EECE 7110: High-Performance Computing on GPUs

Course Name: EECE 7110: High-Performance Computing on GPUs

Course Hours and Location: M 6:30pm – 9:20pm; Ball Hall 328 North Campus

Website: via Blackboard

Instructor: Prof. Hang Liu, Ph.D. (hang_liu@uml.edu)

Course Hours and Location: M 1:30pm – 4:30pm; Cumnock Hall Suite 6, Room 6A

Catalog Description: This course aims to provide students with knowledge and hands-on experience in developing applications on Graphics Processing Units (GPUs) which feature massive parallel computing capability and tremendous data delivering rate. In general, we refer to a processor as massively parallel if it has the ability to complete more than 64 arithmetic operations per clock cycle. Sufficiently exploiting the potential of GPUs demands in-depth knowledge about the processor hardware feature and parallel algorithm design principles, as well as the parallelism models of GPU architecture. All of them will be covered in this course. The target audiences of this course are students who want to develop applications for these GPUs, for fun, profit, and for their research, as well as those who want to understand the feature of GPUs in order to propose techniques to further enhance their architectures.

The course will involve a number of programming projects with steadily growing complexities. All programming assignments will involve programming a massively parallel system in CUDA, which is a popular commercial language extension for C/C++ for GPU programming. Assignments involve tasks such as matrix operation, vector reduction, prefix-scan, radix sorting, graph computing and machine learning. Through the entire semester, students are expected to work on a large and complex, sometimes publishable, project in groups.

Prerequisites/Co-requisites: Data structure C/C++ (EECE 3220), Programming (EECE 2160), Microprocessor I (EECE 3170), and Computer Architecture (EECE 4820). Or equivalent courses from other departments.

Textbook: 1. CUDA By Examples: An Introduction to General Purpose GPU Programming by Jackson Sanders and Edward Kandrot; 2. Programming Massively Parallel Processors: A Hands-on Approach (David Kirk and Wen-mei W. Hwu).

Academic Integrity: The contents of your homework and projects should comply the academic integrity code from our University at the following two websites for undergrad and graduate students, respectively: https://www.uml.edu/Catalog/Undergraduate/Policies/Academic-Policies/Academic-Integrity.aspx and https://www.uml.edu/Catalog/Graduate/Policies/Academic-Integrity.aspx.

Homework: Homework and projects are assigned (via Blackboard) and collected (via Blackboard). In particular, homework will be assigned by the end of the class and should be submitted before next class. **No late homework is accepted.**

Presentation: Students need to send the instructor presentation slides three days before the scheduled presentation via email (hang_liu@uml.ed).

Grading Policy: Homework: 15%, Attendance: 5%, Project proposal: 10%, Midterm: 15 %, Final project: 35%, Midterm presentation 10%, Final presentation 10%.

Final Grade Computation: The above procedure is used to determine a weighted score. The final grade is based on a straight scale: A: 92 – 100; A-: 90 – 91.9; B+: 88 – 89.9; B: 82 – 87.9; B-: 80 – 81.9; C+: 78 – 79.9; C: 72 – 77.9; C-: 70 – 71.9; etc.

Relevant Dates:

Due by email:

- Homework 1 due: 2/5, before 6:30pm
- Homework 2 due: 2/12 before 6:30pm
- Homework 3 due: 4/9 before 6:30pm
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- Project proposal due: 2/19 before 6:30pm
- Midterm project report due: 3/26 before 6:30pm
- Final project report due: 5/14 before 6:30pm

Due by email (hang_liu@uml.edu)

- Midterm presentation slides due: 3/23 before 6:30pm
- Final presentation slides due: 5/11 before 6:30pm

Classroom Conduct: Students are expected to exhibit professional and respectful behavior that is conducive to a mutually beneficial learning environment in the classroom. Examples of inappropriate behavior include: text messaging, listening to music, cell phone use (other than the campus alert system), late arrivals, early departures, use of laptops for other than class purposes, disrespectful comments or behavior, intentional disruptions, failure to follow faculty directives, etc. Students in violation of these standards may be asked to leave class and/or be referred to the Dean of Students for disciplinary action.

Accommodations: In accordance with University policy and the ADA, accommodations are provided for students with documented disabilities. If you have a disability, please contact the Office of Disability Services as soon as possible. Their office is in UC 220 (978-934-4574, Disability@uml.edu). Documentation of disability is confidential. Requests for accommodation for religious reasons should be directed to Equal Opportunity and Outreach at 978-934-3565, Wannalancit Mills, Suite 301.

Counseling Services: As part of the Wellness Center, Counseling Services at UMass Lowell provide mental health counseling, consultation and referrals to help students achieve personal and academic success. They also assist students in better understanding and coping with their feelings, relationships, and choices surrounding their academic success. Visit https://www.uml.edu/student-services/Counseling/

Veterans' Services: UMass Lowell is committed to helping our military students take full advantage of all the educational benefits available through the federal and state governments. For complete information on the services and resources available please visit our website at: https://www.uml.edu/student-services/Veterans/

University Cancellation Information: If campus is closed (most likely for weather), visit the website for announcements relevant to the class.

Syllabus

Time	Course Topics	Homework
1/22 (Week 1)	Introduction to GPU and CUDA	
1/29 (Week 2)	Basics in CUDA Programming	
2/5 (Week 3)	CUDA Parallel Execution Model	Homework 1 Due
2/12 (Week 4)	CUDA Memory Model	Homework 2 Due
2/20 (Week 5) Tues	Continued CUDA Memory Model	Project Proposal Due
2/26 (Week 6)	**No class**	
3/5 (Week 7)	Matrix Multiplication (MM) on GPU	
3/12 (Week 8)	**Spring Break (No class)**	
3/19 (Week 9)	Continue MM on GPU	
3/26 (Week 10)	**Midterm Project Presentation**	Midterm Project Report Due
4/2 (Week 11)	Atomic/Vote/Sync Instruction	
4/9 (Week 12)	Reduction Tree on GPU	Homework 3 Due
4/16 (Week 13)	Continue	
4/23 (Week 14)	Prefix-scan on GPU	
4/30 (Week 15)	Continue	
5/7 (Week 16)		
5/14 (Week 17)	**Final Project Presentation**	Final Project Report Due

Sample projects

1. Machine Learning:
    a. Deep Artificial Network
    b. K-means
    c. Recommendation System
    d. Belief Propagation
2. Linear Algebra:
    a. Conjugate Gradient Solver
    b. Fast Fourier Transform
    c. Sparse Matrix-Matrix Multiplication
3. Graph Algorithms:
    a. Breadth-First Search
    b. PageRank
    c. Graph Coloring
    d. Single Source Shortest Path
4. Sorting on GPUs.

You can always come up your own projects (not included above) and discuss with me