Proposal for a Graduate Certificate in Digital Signal Processing

Submitted

by the

Department of Electrical and Computer Engineering
School of Engineering and Technology

IUPUI
Request for a New Graduate Certificate Program
Department of Electrical and Computer Engineering,
School of Engineering and Technology, IUPUI

Digital Signal Processing Certificate
To be offered as a Purdue Certificate at IUPUI

Revised: March 28, 2002

Purpose of the program:

The objective of this graduate-certificate program in digital signal processing proposed by the Department of Electrical and Computer Engineering at IUPUI is to enable practicing engineers to acquire the signal processing knowledge and tools to help them

• use this technology effectively, and
• improve customer satisfaction.

Digital signal processing (DSP) techniques and methodology have been widely employed in many application areas, ranging from consumer electronics to space exploration to medicine. With the advances in microelectronics and high-speed microprocessors/microcontrollers/DSP processors, many complex DSP algorithms for solving real-world application problems can be implemented in real-time in a cost-effective manner. Examples are high-performance telecommunication and networking, video/audio/data communications, control of complex systems, medical imaging, etc. This certificate program is designed to help practicing engineers become knowledgeable about the area of digital signal processing. The certificate the students earn will serve as evidence that they have achieved a significant level of expertise in digital signal processing.

This certificate program meets the needs of

• mid-career and late-career engineers
• engineers new to the digital signal processing area
• engineering managers who need a background in digital signal processing.

The certificate is being proposed as a Purdue University certificate that would appear on a student's transcript upon completion.

Relation to existing certificate programs:

None.

The target audience:

Students are expected to be from local industries based in Indianapolis and Central Indiana. Most of the students expected to participate will be newly enrolling for graduate work at IUPUI in Electrical and Computer Engineering and Science.
Plan for sustaining steady-state enrollment:

In Fall 2002, we expect 10 to 15 students to participate in the program. It is anticipated that this number will increase to 20 in Fall 2003 and 25 in Fall 2004. We have received a positive feedback from our industrial partners concerning this certificate.

New resources:

No new resources are needed. All courses are currently taught at IUPUI.

Proposed date of the initiation of the certificate program:

Proposed date of implementation is Fall 2002, assuming all necessary approvals have been received at that time.

Person designated as the certificate program head:

Dr. Nasser Paydar, Associate Dean, School of Engineering and Technology, will provide school administrative oversight.

Dr. Russ Eberhart, Chair, Department of Electrical and Computer Engineering, will provide department administrative oversight.

Dr. Mohamed El-Sharkawy, Professor, Department of Electrical and Computer Engineering, will advise students.

Faculty initially involved in the program and their credentials:

Russell C. Eberhart
Professor of Electrical and Computer Engineering.
Research and Teaching Interests: Computational intelligence theory and applications. Particle swarm optimization and other evolutionary computation methodologies. Biomedical engineering diagnostic systems and signal analysis.

Mohamed El-Sharkawy
Professor of Electrical and Computer Engineering.
Research interests include multimedia and DSP applications, telecommunications, and computer-networks. He is the director of the Applied Digital Electronics Research Facility at Purdue University, Indianapolis. He is the author of four textbooks in the area of digital signal processing. He has published over 100 papers in the areas of digital signal processing, image processing, multimedia and communications.
Maher E. Rizkalla  
Professor of Electrical and Computer Engineering.  
Research area includes solid state devices, VLSI design, and electromagnetics. He has published over 80 papers in these areas. He is a senior member of IEEE, and a PE registered in the State of Indiana.

Stanley Chien  
Associate Professor of Electrical and Computer Engineering.  
Research and Teaching Interests: Research interests include parallel computing, embedded systems, software engineering, and robot task planning. Currently, he is working on software modeling and the dynamic load balancing of multiple parallel jobs on distributed heterogeneous computers.

Paul Salama  
Assistant Professor of Electrical and Computer Engineering.  
Research and Teaching Interests: Image and video compression, streaming multimedia data across data networks, error concealment in compressed video, image enhancement, image segmentation, digital communications, error control coding, statistical signal processing, information theory, digital image processing, data networks, wavelets and subband filtering.

Akhouri Sinha  
Professor of Electrical and Computer Engineering.  
Research interests include control, linear and nonlinear deterministic and stochastic control systems, large-scale systems, time-delay control systems and robust control systems. Other areas of interest include the application of control problems to bioengineering, robotics, and signal processing.

Sergey Edward Lyshevski  
Associate Professor of Electrical and Computer Engineering.  
Research areas are micro- and nanoelectromechanical devises and systems (HEMS and MEMS), signals and systems theory, electromechanical systems and mechatronics, microprocessor and DSP systems, advanced aerospace, automotive, marine, and manufacturing systems. He is the author and co-author of 7 books and more than 200 journal articles and conference papers.

