EE 5359 Sections 551, 560 and 572  
Summer 2003 TTh 6:00-7:50 PM  
Room: 112 NH

Instructor: K.R. Rao 
Office: Room 530 NH 
Office Hours: Monday, 11 a.m. - 12 noon  
Wednesday 2 p.m. - 3 p.m. 
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Course WWW site: http://www-ee.uta.edu/dip 

Required Textbook(s): 


Course description 
The course covers the fundamentals, principles, concepts and techniques of data (video/audio) compression such as: 
* Huffman coding  
* Arithmetic coding  
* Lempel-Ziv coding  
* G3 and G4 Facsimile coding  
* Scalar quantization  
  • Differential pulse code modulation  
  • Delta modulation  
  • Mathematical preliminaries for lossy coding  
  • Mathematical preliminaries for transforms, subbands and wavelets  
* Subband coding  
* Transform coding  
* Hybrid (mixed) coding  
* Brief introduction to ITU/ISO/IEC standards related to audio/video/image/data compression  
* Vector quantization  
  • Motion estimation and motion compensation  
  • Wavelet- based compression  
  • Analysis/synthesis schemes  
  • Video compression  
  • Course learning Goals/Objectives
The goals of the course are to familiarize the students with these techniques so that they have not only a thorough grasp but also the ability to implement them through computer projects (simulation) using standard test sequences.

**Attendance and drop policy**
Follow university guidelines

**Tentative Lecture/Top Schedule (Course Content)**

**Introduction**
Compression Techniques..............................................
  Lossless Compression...........................................
  Lossy Compression............................................
  Measures of Performance.................................
Modeling and Coding...........................................
Coding..............................................................
  Uniquely Decodable Codes............................
  Prefix Codes................................................

**Huffman Coding**
Overview............................................................
The Huffman Coding Algorithm...............................
  Minimum Variance Huffman Codes.....................
Golomb Codes.................................................
Rice Codes.......................................................
  CCSDS Recommendation for Lossless Compression
Tunstall Codes................................................
Application of Huffman Coding............................
  Lossless Image Compression.........................
  Text Compression...........................................
  Audio Compression........................................

**Arithmetic Coding**
Overview..........................................................
Introduction....................................................
Coding a Sequence............................................
  Generating a Tag........................................
  Deciphering a Tag..................................
Generating a Binary Code..................................
  Uniqueness and Efficiency of the Arithmetic Code
  Algorithm Implementation.........................
  Integer Implementation..........................
Comparison of Huffman and Arithmetic coding........
Applications....................................................
  Bi-level Image Compression-The JBIG Standard....
  JBIG2.....................................................
  Image Compression.....................................
Dictionary Techniques
Overview .................................................................
Introduction ............................................................... 
Static Dictionary ...........................................................
The LZ77 Approach .......................................................... 
The LZ78 Approach ..........................................................
Applications .................................................................
File Compression-UNIX Compress ............................................. 
Image Compression-The Graphics Interchange Format (GIF)....
Compression over Modems-V.42 bis .................................

Predictive Coding
Overview .................................................................
Introduction ............................................................... 
Prediction with Partial March (\textit{ppm}) .................................
The Basic Algorithm ......................................................
The Escape Symbol ......................................................
Length of Context ......................................................
The Exclusion Principle ...................................................
The Burrows-Wheeler Transform ........................................... 
Move-to-Front Coding ...................................................
CALIC .................................................................
JPEG-LS .................................................................
“Current” Standard ......................................................
“New” Standard ....................................................... 
Multiresolution Approaches .............................................
Progressive Image Transmission ...........................................
Facsimile Encoding ......................................................
Run-Length Coding .....................................................
CCITT Group 3 and 4-Recommendation T.4 and T.6 ..............
Comparison of MH, MMR, and JBIG ................................. 
Dynamic Markov Compression ...........................................

Scalar Quantization
Overview .................................................................
Introduction ............................................................... 
The Quantization Problem ..................................................
Uniform Quantizer ......................................................
Adaptive Quantization ..................................................
Forward Adaptive Quantization ...........................................
Backward Adaptive Quantization ....................................... 
Nonuniform Quantization ................................................
\textit{Pdf}- Optimized Quantization ....................................
Companded Quantization ............................................... 
Entropy-Coded Quantization .............................................
Entropy Coding of Lloyd-Max Quantizer

Vector Quantization

Overview
Introduction
Advantages of Vector Quantization over Scalar Quantization
The Linde-Buzo-Gray Algorithm
  Initializing the LBG Algorithm
  The Empty Cell Problem
  Use of LBG for Image Compression
Tree-Structured Vector Quantizers
  Design of Tree-Structured Vector Quantizers
  Pruned Tree-Structured Vector Quantizers
Structured Vector Quantizers
  Pyramid Vector Quantization
  Polar and Spherical Vector Quantizers
  Lattice Vector Quantizers
Variations on the Theme
  Gain-Shape Vector Quantization
  Mean-Removed Vector Quantization
  Classified Vector Quantization
  Multistage Vector Quantization
  Adaptive Vector Quantization
Trellis-Coded Quantization

Differential Encoding

Overview
Introduction
The Basic Algorithm
Prediction in DPCM
Adaptive DPCM
  Adaptive Quantization in DPCM
  Adaptive Prediction in DPCM
Delta Modulation
  Constant Factor Adaptive Delta Modulation (CFDM)
  Continuously Variable Slope Delta Modulation
Speech Coding
  G.726
Image Coding
Transform Coding
Overview .............................................................................................
Introduction ...........................................................................................
The Transform .........................................................................................
Transform of Interest ............................................................................... Karhunen-Loeve Transform .............................................................
Discrete Cosine Transform.................................................................
Discrete Walsh-Hadamard Transform ............................................
Quantization and Coding of Transform Coefficients ......................
Application to Image Compression-JPEG ...........................................
The Transform .........................................................................................
Quantization .........................................................................................
Coding ......................................................................................................
Application to Audio Compression .....................................................

