Image Compression

- What to code:
  - How to quantize
  - How to do bit allocation

- Lossy vs. lossless.

- Request on compression system:
  - Compression efficiency/ratio
  - Encode/decode complexity

- Video: very low delay for interactive applications < 150 msec.

  - Strategy: one-time encode → many-time decode

April 19, 06
Image Compression

"What To code?"

1. Waveform Coding
   - PCM = Pulse Code Modulation
   - DPCM = Differential

2. Transform coding
   - DCT
   - KLT

3. Subband/Wavelet/Multiresolution Coding

4. Fractal Coding, Vector quantization
Video coding → motion estimation/Compensation
Audio coding

Pick one standard.

→ JPEG
→ JPEG 2000
→ MP3
→ H.264, H.263
→ MPEG 1, 2, 4

How to Evaluate/calculate various compression techniques

\[ f(u_1, u_2) \rightarrow \text{Compression} \rightarrow \hat{f}(u_1, u_2) \]
Normalized mean square error

\[ \text{NMSE in } \% = 100 \left( \frac{\text{Var} \left[ f(n, \text{sn2}) - \hat{f}(n, \text{sn2}) \right]}{\text{Var} \left[ f(n, \text{sn2}) \right]} \right) \% \]

\[ \text{SPR in dB} = 10 \log_{10} \left( \frac{\text{NMSE in } \%}{100} \right) \text{ dB} \]

\[ \text{SPR in dB} = 10 \log_{10} \left( \frac{\text{Var} (f)}{\text{Var} (\hat{f} - f)} \right) \]
Pulse Coding Modulation

Encoder: \( f(u_1, u_2) \) → Uniform Quantize → \( \hat{f}(u_1, u_2) \)

Show 10.22 (a), (b) J. Lin.

How To fit

Robert's Pseudonoise Technique.

Transmitter/Receiver
$f(n_1, n_2) \rightarrow + \rightarrow \text{uniform quantizer} \rightarrow + \rightarrow f(n_1, n_2)$

$W(n_1, n_2)$ is known both at $Rx$ and at $Tx$.

Choose $W(n_1, n_2) = \text{white noise seq with uniform PDF}$.

$$P_W(W_0) = \begin{cases} \frac{1}{\Delta^2} & -\frac{\Delta}{2} < W_0 < \frac{\Delta}{2} \\ 0 & \text{otherwise} \end{cases}$$

$\Delta$ = quantization step size.
Improve visual quality by doing postprocessing to reduce noise.

Delta Modulation

\[ e(n) = \frac{A}{2} \cdot a - \frac{A}{2} \]
Recall $\hat{e}(a) = e(a) - \hat{e}(a) = e(a) - \hat{e}(a)$

$$\frac{\hat{e}(a)}{e(a)} = \frac{\hat{e}(a)}{\hat{e}(a)} = 1$$

Quantization noise $f(a) - f(a) = \hat{e}(a) - \hat{e}(a)$

How to plot $D$ optically.
DPCM = Differential Pulse Code Modulation

Transmitter

\[ f(n_1, n_2) \]

\[ \hat{e}(n_1, n_2) \]

\[ \hat{e}(n_1, n_2) \rightarrow e(n_1, n_2) \rightarrow f(n_1, n_2) \]

\[ \hat{f}(n_1, n_2) \rightarrow f(n_1, n_2) \]

\[ f(n_1, n_2) \]

\[ \hat{f}(n_1-1, n_2) \rightarrow f(n_1-1, n_2-1) \rightarrow \hat{f}(n_1-1, n_2-1) \]

Prediction

Previously coded pixels:
- \[ f(n_1-1, n_2) \]
- \[ f(n_1, n_2-1) \]

delay
Receive \( e(n,m) \)

\[
f(n,m) = \text{delay} \rightarrow f(n,m) \\
\text{Prediction} \rightarrow f(n-1,m) \\
\text{Correction} \rightarrow f(n,m)
\]
How to do Prediction

\[ f(n_1, n_2) = \sum_{(k_1, k_2) \in \mathbb{R}_a} \sum a(k_1, k_2) \hat{f}(u_1 - k_1, n_2 - k_2) \]

how to choose a

\[ \min_{\hat{e}} E[e^2(n_1, n_2)] = \frac{1}{2} \sum_{(k_1, k_2) \in \mathbb{R}_a} \sum a(k_1, k_2) \hat{f}(u_1 - k_1, n_2 - k_2) \]

\[ E[(f(n_1, n_2) - \hat{f}(u_1 - k_1, n_2 - k_2))^2] \]