Admissions requirements and procedures:

In order to be admitted to the certificate program, students must have a Bachelors degree from an accredited institution in Electrical and Computer Engineering with a recommended minimum GPA of 3.0 out of 4.0. Applicants with non-engineering degrees, including Science, Mathematics, and Engineering Technology, may be required to take undergraduate electrical and computer engineering courses before admission to the program. Students will be required to submit a statement of interest and three letters of recommendation.

Students admitted directly to the Purdue University graduate program will not be considered for this certificate program unless the student decides to leave the graduate program before completion. In that case, a petition must be submitted to the graduate committee to receive approval provided that all the requirements of the certificate program are satisfied.
Completion requirements, audit and certification procedures:

**a. Requirements for the certificate program:**

All courses are three semester credits and are taught by the graduate faculty of the Purdue School of Engineering and Technology at IUPUI; total of twelve credit hours, of which six are required. The required and elective courses are:

**Required courses**
- EE 538: Digital Signal Processing I
- EE 600: Random Variables and Signals

**Electives (choose two courses)**
- EE 536: Introduction to computational Intelligence
- EE 537: Multimedia Applications
- EE 544: Digital Communications
- EE 559: MOS VLSI Design
- EE 580: Optimization Methods for Systems and Control
- EE 595: Topics - Multimedia and Mobile Computing
- EE 595: Topics - Advanced Digital Signal Processors
- EE 602: Lumped System Theory
- EE 608: Computational Models and Methods
- EE 626: Adaptive Signal Processing
- EE 629: Introduction to Neural Networks
- EE 637: Digital Image Processing I
- EE 645: Estimation Theory
- EE 648: Digital Signal Processing II
- MA 511: Linear Algebra with Applications

(Note: Either EE 602 or EE 608 can be applied to the certificate, but not both.)

**b. Minimum overall GPA:**

Students will be required to have a final cumulative grade point average of 3.0 or better to be awarded the certificate. The minimum grade that will be accepted in any single course is C.

**c. Maximum number of credits that can be transferred from another institution:**

Applicants who have already earned credit for one or more of the equivalent courses from other institutions and other certificate programs may request to apply up to a maximum of three credits of these courses toward this certificate. Any waivers or substitutions have to be approved by the committee that oversees the program.

**d. Maximum number of undergraduate courses that can be applied:**

None
e. **Maximum time for completion:**

Maximum time for completion is three years. Most students enrolled in this program will be part-time students, employed full-time. Thus three years may be needed for the completion of all courses if students take one course per semester assuming no significant breaks (i.e., more than two semesters).

f. **Number of credit hours taken prior to admission to the certificate program that may be counted to completion of the certificate program:**

Up to 6 equivalent credit hours including 3 hours from another institution will be counted towards the certificate. The rest of the courses must be completed at IUPUI within a three-year period from the time of admission.

**Course lists for the program including course descriptions:**

The following is a list of the required and elective courses that will be scheduled in the evening to accommodate working part-time students in the Indianapolis area.

EE 536: Intro. to Computational Intelligence. 3 credit hours. Introduction to computational intelligence concepts and applications. Included are artificial neural networks, evolutionary computation, fuzzy systems, and hybrids of these methodologies. Engineering applications are stressed.

EE 537: Multimedia Application. 3 credits. A treatment of multimedia algorithms and their implementation using high speed multimedia processors. Detailed discussion of entropy coding, transform coding, speech compression, image compression, video compression and architecture, addressing modes and instruction set multimedia processors.


EE 559: Mos VLSI Design (3 cr.) Class 3. P: EE 305 and 365. Introduction to most aspects of large scale MOS integrated circuit design, including device fabrication and modeling; useful circuit building blocks; system considerations; and algorithms to accomplish common tasks. Most circuits discussed are treated in detail, with particular attention given those whose regular and/or expandable structures are primary candidates for integration. All circuits are digital and are considered in the context of the silicongate MOS enhancement-depletion technology. Homework requires the use of existing IC mask layout software; term projects assigned.
EE 580: Optimization Methods for Systems and Control (3 cr.) Class 3. P: EE 383, 483, or graduate standing. Introduction to various methods of obtaining the extreme of a nondynamic or dynamic system and their use in control system design. Linear programming, various search methods, nonlinear programming and dynamic programming are presented for discrete-time as well as continuous-time systems. Various real-life applications are discussed, and appropriate case studies are investigated.

EE 595: Advanced Multimedia and Mobile Computing. Credit 3. An advanced treatment of multimedia and mobile algorithms and implementation using digital signal processors and communications processor modules. Detailed discussion of voice over IP, video in multimedia, multimedia communication systems, mobile computing and advanced multimedia and mobile computing applications.

EE 595: Advanced Digital Signal Processors (3 cr.) Class 3. P: EE 362. This course provides an overview of the architectures and features of programmable digital signal processors (DSPs) and their applications in DSP applications. The course emphasizes design consideration for DSP processor based computer systems: two half-semester design projects focus on interfacing techniques to codecs, other hosts, and memories.

