3 Graphics and Image Data Representation

- Categories of Images
  - 1-Bit Images, 8-Bit Grey-Level Images, 24-Bit Color Images
  - Definitions, Storing space, and Usage
  - The feature of 32-bit color image
- 8-Bit Color Images
  - Concept and features
  - Applications
- LUTs(Color Lookup Tables)
- Dithering Algorithm
  - an $N * N$ matrix represents $N^2 + 1$ levels of intensity
  - 打印机

4 Color in Image and Video

- Gamma Correction
  - Concept
  - Method: $R \rightarrow R' = R1/\gamma \rightarrow\rightarrow (R')\gamma \rightarrow R$
- Other color models
  - HSL(HSB)——hue, Saturation, Lightness/Brightness
  - HSV——Hue Saturation Value
  - HIS——Hue, Saturation and Intensity
  - HCI——C=Chroma
  - HVC——V=valu
- Color Models in Images
  - RGB color model for CRT Display
  - CMY color model
  - Transformation from RBG to CMY
- Color Models in Video
  - YUV, YIQ, YCbCr
  - Definition and application
  - Relationship of various models

$$
\begin{gathered}
Y = 0.299R + 0.587G + 0.114B \\
\text{Chrominance as: } -U = B - Y; V = R - Y \\
I = 0.736(R - Y) - 0.268(B - Y) \\
Q = 0.478(R - Y) + 0.413(B - Y) \\
Cb = (B - Y)/1.772 + 0.5 \\
Cr = (R - Y)/1.402 + 0.5
\end{gathered}
$$

5 Fundamental Concepts in Video

- Types of Video Signals
  - Component video, Composite Video, s-Video
  - Concepts and Usages
- Analog Video
  - Related Concepts
    - Progressive and interlace scanning
    - vertical retrace and horizontal retrace
    - Field and frame
  - NTSC, PAL and SECAM
  - How to encoding and decoding the composite video signal
  - Chroma subsampling
- Digital video CCIR standard
  - NTSC standard
    - 525 lines; 858 pixels(where, 720 is visible)
    - 4:2:2 schema
    - one pixel——2bytes
  - 4CIF/CIF/QCIF/SQCIF
  - HDTV

6 Basics of Digital Audio

- Quantization
  - Sampling in the amplitude dimension
    - Uniform sampling
    - Nonuniform sampling
- Nyquist Theorem
  - Nyquist rate
    - For correct sampling, sampling rate must be at least twice the maximum frequency content in the signal
    - Nyquist frequency: Half the Nyquist rate
- Some basic concepts
  - SNR
  - SQNR
  - Linear and Nonlinear Quantization
    - U-Law; A-Law
- Coding of Audio
  - PCM, Pulse Code Modulation
  - DPCM, Difference version of PCM
  - ADPCM, Adaptive DPCM
- How to calculate the bit-rate of coded audio signal

  采样频率48kHz，量化位数32位，4声道：每个采样点4*32=128bit，每秒48000个采样点，bit-rate为128*48000 bit/sec

- PCM signal encoding and decoding
- DPCM workflow

7 Lossless Compression Algorithms

- Basics of Information Theory
  - The entropy of an information source(熵)
    - Alphabet S={s1,s2,...,sn}
    - $\eta = H(S)$
    - $-\Sigma_{i=1}^{n} p_i \log_2 p_i$
  - Self-information: $\log_2 \frac{1}{P_i}$
  - The concept of entropy
    - A measure of the disorder of a system
    - The more entropy, the more disorder
- Identifying often-occurring symbols as short codewords
- Lossless Coding Algorithms
  - RLC(Run-Length Coding)
  - Variable-Length Coding
    - Shannon-Fano algorithm
    - Huffman Coding
    - Adaptive Huffman Coding
  - Dictionary-Based Coding
  - Arithmetic Coding
- Lossless Image Compression
  - Differential Coding
  - Lossless JPEG

8 Lossy Compression Algorithms

- The Rate-Distortion Theory
  - Distortion Measures
    - MSE, SNR, PSNR
  - The concept of R(D)
- Quantization: The heart of any lossy sheme
  - Nonuniform Scaler Quantization
    - The LIoyd-Max Quantizer
    - The companded Quantize
  - Uniform Scalar Quantization
  - Two types quantizers: midrise and midtread
- Transform Coding
  - 1D DCT
  - 2D DCT

9 Image Compression Standards

- Main Steps in JPEG Image Compression
- JPEG Modes
  - Sequential Mode
  - Progressive Mode
  - Hierarchical Mode
  - Lossless Mode
- JPEG Bitstream

10 Basic Video Compression Techniques

- Basic Concept
  - Temporal redundancy: Predictive Coding
    - Subtract images in time order
    - Code the residual error
  - Better methods:
    - Search for the right parts
    - Motion Estimation
    - Motion Compensation
- Video Compression Based on Motion Compensation
  - Reduce spatial redundancy and temporal redundancy
  - Intra-Frame: similar as JPEG
  - Inter-Frame: based on motion prediction and compensation
- The three main steps
  - Motion estimation: motion vector search
  - Motion-compensation: based prediction
  - Derivation of the prediction error
- Search For Motion Vectores
  - Criteria of matching($MAD(i,j)$)
  - Sequential Search
  - 2D-Logarithmic-search
  - Hierarchical Search
- H.261-Overview
  - 2 video format: QCIF, CIF
  - 2 type frame image: I-Frame, P-Frame
  - Coding method: Intra-frame, inter-frame
- Quantization in H.261
  - Constant Step-size in the range $[2, 62]$ instead of 8*8matrixes

$$QDCD = \lfloor \frac{DCT}{step\_size} \rfloor = \lfloor \frac{DCT}{2 \times scale} \rfloor$$

  - Intra-frame, for DC, stepsize=8

- H.263-overview
    - sub-QCIF, 4CIF and 16CIF
    - GOBs don't have a fixed size
    - half-pixel positions
- Optional H.263 Coding Modes
    - Unrestricted motion vector mode
    - Syntax-based arithmetic coding mode
    - Advanced prediction mode(4 MV for a macroblock)
    - PB-frames mode

11 MPEG Video Coding

- MPEG-1-Overview
    - Support only non-interlaced Video
    - 352*240 for NTSC at 30 fps
    - 352*288 for PAL at 25 fps
    - 4:2:0 chroma subsampling
- Difference from H.261
    - B frames——Bidirectional Motion Compensation
    - Format specifications
    - Picture can be divided into 1 or more slices
    - Different quantization tables for intra- and inter- coding
    - Motion vectors to be of 0.5pixel
    - Larger gaps between I and P frames and larger motion-vector search range
- MEPG-2 Scalabilities
    - SNR
    - Spatial
    - Temporal
    - Data
- Other Major difference from MPEG-1
    - Better resilience to errors
    - Support to 4:2:2 and 4:$:4 chroma subsampling
    - Nonlinear restricted structure
    - More restricted slice structure
    - More flexible video formats
- MPEG-4-Overview
    - User interactivities
    - A large range between 5kbps and 10Mbps
    - Some characteristics
        - Motion Compensation
        - Object based coding
        - Arbitrary Shape Coding
        - Static texture coding
        - Face object coding and Animation
        - Body object coding and Animation