Course Syllabus - Spring 2022
18-743: "*Neuromorphic Computer Architecture & Processor Design*"

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Class Schedule:

Section A (48): ***TR 03:05PM - 04:25PM ET, HH 1107, Pittsburgh, Pennsylvania***

Section SV (5): ***TR 12:05PM - 01:25PM PT, B23 211, Silicon Valley, California***

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Course Description:

♦This course focuses on the investigation of biologically inspired neural networks that mimic both the functional behavior as well as organizational structure of the mammalian neocortex, with the objective of engineering silicon-based implementations possessing brain-like capabilities. ♦This course introduces a taxonomy of Neural Networks (NN), based on: 1) *Neuron Model*, 2) *Neural Coding*, and 3) *Learning Paradigm*. The taxonomy includes three major classes of NNs: *Artificial Neural Networks* (ANN), *Spiking Neural Networks* (SNN) and *Temporal Neural Networks* (TNN). This course focuses mainly on TNNs because of their "neuromorphic" attributes that strongly adhere to biological plausibility. Based on TNNs, this course explores the potential of designing *Neuromorphic Sensory Processing Units* (NSPUs), that exhibit both brain-like processing capability and brain-like energy efficiency. ♦In this course, students will work in small teams to pursue eight-week long projects exploring and prototyping application-specific NSPUs. These diverse projects can span applications, architectures, hardware designs, and CMOS implementations of NSPUs. Each team will have the opportunity to define and carry out a specific project with support and guidance from the teaching staff and industry advisors. This semester we plan to incorporate Brainchip's AKIDA neuromorphic chip/board and framework as one more experimental platform. These team projects can help prepare students for joining industry innovation teams developing AI/ML/DL accelerators or research teams pursuing neuromorphic computing systems research.

Number of Units: 12 units. **Pre-requisite: 18-740.**

Background References on DL, DNN, & new AI:

- **Brandon Reagen, Robert Adolf, Paul Whatmough, Gu-Yeon Wei, and David Brooks, *"Deep Learning for Computer Architects,"* Synthesis Lectures on Computer Architecture, Morgan Claypool, August 2017. https://www.morganclaypool.com/doi/10.2200/S00783ED1V01Y201706CAC041**
- **Vivienne Sze, Yu-Hsin Chen, Tien-Ju Yang, and Joel S. Emer, *"Efficient Processing of Deep Neural Networks,"* Synthesis Lectures on Computer Architecture, Morgan Claypool, June 2020. https://www.morganclaypool.com/doi/pdfplus/10.2200/S01004ED1V01Y202004CAC050**
- **Hawkins, Jeff. "A thousand brains: A new theory of intelligence." (2021), part 1 (91 pages). https://www.amazon.com/Thousand-Brains-New-Theory-Intelligence/dp/B08VWV2WDK**

Tentative Course Calendar (18-743 Spring 2022):

Week	Date	Day	Class Activity	
Week 1	18-Jan	Tues	Lecture 1: Background & Motivation: "Why introduce this course now?"	JPS
	20-Jan	Thurs	Lecture 2: Course Overview: "What is this course all about?"	JPS
Week 2	25-Jan	Tues	Recitation 1: Tutorial on PyTorch Simulation Tools (Lab 1 intro)	HN
	27-Jan	Thurs	Lecture 3: Neuromorphic Architecture Overview	JES
Week 3	1-Feb	Tues	Lecture 4: Neuron Modelling and Column Organization	JES
	3-Feb	Thurs	Lecture 5: Agent Architectures: Reinforcement & Supervised Learning	JES
Week 4 (Lab 1)	8-Feb	Tues	(no class)	
	10-Feb	**Thurs**	Recitation 2: Tutorial on Verilog Implementation Tools (Lab 2 intro)	PV
Week 5	15-Feb	Tues	Lecture 6: Cortical Architectures and Promising Applications	JES
	17-Feb	Thurs	Lecture 7: AKIDA Neuromorphic SoC [Kris Carlson, Brainchip]	KC
Week 6	22-Feb	Tues	Lecture 8: AKIDA MetaTF Tools & HDK [Nikunj Kotecha, Brainchip]	NK
	24-Feb	Thurs	Recitation 3 Highlight of Previous Team Projects (3 projects from S21)	TAs
(Lab 2) Week 7	**1-Mar**	**Tues**	Lecture 9: Potential Team Projects & CMU's Neuromorphic Big Picture	JPS
	3-Mar	Thurs	Recitation 4: Discussion on Specific Project Proposals (finalize teams)	TAs
	7-Mar – 11-Mar		SPRING BREAK; NO CLASSES	
Week 8	**15-Mar**	**Tues**	**Research Project Proposals #1** (10-15 min per team)	
	17-Mar	**Thurs**	**Research Project Proposals #2** (10-15 min per team)	
Week 9	22-Mar	Tues	Lecture 10: Survey of Neuromorphic Circuits [Quinn Jacobson]	QJ
	24-Mar	Thurs	Lecture 11: Neuromorphic Research Results [Mikko Lipasti, U. Wisc.]	ML
Week 10	29-Mar	Tues	Recitation 5: Project discussions (Teams 6, 7, 8 Project Proposals)	TAs
	31-Mar	Thurs	Lecture 12: Personal Perspective and Latest Ideas on Neuromorphic	JES
Week 11	**5-Apr**	**Tues**	**Research Project Updates #1** (10-15 min per team)	
	7-Apr	**Thurs**	**Research Project Updates #2** (10-15 min per team) **Recorded Zoom Videos**	
Week 12	12-Apr	Tues	Recitation 6: Project discussion and guidance	TAs
	14-Apr	Thurs	**Lecture 13: Emerging Neuromorphic Industry Landscape**	JPS
Week 13	19-Apr	Tues	Lecture 14: Personal Perspective on Neuromorphic [Gopal Srinivasan]	GS
	21-Apr	**Thurs**	**Research Project Presentations #1** (15-20 min per team)	
Week 14	**26-Apr**	**Tues**	**Research Project Presentations #2** (15-20 min per team)	
	28-Apr	**Thurs**	**Research Project Presentations #3** (15-20 min per team)	
Week 15	3-May	Tues		
	10-May	**Tues**	**Research Project Reports Due**	