SUBJECT DESCRIPTION FORM

Subject title: Advanced DSP for Multimedia Communications

Subject code: EIE556

Credit value:
3

Responsible staff and department:
Prof. W.C. Siu, Dr Kenneth K.M. Lam, and Dr Y.L. Chan, EIE

Pre-requisite:
Nil

Recommended background knowledge:
The student is expected to have background knowledge of Digital Signal Processing in his undergraduate studies. In particular, he is expected to have a basic understanding of the following topics: linear systems, convolutions, FIR and IIR Digital Filters and Discrete Fourier Transform. Students without relevant background knowledge may consider taking EIE541 Digital Signal Processing first.

Mutual exclusions: Nil

Learning approach:

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<tr>
<th>Lecture/Seminar/Tutorial</th>
<th>Laboratory/Demonstration</th>
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<td>33 hours</td>
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<td>9 hours</td>
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Assessment:

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<th>Continuous Assessment</th>
<th>50%</th>
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<td>Examination</td>
<td>50%</td>
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Objectives:
This subject is to enable students to study advanced topics of digital signal processing, which include modern transforms, fast computational algorithms, DSP processor structures, adaptive filter design, wavelet theory for Image, Video, Speech, Audio, multimedia and Communication Applications. After the completion of this subject, the student should readily be able to realize modern DSP algorithms for Multimedia Communications and is possible to carry out research in the area.
Keyword syllabus:

1. **Basic Revision**
   FIR and IIR filters design, the discrete Fourier transform, FFT and basic theory of random processes. (3 hrs)

2. **Advance Digital Signal Processing Theory**
   **Optimal/Adaptive Filters for Multimedia Communication:**
   Linear Random processes; optimal filter design, Wiener filter; linear predictor, adaptive filter, Least Mean Square (LMS) filter and Recursive Least Square (RLS) filter. (7 hrs)

   **Fast Algorithms:**
   Cyclic Convolutions, Radix-2 fast Fourier transform(FFT), Radix-4 algorithm, Split-Radix algorithm, Rader algorithm, Goertzel algorithm, prime factor algorithm, and Winograd Fourier Transform Algorithm (WFTA). (3 hrs)

   **Modern Transforms for Multimedia Applications**
   *DCT (Discrete Cosine Transform)* - Orthogonal transforms, Karhumen Loeve transform, correlation properties, discrete cosine transform, fast DCTs and integer cosine transform.

   *Wavelet Transform* - multirate systems, wavelet basis and scaling function, continuous and discrete wavelet transforms, dyadic structure, multi-resolution analysis, pyramid algorithm, wavelet filters, realization and application examples. (7 hrs)

3. **Digital Processor Design and Realisation Techniques**
   Arithmetic consideration, high speed multiplication, fast techniques for sum-of-products evaluation, pipelining, memory hierarchy, Harvard architecture and parallel processor realisations, VLSI array processors and distributed arithmetic. Current digital signal processors (such as TMS320, DSP96000 or ARM families for Video Phone, PDA, other audio and visual applications), timing and error analysis. (3 hrs)

4. **Video Algorithms and Coding**
   Critical issues and fast algorithms for image coding and motion picture processing, motion estimation, and compression. Realisation aspects on video compression, standards, such as JPEG and MPEG, and essence of video-conferencing systems. (3 hrs)

5. **Speech and Audio Coding**
   DSP aspects of Linear Prediction Model, Realisation of speech processing & synthesis algorithms, speech processor structure.
   Audio Compression and Psychoacoustic Model, and AC3 and voice part of MPEG standard. (3 hrs)

6. **DSP in Multimedia Communications Systems**
   Applications of Advanced DSP techniques (choose at least one of the following areas):
   Channel identification/equalization
   Echo cancellation
   ADSL - high speed telephone line modem (Asymmetric Digital Subscriber Line modem)
   Modulation for digital TV (Orthogonal Frequency Division Multiplexing - OFDM)
   Mobile phone (LPC coding, equalization)
   etc. (4hrs)

**Total: 33 hrs**
Indicative reading list and references:

Laboratory Exercises:

**Three** Laboratory exercises will be assigned (Lab 1 and 2 are mandatory).
1. Preliminary Laboratory Session: Using Matlab for DSP Lab Exercises
2. Realization of Radix-2, Radix-4, Split-radix Fast Fourier Transform
5. Wavelet Transform for image compression.
6. Problems and design of Echo Cancellers.
8. DSP Programming using a Digital Signal Processor.
9. Adaptive filter design using LMS (Least Mean Square) and RLS (Recursive Least Square) filters.
10. Wiener filter as a tool for linear prediction and interpolation.

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