NEW JERSEY INSTITUTE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

ECE 641
Laboratory for High Performance Digital Signal Processing
Fall 2014

COURSE DESCRIPTION: Field Programmable Gate Arrays (FPGAs) and General Purpose Graphical Processing Units (GPUs) have become two industry standards to implement popular digital signal processing (DSP) and other algorithms in firmware and software, respectively. Many DSP algorithms previously implemented using application-specific integrated circuits (ASICs) and programmable digital signal processors (PDSPs) are now replaced by FPGAs. Many DSP algorithms run on GPUs today instead of Central Processing Units (CPUs).

This course introduces today's FPGA and GPU technologies and the design tools for the state-of-the-art DSP algorithms. It starts with a set of DSP implementations spanning from finite impulse response (FIR) and infinite impulse response (IIR) filters to wavelet processors with two-channel filter banks and fast Fourier transform (FFT). Then, it focuses on computer arithmetic including possible number representations for DSP with FPGA like distributed arithmetic (DA) and CORDIC algorithm. Finally, three GPU experiments cover fundamentals of programming parallel algorithms and introduce the state-of-the art GPU programming language: CUDA.

INSTRUCTOR: Ali Akansu, [akansu@njit.edu, http://web.njit.edu/~akansu, Office Hours: Wednesdays 5.00pm to 6.00pm or by appointment]

PREREQUISITE/COREQUISITE: ECE 640 Digital Signal Processing and undergraduate level C programming course (for GPU track) or instructor's permission.

REQUIRED TEXTBOOKS:
U. Meyer-Baese, Digital Signal Processing with Field Programmable Gate Arrays. Third Edition, Springer, 2007.
http://www.springer.com/engineering/signals/book/978-3-540-72612-8

Jason Sanders and Edward Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming. 1st Edition, Addison-Wesley, 2010.
http://developer.nvidia.com/cuda-example-introduction-general-purpose-gpu-programming

RECOMMENDED READING:

"Circuit Design and Simulation with VHDL, Second Edition" by Volnei A. Pedroni, 2010, ISBN: 978-0-262-01433-5
http://mitpress.mit.edu/catalog/item/default.asp?tid=12244&ttype=2

"Programming Massively Parallel Processors: A Hands-on Approach" by David Kirk and Wen-mei Hwu, 2010, ISBN: 978-0-12-381472-2
http://www.elsevierdirect.com/morgan_kaufmann/kirk

LAB MANUAL: A. N. Akansu and M. U. Torun, Graduate Laboratory Manual for ECE 641 High Performance Digital Signal Processing, 6th Edition, January 2013.
(Soft copy of the manual will be freely distributed at the first day of the course.)

WEB: http://web.njit.edu/~akansu/COURSES/ECE641.html and http://moodle.njit.edu/

FALL 2014 TENTATIVE SCHEDULE

Week	Experiment	Chapter
1	Laboratory Orientation and Software Installations	N/A
2	Finite Impulse Response (FIR) Digital Filters	3
3	Infinite Impulse Response (IIR) Digital Filters	4
4	Two-Channel Orthogonal Filter Bank	5
5	Interacting with the Peripherals on the DE2-70 Board	N/A
6	Radix-2 Cooley-Tukey Algorithm for 4-Length FFT	6
7	Modulation Using CORDIC Algorithm	7.3
8	Memory Blocks, Megafunctions, Flash Memory, and Building a Simple Function Generator	N/A
9	Fast Convolution Using Number Theoretic Transform Error Control and Cryptography (Note: Two FPGA experiments in one day!)	7.1 7.2
10	Adaptive Filters and LMS Algorithm	8
11	GPU Experiment 1: Software Installation for CUDA and Vector Operations	1 -4
12	GPU Experiment 2: Memory, Blocks, Threads, Synchronization, and Matrix Multiplication	5
13	GPU Experiment 3: Discrete Cosine Transform on GPU	N/A
14	Term Project Presentations	N/A

REQUIREMENTS:

1. Each lab group consists of two students. Each group submits one report for each experiment one week after the completion of an experiment (Except the first experiment which does not require a report). **Reports must be submitted before**

or at the beginning of class. No late reports will be accepted. There will be a group leader for each experiment who is accountable for the completion of the experiment in full including the submission of the lab report. must be prepared in a professional presentation style.

2. Each student defines a "Term Project". The term project topic must be agreed by the instructor. The students are advised to work concurrently on their individual term projects along with the experiments of the laboratory. Each student must perform their term project presentation during the last class of the semester.

3. **Students are required to bring their laptops to the lab. Windows must be installed on your laptop.** There is no MacOS support. If you have a Mac, please install Windows as an alternative OS in advance. If a student is unable to bring a laptop to the class, he/she is encouraged to contact the instructor before the semester starts.

4. At the beginning of each class, a group member must obtain a DE2-70 board from the stock room located on the third floor of the FMH building (Room 304).

GRADING POLICY:

50% Reports
50% Individual Term Project