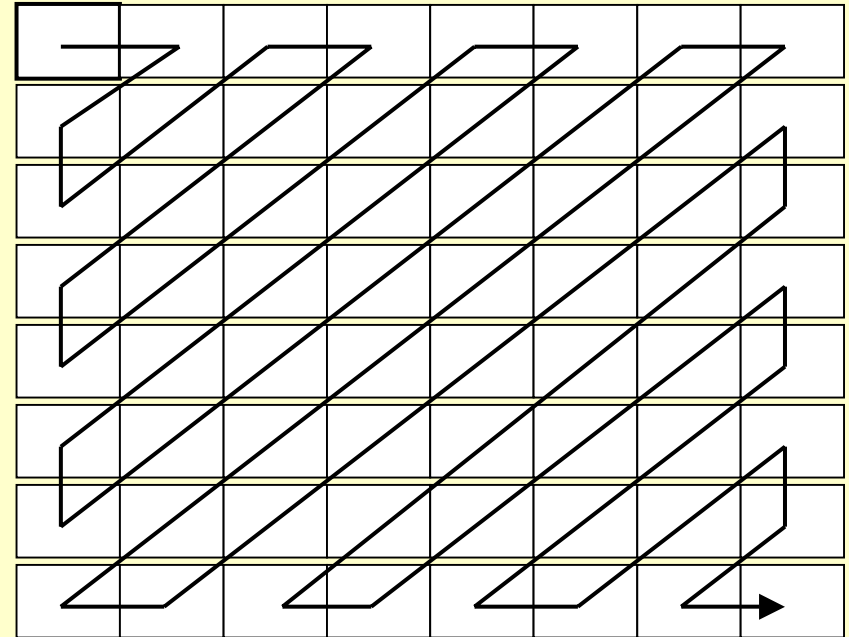
Chrominance

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	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	99



# JPEG: Entropy Coding

39	-3	2	0	0	0	0	0
2	-1	0	0	0	0	0	0
1	0	0	0	0	0	0	0
3	-1	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0



Previous DC = 36, Diff = 39 - 36 = 3  
(3, -3, 2, 1, -1, 2, 0, 0, 0, 3, 0, -1, EOB)

1001/0100/0110/001/000/0110/11111011111/11000/1010 = 42b = 0.65 b/pel

# ***JPEG: blocking effects***



Gromit1bpp.jpg ~ 1 bpp

Gromit02bpp.jpg ~ 0,2 bpp

# ***MPEG-1***

## **Goals**

- *Video + audio @ 1.5 Mb/s*
- *Constant throughput (same as audio CD)*

## **Algorithms**

- *JPEG for reference images (Intra Frame)*
- *Movement Compensation*
- *Inter Frame Prediction*
- *Audio Compression (MP3)*
- *Bit Rate Control (macro block table change)*

# MPEG-1: Images



**I B P B P B I**

## Frame Types

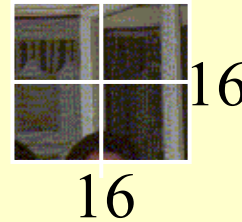
**I** : Intra (JPEG)

