# ITM 1010
# Computer and Communication Technologies

## Lecture #17

## Part II Introduction to Communication Technologies:

## Data Compression II

# Image Compression

- Digitised images typically contain huge amount of data if not compressed eg:

| Image type | Data File Size (Mbits) |
|---|---|
| Monochrome image (352x288 pixels) | 0.81 |
| Colour image (352x288 pixels) | 2.4 |
| Colour TV images (625x720 pixels x 24 bits) | 10 |
| High Resolution Photograph (1200x1024 pixels x36 bits) | 44 |

# JPEG Compression

- JPEG (joint photographic experts group) usually refers to a set of standards for both lossy and lossless compression methods.
  - "baseline codec" is the most popular JPEG standard and achieves very high compression ratio but is lossy.

- Baseline Process
  - Uses Discrete Cosine Transform (DCT) to reduce information content of image
  - Huffman coding is used to compress data further

***ENCODING***

raw image X $\xrightarrow[\text{DCT}]{}$ C $\xrightarrow[\text{Quantization}]{}$ $C_q$ $\xrightarrow[\text{Huffman coding}]{}$ compressed image

***DECODING***

Compressed JPEG $\xrightarrow[\text{Decoding}]{}$ $C_q$ $\xrightarrow[\text{inverse DCT}]{}$ $X_q$

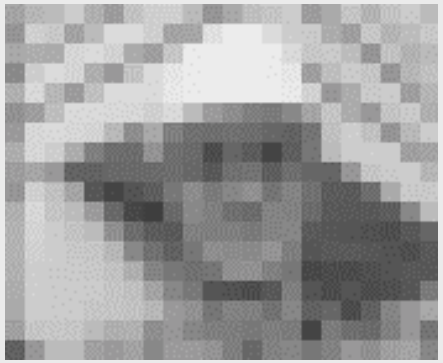
# JPEG Overview

- Pixels in input image are grouped into 8x8 blocks
- Discrete Cosine Transform (DCT) is applied to each block
  - DCT produces 64 coefficients from the 64 input pixels
  - Most of these coefficients are small (image pixels usually do not change rapidly from pixel to pixel); large coefficients usually arise from low frequency component of image
  - Coefficients are stored in 8-bit numbers (most are zero)
  - DCT effectively discards information that is not readily apparent to the human eye
- DCT of a sequence of N numbers $x(n)$ is similar to DFT:

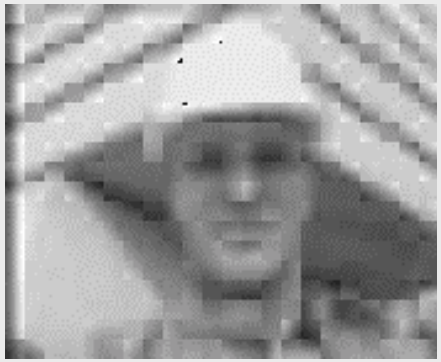
$$c(k)=\alpha(k)\sum_{n=0}^{N-1}x(n)\cos\frac{\pi(2n+1)k}{2N},\quad 0\le k\le N-1$$

$$\alpha(0)=\sqrt{\frac{1}{N}},\qquad \alpha(k)=\sqrt{\frac{2}{N}}\ \text{for}\ 1\le k\le N-1$$

