Method to Increase Watermark Robustness

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April 30, 2003
Introduction

- What is watermarking?
- How does it relate to a channel problem?
- How can we make watermarking more reliable?
- Possible solution: Add redundancy!
  - Made possible by multiple audio channels
  - Use multiple watermarking schemes
Overview of Method
Error Correction: Linear Block Codes

- A \((n, k)\) block code is ...
  - Defined by \(M = 2^k\) binary sequences of length \(n\).
  - Code words make up code set
- Linear – Any linear combination of two code words is also a code word.
- Example: \((5,2)\) – \(\{00000, 10100, 01111, 11011\}\)
- Hamming codes
  - \(n = 2^m - 1\)
  - \(k = 2^m - m - 1, m \geq 2\)
  - Uses parity to determine which bit (if any) has flipped because of channel
- Decode using “soft” or “hard” decision
Quadrature Amplitude Modulation

- Combined digital amplitude and phase modulation

\[ u_m(t) = A_{mc} \cdot g_T(t) \cdot \cos(w_c t) + A_{ms} \cdot g_T(t) \cdot \sin(w_c t) \]
  - \( u_m(t) \) is the transmitted signal
  - \( g_T(t) \) is the transmission pulse
  - \( \{A_{mc}, A_{ms}\} = \) set of amplitude levels

- \( M \) = number of QAM constellation points
- Simultaneously transmit \( \log_2(M_1 \cdot M_2) \) bits

  - \( M_1 = 2^{k_1} \)
  - \( M_2 = 2^{k_2} \)
Geometric representation of encoded symbol $s_m$

$$s_m = \left( \sqrt{E_s} A_{mc}, \sqrt{E_s} A_{ms} \right)$$
Revised Block Diagram
Watermark Method 1: Echo Hiding

- **Authors:** Daniel Gruhl, Anthony Lu, Walter Bender
Echo Hiding - Decoding

Step 1 - Find cepstrum of $y[n] = \text{conv}(x,e)$

Step 2 – Find autocepstrum of $y[n]$

Step 3 - Find peak at echo offset
Method 2 – LSB Replacement

- **Current Implementation**
  - Take cover audio
  - Replace LSB with hidden message
  - Encode length of hidden message

- **Future Implementation**
  - Spread message bits in time using a m-sequence
Results

- **Echo Hiding**
  - Inaudible for echo decay rate of .3
  - Noticeable for decay rates above .6

  | orig. | 0.3 | 0.7 | 1.0 |

- **LSB Encoding**
  - Great for replacing bits 10 - 16
  - Likely to be more susceptible to attacks

- **Expected results of channel coding**
  - Improved reliability and robustness
  - *At worst*, no change.
Future Work

- Investigate other forms of error correction encoding
- Explore other methods of QAM decoding
- Use more sophisticated watermarking schemes
- Can extend this approach to higher dimensional signals, such as Dolby 5.1 Surround sound.