Video Compression Basics

Why Compression Is Critical

- **Digital video formats generate huge numbers of bits**
  - HD video creates 1 *trillion* bits every 12 minutes
- **Bits are not free**
  - A cost to store, transmit each one
  - However small the cost becomes per bit, any number multiplied by trillions is still large
- **Bits are not unlimited**
  - Transmission and storage have physical limits
  - Limits expand over time *but* operations usually constrained by older infrastructure

Value and Types of Compression

- **By eliminating bits, compression will**
  - **Cut costs**
  - **Fit data within current physical limits for storage, transmission**
- **Two basic types of compression**
  - **Lossless: eliminate just redundant bits**
    - **Modest reductions (for images, 2-3X on average)**
    - **Decompression reproduces exact original dataset**
  - **Lossy: eliminate least important bits (too)**
    - **Major reductions (up to 100X or more)**
    - **Decompression reproduces only a similar copy**
      - May be indistinguishable (to HVS) from original

Human Visual System (HVS)

- **Visual inputs are very heavily processed**
  - **Visual cortex most massive system in brain**
  - **Intended to let us see what is *important***
    - Don't see everything in our field of vision
    - Don't notice everything we see

- **Lossy image compression makes use of limits and preferences of HVS**
  - **Keeps cost/effort of digital video manageable**
  - **Produces images that are "good enough"**
    - HVS can't appreciate perfection, even if we could afford to achieve it

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Digital Compression Overview

- **Like many other technical subjects**
  - Basic ideas are simple, difficulty is all in details
  - Principles, strategies, terminology easy to understand
  - Don't need to know the math
- **Why better video compression is better**
  - Higher image quality for same cost
  - Lower cost for same image quality
  - Makes possible what otherwise would not be technically feasible

Compression Strategy

- **First, eliminate least interesting bits**
  - "Lossy" compression is fundamental
  - Preserve picture quality *relative to HVS*
  - Stop when reach target bits-per-second rate
    - The lower the bit rate, the more challenging the task of preserving picture quality

- **Then, eliminate redundant bits in remainder**
  - Lossless "entropy" encoding

Compression Standards

- **Best-known standards from joint ISO & ITU expert groups**
  - ISO: International Standards Organization
  - ITU: International Telecommunications Union
  - JPEG (Joint Photographic Experts Group)
    - Still pictures, formed in 1986
  - MPEG (Motion Pictures Experts Group)
    - Moving pictures, formed in 1988

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Why Lossy Compression?

- **Most important image compression technologies (JPEG, MPEG, etc.) are lossy**
  - **Simply too much data for lossless compression (2-3X reduction not interesting)**
  - **Lossy compression is a spectrum**
    - **Nondegrading: increasing differences from original when uncompressed, but still unnoticeable**
    - **Degrading: differences from original increasingly noticeable when uncompressed, but still within acceptable limits**
      - "Acceptable" relative to purpose, audience, and available bit budget