# Trade off between quality and compression



one coefficient



3 coefficients

6 coefficients

10 coefficients

15 coefficient

21 coefficients

36 coefficients

all 64 coefficients

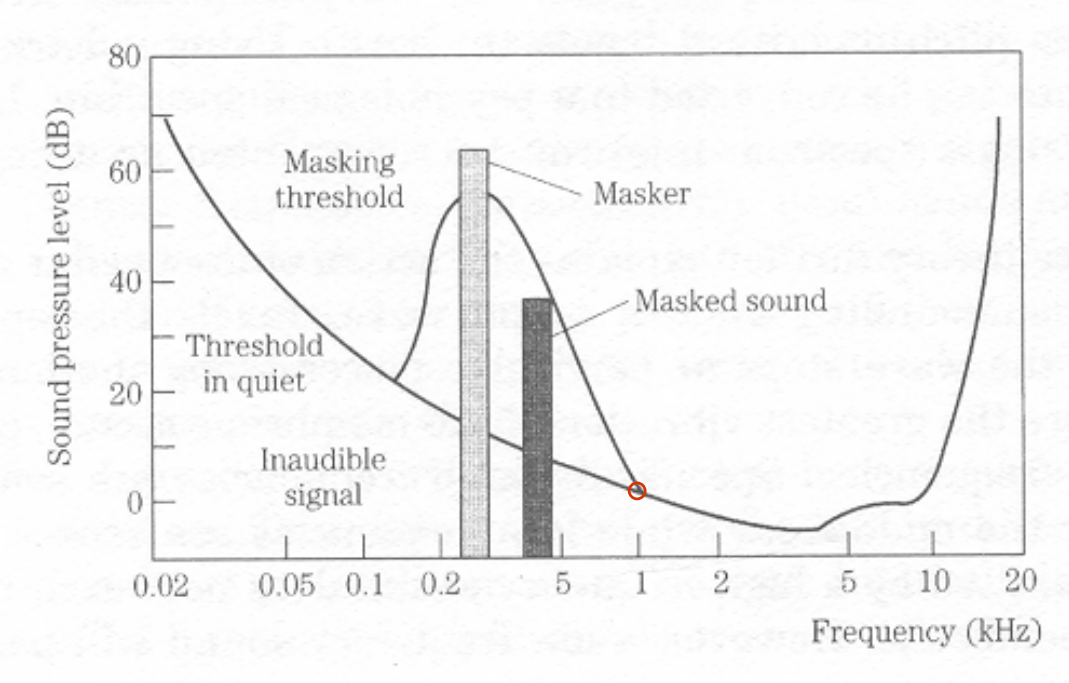
# MPEG

- Motion Photographic Experts Group (MPEG) defined a number of standards for compressing audio-visual data
- MPEG-1 standard is used in VCDs and mp3 audio files
  - MPEG-1 compresses 320x240 images (30 frames per second, equivalent to 55Mbit/s image data rate) and CD-quality audio onto a 1.5Mbit/s data-stream
- Audio compression (MPEG-1 layer3, or commonly called mp3) can compress a 768kb/s stereo signal to 16kb/s
- MPEG-2 standard is used in DVDs, HDTV, digital TV broadcasts

# mp3 Compression Overview

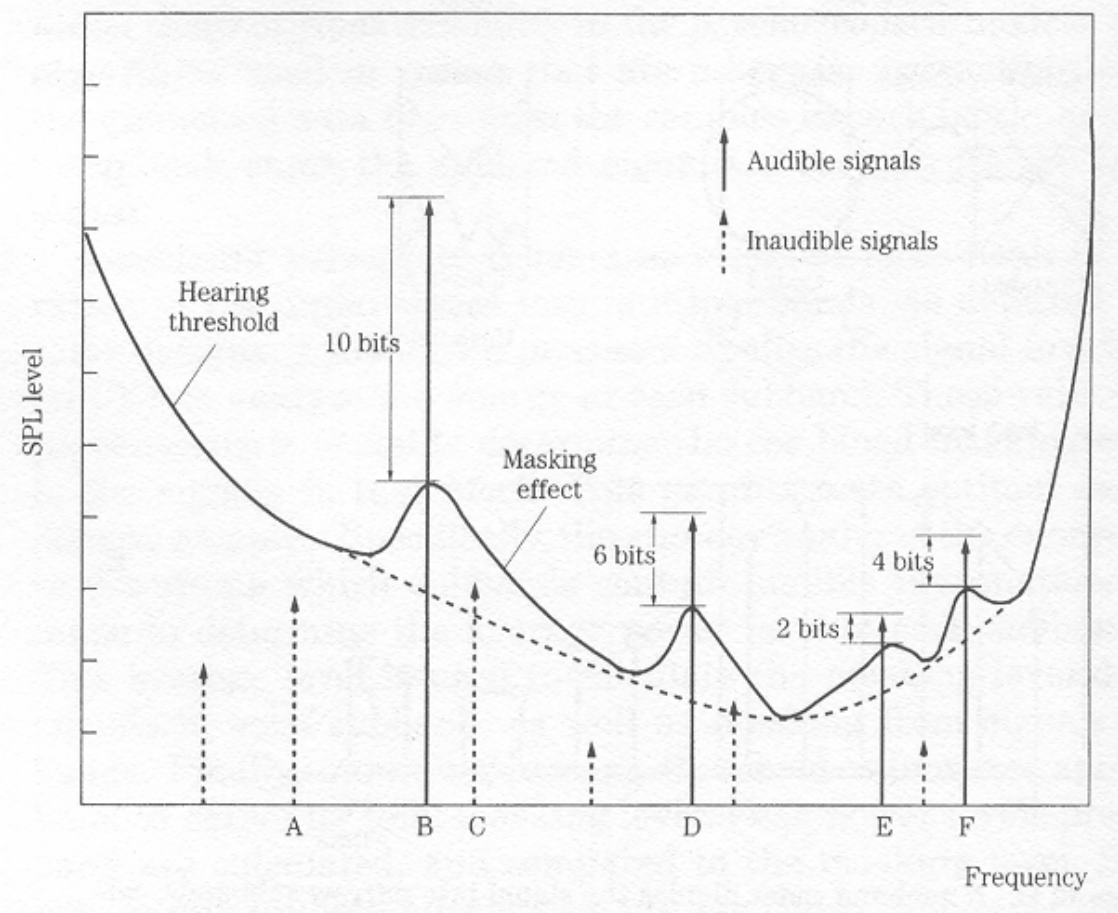
- High compression ratio achieved by exploiting knowledge of human perceptual limitations
- mp3 coding has 4 distinct parts:
  - Transform time to frequency domain, and grouping of audio signal into frequency subbands
  - Apply psychoacoustic model whereby sound components below a certain threshold or which are masked by a large signal in the same frequency subband (using the known behaviors of human hearing) may be discarded
  - Quantization and coding to keep noise below the level which can be discerned by the human ear
  - Output data frame packing to format the quantized audio data into a decodable data-stream

