Helen and John C. Hartmann Department of Electrical and Computer Engineering

New Jersey Institute of Technology

ECE 452: High Performance Computer Architecture (3 credits, 3 contact hours)

Instructor: Shaahin Angizi, email: shaahin.angizi@njit.edu, Tel.: 973-596-3516

Text books:

John L. Hennessy and David A. Patterson, *Computer Architecture: A Quantitative Approach*, ISBN: 012383872X.
Morris Mano, *Computer System Architecture*, ISBN: 0131755633
Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep learning*, ISBN: 0262035618

Catalog Description:

This course focuses on recent advances and topics of current active research in the field of computer architecture. It includes new computing paradigms such as brain-inspired non-von-Neumann architectures, heterogeneous computing systems, and parallel machine learning accelerator architectures. It also covers topics related to hybrid memory systems, architectures of emerging memory technologies, rowhammer and secure and reliable memory systems, and memory consistency.

Prerequisite: Advanced Computer Architecture (ECE 451)

Specific course learning outcomes (CLO):

The student will be able to:

1. Understand the Artificial Neural Networks (ANN) basics and decision boundaries to implement basic gates;

2. Understand terminology and algorithms developed for machine learning and design and implement Multi-layer Perceptron (MLP) and Convolutional Neural Networks (CNN);

3. Understand temporal vs. spatial hardware architectures for CNN acceleration, hardware mapping approaches, and computation and data movement reduction techniques in modern accelerators;

4. Design basic accelerators and quantitatively evaluate and compare the designs;

5. Understand DRAM structure and security challenges, Row Hammer security attack on DRAM, and DRAM testing methodology and analysis;

6. Understand the mitigation methods developed for Row Hammer attacks;

7. Understand fundamentals of intrinsically pipelined systems, i.e., Quantum dot Cellular Automata and Lateral Spin Valve, design and simulate simple designs;

8- Understand in-cache computing idea, cache coherence, and virtual memory.

Student Outcomes:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (CLOs 1,2,4,5,7)

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (CLOs 4,6,7)

3. an ability to communicate effectively with a range of audiences (CLOs 2,7)

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (CLOs 2,7)

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions (CLOs 2,4,5,7)

Course Schedule:

Topic	Weeks
Artificial Neural Networks (ANN) Basics	1
Multi-layer Perceptron (MLP) and Convolutional Neural Networks (CNN)	2,3
Hardware Architectures for Machine Learning Basics	4,5
Hardware Mapping Approaches in Accelerators	6,7
Secure Memory Systems and Row Hammer Security Attack on DRAM	8
Mitigation Methods for Row Hammer Attacks	9
Intrinsically Pipelined Systems (Lateral Spin Valve)	10
Intrinsically Pipelined Systems (Quantum-dot Cellular Automata)	11
In-Cache Computing	12
Cache Coherence and Virtual Memory	13
Project Presentation	14

Grading Policy:

HomeWorks, Quizzes, and Critical Reviews: 20%
Group Research Project: 40% (20% Report +20% Presentation)
Exams: 40% (20% Midterm + 20% Final)

Updates and Assignments

to be distributed via NJIT Canvas

Office hours, recitations, and group studies:

Two-hour-a-week after class office hours or by appointment

Honor Code:	The NJIT Honor Code will be upheld; any violations will be brought to the immediate attention of the Dean of Students
Office	ECE Bldg., Room 325
Prepared by:	S. Angizi