

Image and Video Compression

CS457 Seminar
Gulcin Caner
November 25, 2001

Outline

- ✦ Introduction
- ✦ Lossless compression
- ✦ JPEG (Still image compression standard)
- ✦ Video compression standards
- ✦ Multiple description coding (MDC)

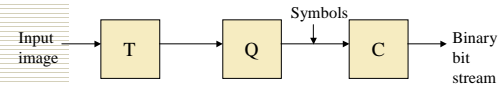
What makes compression possible ?

- ✦ Image signals contain a high degree of
 - spatial redundancy
 - psychovisual redundancy

The higher the redundancy, the higher the achievable compression !

Basic Components

Elements of an image compression system



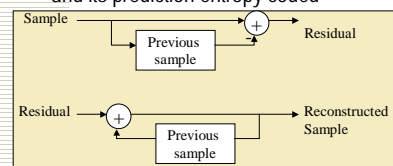
- Transformation: Compact energy in a few coefficients for efficient compression
- Quantization: Reduce the number of symbols to represent data
- Symbol Coding: Minimize the average length of binary codes representing the symbols, entropy coding(VLC), Huffman Codes

Lossless Compression Algorithms

- ✦ Run-length coding of bit planes
 - Image is decomposed into bit planes
 - Run lengths of zeros and ones in these planes are entropy coded
- ✦ Dictionary-based methods
 - Lempel-Ziv compression algorithm, best known
 - Used for compression of binary data files

Cont'd

- ✦ Lossless predictive coding
 - Difference between the actual intensity of the pixel and its prediction entropy coded



Block diagram of a simple predictor

JPEG

- ✦ Discrete Cosine Transform(DCT)
 - Near-optimum energy compaction
 - Converts 8*8 matrix of pixel values into 64 spatial frequencies
 - First frequency coefficient called DC coefficient, the rest AC coefficients
- ✦ Quantization
 - Eliminates the coefficients that carry the least amount of information

Cont'd

- Uses quantization matrix,

$$S(k1,k2) = \text{NINT}\{S(k1,k2)/Q(k1,k2)\}$$
 - Weighted quantization, adapted to human visual system
- ✦ Coding
 - Zigzag scan all AC coefficients
 - Coefficients along zigzag line mapped into symbols (run, level), and symbols entropy coded
 - DC coefficient separately encoded

Video Compression

- ✦ Approaches to video compression
 - Intra-Frame compression (eg JPEG)
 - Inter-Frame compression (eg MPEG)
- ✦ Video Compression Standards
 - MPEG-1
 - MPEG-2
 - MPEG-4
 - H.261
 - H.263

MPEG Video Compression

- ✦ Real-time decoding
- ✦ Group of pictures (GOP), slices
- ✦ I, B, and P pictures

Multiple Description Coding

An Error Resilient Data Compression Algorithm

Motivation

- ✦ Transient channel shutdowns
- ✦ Network congestion
- ✦ A deep fade in wireless communication

Our goal is to develop data compression algorithms, capable of producing representation of images, which are robust to the presence of errors of this nature

Conventional Approaches to Overcome Packet Loss

- Retransmission based approaches :
Not an appropriate solution, in cases when a back-channel is not available or when delay is not acceptable
- FEC (forward error correction) based approaches :
For highly dynamic network conditions, an inefficient or ineffective solution

Description of MDC

- Source is encoded into multiple, equally important descriptions
- Each description can be decoded independently
- One decoded description achieves a reasonable quality of the reconstructed signal, whereas more than one decoded description can be combined to give a better quality

Why MDC ?

- Suitable for noisy channels with long bursts of errors, such as mobile channels or internet
- Reduces probability of an outage (where all packets are lost during outage)
- A good option for applications which can not tolerate retransmission
- Solves error propagation problem in motion compensated prediction based coders
- Superior to layered approaches, eg multi-resolution coding

Two MDC approaches

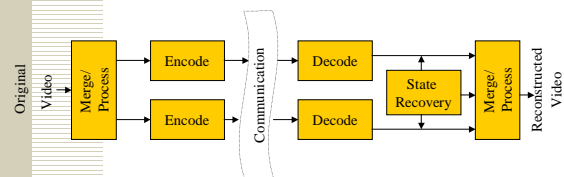
- Source interleaving
- Using multiple description scalar quantizer

Source Interleaving

- Designed to prevent error propagation in motion compensated prediction based coders
- In the simplest approach, video is partitioned into two subsequences of frames (even and odd)
- Each subsequence is encoded separately, and transmitted over different channels

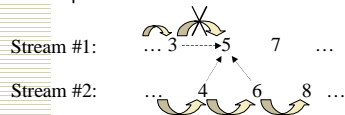
Source Interleaving (Cont'd)

A two-state video communication system



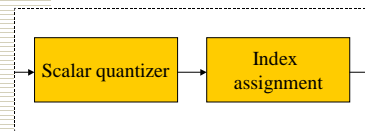
Source Interleaving (Cont'd)

- State recovery at decoder
 - "MCinterp"
 - "InplaceMC"



MD Scalar Quantizer

- Consists of two main components,
 - Scalar quantizer
 - Index assignment



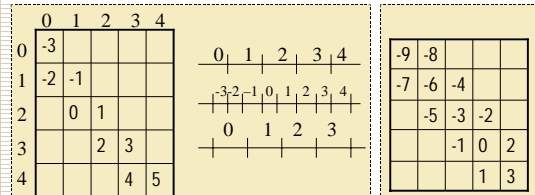
Multi description scalar quantizer

Cont'd

- MD transform coding architecture

Index Assignment

Two index assignments:



a) Staggered quantization cells

b) Higher spread cells