**P** : Inter prediction

*unidirectional*

**B** : Inter prediction

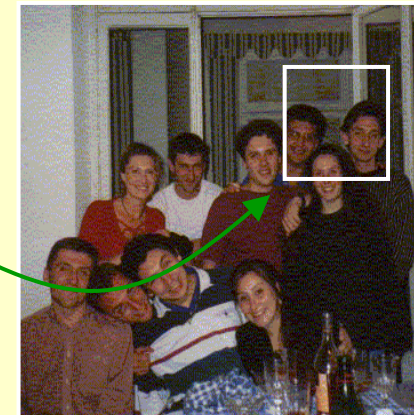
*bi-directional*



Macro block  
4:2:0



Movement Estimation



# ***MPEG-1: Audio***

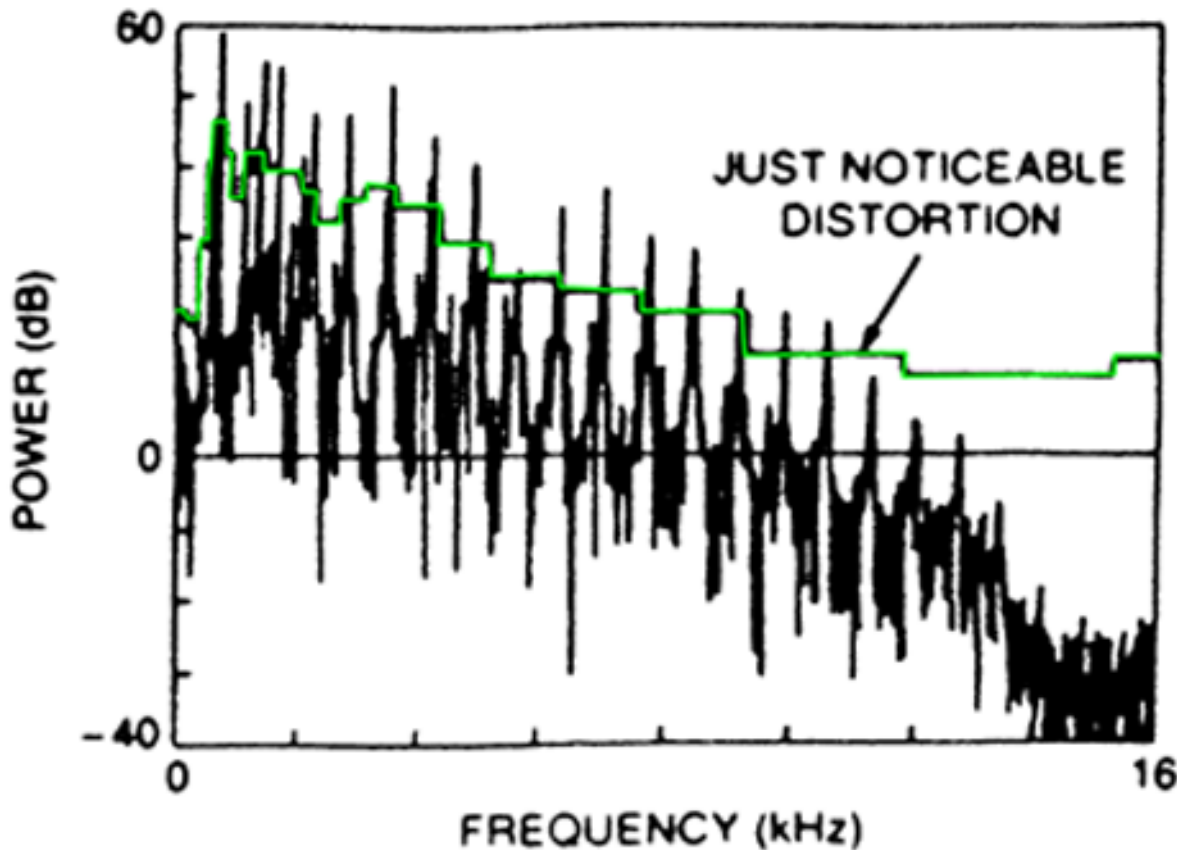
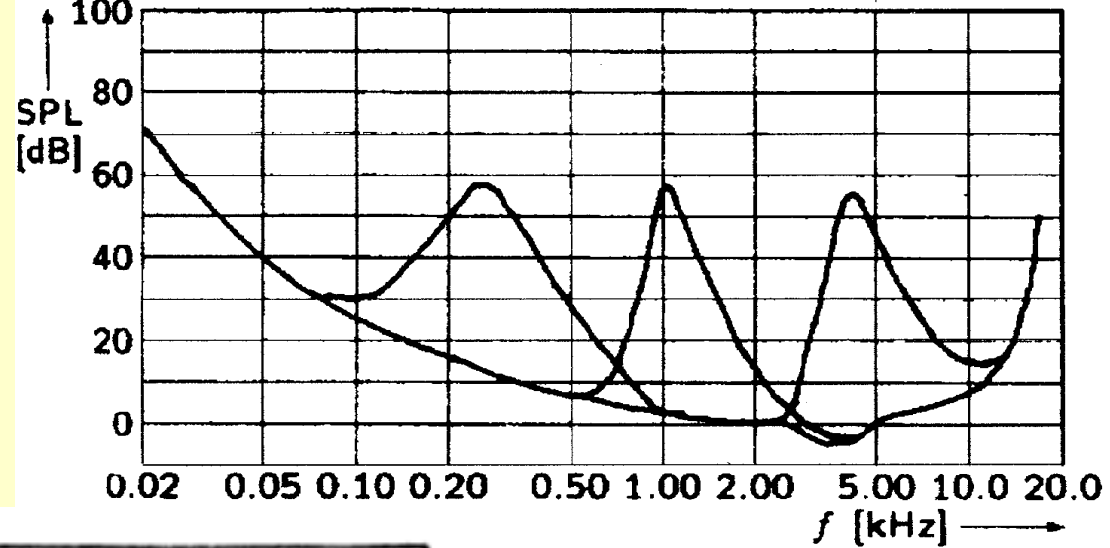
## **Goals**

- *High quality audio: human perception.*
- *Compression factor: 5 to 20*

## **Algorithms**

- *Time representation -> Frequency representation*
- *DCT on sliding window: 16 joint stereo samples*
- *Psycho Acoustic Masking + Perceptual Thresholds*
- *Entropy code*

# ***Auditory noise masking***



***Perceptual  
Threshold***