EE 600: Random Variables and Signals (3 cr.) Class 3. P: EE 444 or EE 483 or graduate standing. Engineering applications of probability theory. Problems of events, independence, random variables, distribution, and density functions, expectations, and characteristic functions. Dependence, correlation, and regression; multivariate Gaussian distribution. Stochastic process, stationarity, ergodicity, correlation functions, spectral densities, random inputs to linear systems, Gaussian processes.

EE 602: Lump System Theory (3 cr.) Class 3. P: EE 301. P or C: MATH 511 or consent of instructor. An investigation of basic theory and techniques of modern system theory, emphasizing linear state model formulations of continuous- and discrete-time systems in the time and frequency domains. Coverage includes notion of linearity, time invariance, discrete- and continuous-time state models, canonical forms, associated transfer functions, and impulse response models, the state transition matrix, the Jordan form, controllability, observability, and stability.

EE 608: Computational Models and Methods (3 cr.) Class 3. P: EE 359 or equivalent or consent of instructor. Computation models and techniques for the analysis of algorithm complexity. The design and complexity analysis of recursive and no recursive algorithms for searching, sorting, and set operations; graph algorithms; matrix multiplication; polynomial evaluation; FFT calculations; and NP-complete problems.

EE 626: Adaptive Signal Processing (3 cr.) Class 3. P: EE 600. P or C: EE 638. Adaptive transversal and lattice filters based on mean square and least squares error criteria will be discussed. This includes the least-mean square and recursive least squares transversal filters, the gradient lattice filter, the least squares lattice filter, and the fast transversal filter. The course will conclude with a selection of advanced topics, such as QR decomposition adaptive filters and systolic implementations, finite precision effects, nonlinear adaptive filters, blind adaptive filters, and infinite impulse response adaptive filters. Applications will be considered throughout.

EE 629: Introduction to Neural Networks (3 cr.) Class 3. P: EE 600. Information processing with neural networks, biological and engineering implications, learning algorithms, current neural network models and architectures, implementational topics, applications in areas such as signal/image processing, pattern recognition, optimization, simulation, system identification, nonlinear prediction, communications, and control.
EE 637: Digital Image Processing I. (3 cr.) Introduction to digital image processing techniques for enhancement, compression, restoration, reconstruction, and analysis. 2-D signals and systems, sampling and scanning, random fields, discrete cosine transform, discrete Karhunen-Loeve transform, grayscale transformations, linear, ranked order, and morphological filters, human vision, printing and display of images, entropy-based compression, vector quantization, block truncation coding, transform coding, predictive coding, image degradation models, Wiener filter, constrained deconvolution coding, computed tomography, edge detection, shape, representation, segmentation.

EE 645: Estimation Theory. (3 cr.). Basics of estimation and detection theory that are commonly applied in communications and signal processing systems. Topics covered include sufficient statistics, minimum variance unbiased estimators, testing binary hypotheses, Neyman-Pearson Lemma, Bayesian detectors, Maximum Likelihood estimators, Cramer-Rao bound, Bayesian estimators, Wiener filtering, Kalman filtering, Minimum Mean Squared Error estimators.

EE 648: Digital Signal Processing II (3 cr.) P: EE 538. In this course, a number of advanced topics in digital signal processing are covered. The emphasis is on fast transforms and algorithms, adaptive signal processing, multidimensional and multirate signal processing, inverse problems, nonlinear filtering, time-frequency methods, and processing of signals carried by propagating waves.

MA 511: Linear Algebra with Applications (3 cr.) P: MATH 261. Not open to students with credit in MATH 351. Matrices, rank, and inverse of a matrix, decomposition theorems, eigenvectors, and unitary and similarity transformations on matrices.

Procedures for governing the program including construction of committees that will provide oversight:

A committee comprised of Dr. El-Sharkawy, Dr. Sinha and Dr. Salama will jointly oversee the program. All advising will be done by these faculty members. The Department of Electrical and Computer Engineering and Ms. Valerie Lim, the Graduate Coordinator of the school, will take responsibility for all record keeping and tracking of students.

Procedures for program evaluation including the criteria for success:

An evaluation form will be provided for all students to determine the effectiveness of the program in meeting their needs. Follow-up evaluations will be conducted after three and five years.

The program will be considered successful if 80% of the graduates indicated the benefits of the program as per industrial needs. At the steady state enrollment (after five years from the start of the program), 40 students per year will be targeted for admission to the program.
September 28, 2001

Phillip E. Pope, Associate Dean
Office of the Dean of the Graduate School
170 Young Graduate House
Subject: Review of Certificate Program Proposed by IUPUI

Dear Phil:

The Communications and Signal Processing area faculty in Electrical and Computer Engineering have reviewed the attached IUPUI proposed graduate certificate program in digital signal processing. The faculty found the program relevant and likely it will fill a need in the Indianapolis area. The course requirements are appropriate for the certificate. The program should have no impact on West Lafayette programs or students.

Our faculty do wish to express their strong concern that this not be perceived by students or industry as a West Lafayette certificate program. It must be clearly advertised and designated as an IUPUI program.

Sincerely,

W. Kent Fuchs
Professor and
Head