EE-597 **Fall 1999**

Handout #1 August 26, 1999

EE-597: Audio Signal Processing – Coding and Restoration

Instructors: Phil Schniter (and Prof. Rick Johnson)

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Class Time and Place: Tu/Th 1:25-2:40pm, 314 Rhodes Hall (location may change)
Note: there will be no class on Thursday 9/23.

Number of Credits: 3 credits (letter grade or S/U) or 4 credits (letter grade only)

Prerequisites: EE-310, EE-425 (co-registration), MATLAB familiarity

Course Web Site: `http://www.ee.cornell.edu/~ee597`

Description: This course focuses on two audio applications to which sophisticated digital signal processing techniques have been applied: data-efficient coding of high-quality audio and restoration of corrupted audio. First the following compression tools/methods are presented: quantization, entropy coding, differential PCM, transform coding, and subband coding. Relevant aspects of psychoacoustics are introduced after which the MPEG perceptual coding technique is covered in detail. Shifting focus to restoration, we discuss model-based and statistical approaches to the estimation and removal of pops, clicks, background noise, pitch variations, and non-linear amplitude distortions.

Grading: Grades for the course will be determined by the students' performance on homework assignments, mostly MATLAB based. The weighting of the assignments will be announced during the semester. Students taking the course S/U will be expected to complete the *same* amount of work as those taking the course for a letter grade. For those who just want to "sit in," sign up as an auditor.

For students taking the course for 4 credits (as opposed to 3), an additional semester project will be due at the end of the semester which will count as 25% of the total grade. Project topics will be chosen by the students (with aid from the instructor if needed) and a short project proposal, due mid-semester, will be used to ensure the appropriateness of the project. Details will be provided during the first half of the semester. Only letter grades will be given for the 4 credit option.

Reading Materials: Course notes and related materials will appear on the course web site.

Computer Resources: As much of the work assigned in EE-597 will involve MATLAB processing of (and subsequent listening to) audio signals, each student must have access to a computer with MATLAB and the ability to play sound from MATLAB. The Windows-NT machines in Phillips 318 provide these abilities but require that *each student uses their own set of headphones* with 1/8" phone plug.

Syllabus:

I. Audio Coding
   (a) Quantization
      - uniform and nonuniform quantizer design and performance
      - entropy coding
      - adaptive quantization
   (b) Differential Pulse Code Modulation
      - linear prediction
      - DPCM design and performance
      - delta modulation
   (c) Transform Coding
      - orthogonal transformations
      - optimal bit allocation
      - performance analysis
   (d) Subband Coding
      - design of polyphase filterbanks with aliasing cancellation
      - performance analysis
   (e) MPEG Psychoacoustic Coding
      - psychoacoustic masking
      - filtering, quantization, and bit allocation
      - overview of MPEG standards (MPEG-1,2,4,7 / mp-1,2,3)

II. Audio Restoration
   (a) Detection of Pops/Clicks/Pulses and Estimation of Corrupted Samples
      - prediction-error detection,
      - LS gap filling based on AR signal model
      - Bayesian approaches
   (b) Background Noise Reduction
      - short-time spectral attenuation, "musical noise" phenomena

Related Reading: (* denotes Engineering Library reserve)

T. Berger, *Rate Distortion Theory*, Prentice-Hall, 1971.

T.A. Cover and J.A. Thomas, *Elements of Information Theory*, Wiley, 1991.

A. Gersho, *Vector Quantization and Signal Compression**, Kluwer, 1992.

S. Godsill, P. Rayner, and O. Cappé, "Digital Audio Restoration," in *Applications of Digital Signal Processing to Audio and Acoustics*, ed. M. Kahrs and K. Brandenburg, Kluwer, 1998. (`http://www-com-serv.eng.cam.ac.uk/~sjg/papers/97/chapt.ps.gz`)

ISO/IEC 13818-3, *Information Technology–Generic Coding of Moving Pictures and Associated Audio Information, Part 3: Audio**, 1998.

ISO/IEC 13818-7, *Information Technology–Generic Coding of Moving Pictures and Associated Audio Information, Part 7: Advanced Audio Coding**, 1997.

N.S. Jayant and P. Noll, *Digital Coding of Waveforms**, Prentice-Hall, 1984.

M. Kahrs and K. Brandenburg, *Applications of Digital Signal Processing to Audio and Acoustics**, Kluwer, 1998.

L.R. Rabiner and R.W. Schafer, *Digital Processing of Speech Signals*, Prentice-Hall, 1978.

K. Sayood, *Introduction to Data Compression**, Morgan Kaufmann, 1996.

U. Zolzer, *Digital Audio Signal Processing**, Wiley, 1997.