University of Wisconsin - Madison
College of Engineering [EGR]
Last Offered: 2011-2012 Spring [1124]
Direct Link to this Syllabus:

1. E C E 531, Speech Signal Processing
2. Credits : 3  Contact Hours : 3.0
3. Textbook and Materials:
   a. Other Supplemental Materials : None

   • Specific Course Information :
     a. Brief description of the content of the course (Course Catalog Description) :
        Aerodynamic and acoustic mechanisms of sound production in speech. Multi-tube acoustic
        models of the vocal tract. Pitch detection, spectrographic analysis by Fourier and LPC
        methods. Speech synthesis, low bit rate speech coding, feature extraction for speech
        recognition.
     b. Pre-requisites or Co-requisites : ECE 431 & Comp Sci 302
     c. This is a Selected Elective course.

   • Specific Goals for the Course :
     a. Course Outcomes :
        1. Implement the FFT (Fast Fourier Transform) in an algorithmic and object-oriented
           programming language such as Java or C++.
        2. Interpret sound spectrograms for the characteristics of fricative, nasal, and vowel
           portions of human speech, distinguish vowels on spectrograms based on their formant
           pattern, understand basic male/female acoustic differences relating to pitch ranges and
           ranges of vowel formants.
        3. Design and implement in software digital IIR (infinite impulse response) filters for the
           synthesis of speech sounds based on the series and the parallel formant models.
4. Write a software program to synthesize speech sounds from an acoustic tube model of the vocal tract accounting for acoustic losses, the yielding vocal-tract side wall, and the acoustic lip radiation load.

5. Implement in software a low-bit rate speech coder based on linear prediction or filter-bank principles. Relate the bit-rate reduction that may be achieved to characteristics of the speech spectrum and rate-distortion theory.

- **ABET Student Learning Outcomes:**
  
  (a) Ability to apply mathematics, science and engineering principles.
  (b) Ability to design and conduct experiments, analyze and interpret data.
  (e) Ability to identify, formulate and solve engineering problems.
  (g) Ability to communicate effectively.
  (i) Recognition of the need for and an ability to engage in life-long learning.
  (k) Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

- **Brief List of Topics to be Covered:**
  
  1. Object-oriented architecture for a software system for the acoustic analysis of speech, extending that system using object-oriented techniques of class derivation and design patterns.
  2. The FFT (Fast Fourier Transform) algorithm, the real-valued signal FFT, and its implementation in software.
  3. The interpretation of spectrum analysis of speech signals and relation to physiological processes in speech production.
  4. The source-filter model of speech production, digital filter models for the voice source and for the vocal tract.
  5. Vocal tract shapes for vowels, acoustic equivalent circuits to vocal tract shapes, computing the vocal tract transfer function from an acoustic transmission line description.
  6. Linear predictive coding (LPC) analysis: least-squares design of a serial-pole vocal-tract filter, the Levinson-Durbin algorithm for determining LPC coefficients, the relationship between the LPC vocal tract filter and an acoustic tube.
  7. Pitch analysis based on waveform correlations.
  8. Vocoder and waveform coders.