Current and Future Computing Devices and Technology

Syllabus

Course Description

The end of Moore's Law and the rise of artificial intelligence/machine learning are paradigm shifts which will have a dramatic effect on the future of computing. In this course, we will learn about the next-generation of device technologies that will drive computing advancement in the post-Moore era. These will be broken down into three sections:

(i) What are the current state-of-the-art device technologies?

(ii) Which emerging devices are promising for hardware acceleration of AI/ML algorithms?

(iii) How do we implement hardware accelerators for AI/ML algorithms, and how good can they be?

First, the course will cover current state of the art transistor and memory technologies such as FinFETs, flash memory, DRAM and SRAM technology. Next, emerging technologies for computing (e.g. 1-D/2-D materials, negative capacitance transistors, and tunnel transistors), and emerging non-volatile memory devices (resistive RAM, phase change memories, spin-torque-transfer magnetic memories) will be studied. After covering emerging device technologies, we will review biological neural networks and artificial neural networks, focusing on how emerging device technologies can be used to accelerate neural networks. Finally, students will learn to evaluate the potential performance of emerging device technologies for AI/ML hardware acceleration. The course will close by looking at some of the differences in biological and artificial neural networks and give perspectives on future technologies.

Course Schedule

- Week 1 – Fundamentals of transistors
- Week 2 – State-of-the-art transistors
- Week 3 – Fundamentals of memory technology
- Week 4 – State-of-the-art memory technologies
- Week 5 – Emerging devices: Computing technologies
- Week 6 – Emerging devices: Computing technologies
- Week 7 – Emerging devices: Memory technologies
- Week 8 – Emerging devices: Memory technologies
- Week 9 – Brain-like computing (biological neural networks)
- Week 10 –Artificial neural networks
- Week 11 – Basics of hardware acceleration of artificial neural networks
- Week 12 – Performance of hardware acceleration of artificial neural networks
- Week 13 – Evaluating emerging device technologies for neural network acceleration
- Week 14 – Hardware acceleration of other ML algorithms
- Week 15 – Closing the gap between biological and artificial neural networks

Prerequisite Knowledge

Students should have taken an undergraduate level device physics course and have a basic knowledge of metal-semiconductor junctions, pn junctions, MOS capacitors, and MOSFETs/BJTs.

Evaluation Criteria

Course grades will be based upon the following:

- Homework - 10%
- 1 Midterm - 40%
- Final Exam- 50%

Reading Material

Recommended text (not required):
Fundamentals of Modern VLSI Devices – Yuan Taur, Tak Ning

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus,* the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/ publications/SCAMPUS/gov/.Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.