# Behaviors of Human Hearing




- Minimum hearing threshold
- Amplitude masking

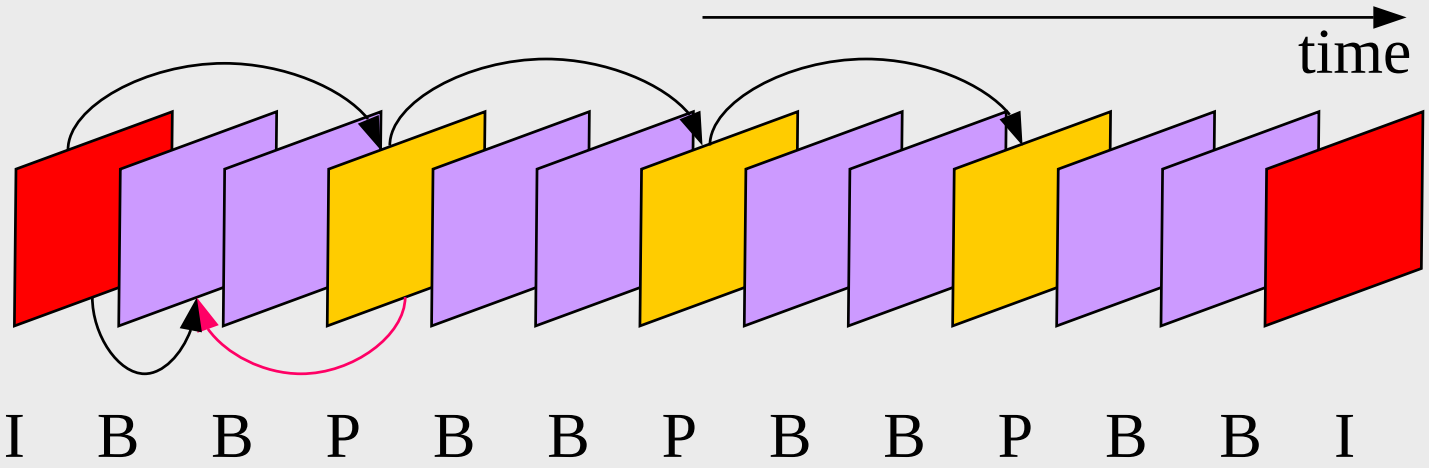
# Sub-band Coding



# MPEG-1 Video coding

- MPEG-1 achieves high compression ratio by exploiting four types of redundancy in the data stream for a moving image:
  - Interframe redundancy
  - Interpixel redundancy within a frame
  - Psychovisual redundancy
  - Entropic encoding redundancy
- Interpixel redundancy reduced by DCT and Huffman coding
- Interframe redundancy: complete pictures are only sent in key frames (Intrapicture or I- frames). Changes between I-frames are sent as P-frames (predicted frames) and changes are smoothed by adding highly compressed B-frames (bidirectional) between the I and P frames

# MPEG-1 : Exploiting inter-frame redundancy




| Type | Size | Compression |
|---|---|---|
| I | 18 KB | 7:1 |
| P | 6 KB | 20:1 |
| B | 2.5 KB | 50:1 |
| Avg | 4.8 KB | 27:1 |

# MPEG-1 and MPEG-2

| | MPEG-1 | MPEG-2 |
|---|---|---|
| ***Standard Finalized in*** | 1992 | 1994 |
| ***Spatial Resolution*** | 1/4TV (CIF Format)<br>~288 x 360 pels | TV: ~ 576 x 720 pels<br>HDTV: 1152 x 1440 pels |
| ***Temporal Resolution*** | 25 - 30 frames/s | TV: 50-60 fields/s<br>HDTV: 100-120 fields/s |
| ***Bit Rate*** | 1.5 Mbit/s | TV: ~4 Mbit/s<br>HDTV: ~20 Mbit/s |
| ***Quality*** | comparable to VHS | TV: comparable to NTSC/PAL |
| ***Compression Ratio*** | 20 - 30 | 30-40 |

# Summary

- Compression of images and sound can be lossy because of limitations in the human perception of sound and images
- MPEG-1 (VCDs) and MPEG-2 (DVD and digital broadcasting) reduce the bandwidth needed for transmitting moving pictures and sound by a factor of about 30