Subband Coding
Overview .............................................................................................
Introduction ...........................................................................................
Filters ........................................................................................................
Some Filters Used in Subband Coding ................................................
The Basic Subband Coding Algorithm ................................................
Analysis ..................................................................................................
Quantization and Coding .....................................................................
Synthesis ..............................................................................................
Design of Filter Banks * ....................................................................... Downsampling * ..................................................................................
Upsampling * ........................................................................................
Perfect Reconstruction Using Two-Channel Filter Banks * .............
Two-Channel PR Quadrature Mirror Filters * ................................
Bit Allocation ........................................................................................
Application to Speech Coding-G.722 ............................................... Application to Audio Coding-MPEG Audio ..................................
Application to Image Compression .....................................................
Decomposing and Image ......................................................................
Coding the Subbands ...........................................................................

Wavelet-Based Compression
Overview .............................................................................................
Introduction ...........................................................................................
Wavelets ............................................................................................... Multiwavelet Analysis and the Scaling Function .........................
Implementation Using Filters .............................................................
Scaling and Wavelet Coefficients ....................................................... Families of Wavelets .................................................................
Image Compression.................................................................
Embedded Zerotree Coder......................................................
Set Partitioning in Hierarchical Trees....................................
JPEG 2000..........................................................................

Analysis/Synthesis Schemes
Overview.............................................................................
Introduction.........................................................................
Speech Compression.............................................................
   The Channel Vocoder......................................................
   The Linear Predictive Coder (Government Standard LPC-10)
   Code Excited Linear Prediction (CELP)..........................
   Sinusoidal Coders...........................................................
Image Compression.............................................................
   Fractal Compression......................................................

Video Compression
Overview.............................................................................
Introduction.........................................................................
Motion Compensation...........................................................
Video Signal Representation...................................................
Algorithms for Videoconferencing and Videophones...............  
   ITU-T Recommendation H.261.....................................
   Model-Based Coding......................................................
Asymmetric Application.......................................................  
   The MPEG-1 Video Standard....................................
   The MPEG-2 Video Standard....................................
   MPEG-4........................................................................
   MPEG-7........................................................................

First day of classes: May 27, 2003
Census date: June 2, 2003
Last date to drop or withdraw: July 25, 2003
Last day of classes: August 8, 2003

Test#1: Thursday, June 19, 2003
Test#2: Thursday, July 17, 2003
Final: Tuesday, Aug. 12, 2003
Grading:  

**PLAN A**  
Test 1  30%  
Test 2  30%  
Final  30%  
Design projects 10%  

A=95-100%  
B=85-94%  
C=75-84%  
D=65-74%  

**PLAN B:**  
(for those who miss a test – not recommended)  
Max of Test 1 and Test 2: 45%,  Final: 45% , Design projects; 10%  

Course grades are based on max. of Plan A and Plan B, i.e., whichever is higher.  

Everyone must take the final.  

1. No makeup. 2. No incomplete. Final exam papers will not be returned. The student, however, has the right to look at his/her exam paper and discuss it with the instructor. Final exam papers will be kept until the midsemester of the following semester. Summer counts as one semester. (No telephone calls or inquiries regarding course grades, please.) Everyone must take the tests and final exam at the same time and at the same place. If you have any questions on your returned tests, please do so within a week. Please bring your work, key and the test. **Videotape students** take the tests one week later at the company sites. Contact: Engineering center for distance education (Room 242 Nedderman Hall): Donya 1-817-272-2352, email: drandolph@uta.edu

**Student Evaluation of Teaching**  
Evaluation forms will be given to the students at the end of the semester.  

**Americans with Disabilities Act:**  
The University of Texas at Arlington is on record as being committed to both the spirit and letter of federal equal opportunity legislation; reference Public Law 93112-The Rehabilitation Act of 1973 as amended. With the passage of new federal legislation entitled Americans with Disabilities Act - (ADA), pursuant to section 504 of The Rehabilitation Act, there is renewed focus on providing this population with the same opportunities enjoyed by all citizens.  
As a faculty member, I am required by law to provide "reasonable accommodation" to students with disabilities, so as not to discriminate on the basis of that disability. Student responsibility primarily rests with informing faculty at the beginning of the semester and in providing authorized documentation through designated administrative channels.  
If you require an accommodation based on disability, I would like to meet with you in the privacy of my office, during the first week of the semester, to make sure you are properly accommodated.  

**Academic Dishonesty**
It is the philosophy of The University of Texas at Arlington that academic dishonesty is a completely unacceptable mode of conduct and will not be tolerated in any form. All persons involved in academic dishonesty will be disciplined in accordance with University regulations and procedures. Discipline may include suspension or expulsion from the University.

"Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts." (Regents' Rules and Regulations, Part One, Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22).

ANY CHEATING WILL RESULT IN SEVERE PENALTIES.