

## EEE 598: Neuromorphic Computing Hardware Design (Spring 2022)

### 1. Class Hours and Location

Hours: Tuesday & Thursday, 9:00 AM – 10:15 AM

Location: (1) Discovery Hall 150 (2) Zoom (link will be provided via Canvas)

### 2. Instructor Contact Information

Name: Jae-sun Seo

Email: [jaesun.seo@asu.edu](mailto:jaesun.seo@asu.edu)

Telephone: 480-727-2660

### 3. Virtual Office Hours

Tuesday: 10:30am-11:30am, Thursday: 1:00pm-2:00pm

Zoom link will be provided via Canvas.

Please email the instructor to set up an appointment outside the office hours above.

### 4. Course Website and Description

This course can be accessed at <https://canvas.asu.edu/> for announcements, lectures, and assignments.

In recent years, both industry and academia have shown large interest in low-power hardware designs for neuromorphic computing (e.g. IBM TrueNorth, Intel Loihi) and deep learning algorithms (e.g. convolutional neural networks) for a wide range of image, speech, and biomedical applications. In this course, we will learn the underlying theory, basic algorithms, and efficient device/circuit/architecture design of neuromorphic computing.

### 5. Course Requirement and Prerequisite

This course requires the student to be comfortable with using Matlab or Python languages for algorithm development, and experienced with RTL coding, synthesis, and automatic place and route (APR).

EEE 525 or an equivalent course is the prerequisite.

### 6. Course Objectives

- Students will gain an understanding on neuromorphic computing and neural networks.
- Students will learn how to design energy-efficient hardware accelerators for neuromorphic computing and neural networks.
- Students will learn how to comprehensively use industry-standard electronic design aided (EDA) tools.
- Students will learn how to properly optimize the performance/power/area of neuromorphic hardware designs.

### 7. Expected Learning Outcomes

- Given a neural network algorithm, students will be able to design the corresponding module in Verilog and automatically generate the layout using EDA tools.
- Given a neural network algorithm, students will be able to implement the custom energy-efficient hardware while exploring the trade-offs in performance/power/area.

### 8. Textbook, Technology Requirement, Assignments, and Examinations

- a. Textbook (optional): **“Event-Based Neuromorphic Systems,” by Shih-Chii Liu, Tobi Delbruck, Giacomo Indiveri, Adrian M. Whatley, and Rodney Douglas, 2015.**

- b. You are encouraged to use a PC/Apple laptop or desktop. You will need an internet connection that can effectively stream live broadcasts (e.g. 3G, 4G, Cable or DSL Wifi).  
If you are not able to personally finance the equipment needed to attend class via ASU Sync, ASU has a laptop and WiFi hotspot checkout program available through [ASU Library](#).

SYNC technology requirements

- Web browsers ([Chrome](#), [Mozilla Firefox](#), or [Safari](#))
- [Adobe Acrobat Reader](#) (free)
- Webcam, microphone, headset/earbuds, and speaker
- Microsoft Office ([Microsoft 365 is free](#) for all currently-enrolled ASU students)
- Reliable broadband internet connection (DSL or cable) to stream videos.

c. Exams and Assignments:

- 2 homework assignments : 30%
- 1 midterm exam : 20%
- Laboratory assignments : 50%
  - Intermediate report: 10%
  - Final presentation: 20%
  - Final report: 20%

d. Course lecture topics:

- Computation in the brain and related learning algorithms
- Biological neuron/synapse models and implementations
- Artificial neural network models and implementations
- Analog vs. digital design of neuromorphic hardware
- Device-level design techniques for neuromorphic computing
- Circuit-level design techniques for neuromorphic computing
- Architecture-level design techniques for neuromorphic computing
- Case studies of neuromorphic hardware implementations
- Deep neural network hardware designs

## 9. Grade Policies

The total weighted sum will be on a curve. Exact borderlines between adjacent grades can depend on the distributions.

- A+ : top 10%
- A :  $> \mu + 0.5\sigma$
- A- :  $> \mu$
- B+ :  $> \mu - 0.5\sigma$
- B :  $> \mu - 1.0\sigma$
- B- :  $> \mu - 1.5\sigma$
- C+ :  $> \mu - 2.0\sigma$
- D : else

## 10. Lecture Information and Attendance/Absence Policies

- a. In Spring 2022, ASU is planning to be in Learning Mode 1, and lectures will be taught in-person at the classroom. At the same time, this course will use ASU Sync for live lecture broadcast. ASU Sync is a technology-enhanced approach, designed to meet the dynamic needs of the class, and you can find out more information about ASU Sync for students here, <https://provost.asu.edu/sync/students>.

- b. ASU strongly recommends that everyone wear a face cover when inside a university building. In addition, face coverings will be required in certain indoor settings, i.e., classrooms and teaching or research labs where distancing is not possible. Please check <https://eoss.asu.edu/health/announcements/coronavirus/management> for further updates.
- c. The instructor will provide the lectures in-person at the classroom, where the lectures will also be live streamed to remote students via zoom. The students can choose to be in the classroom or choose to connect remotely using zoom. We will keenly follow further guidance from CDC and ASU.
- d. All lectures will be recorded and be posted at Canvas, so that the students can recover from technology lapses illness, or other scheduling challenges.
- e. Excused absences related to religious observances/practices that are in accord with [ACD 304-04](#), “Accommodation for Religious Practices”
- f. Excused absences related to university sanctioned events/activities that are in accord with [ACD 304-02](#), “Missed Classes Due to University-Sanctioned Activities”
- g. Excused absences related to missed class due to military line-of-duty activities that are in accord with [ACD 304-11](#), “Missed Class Due to Military Line-of-Duty Activities,” and SSM 201-18, “Accommodating Active Duty Military”

#### 11. Policy regarding expected classroom behavior (e.g., use of pagers, cell phones, recording devices)

Cell phones and pagers should be turned off during class to avoid causing distractions. The use of recording devices is not permitted during class. Any violent or threatening conduct by an ASU student in this class will be reported to the ASU Police Department and the Office of the Dean of Students.

**Until further notified, per ASU policy, faculty, staff, students and visitors, are required to wear face coverings in classrooms, labs, offices and community spaces.**

#### 12. Academic Integrity

Students in this class must adhere to ASU’s academic integrity policy at <https://provost.asu.edu/academic-integrity/policy>. Students are responsible for reviewing this policy and understanding each of the areas in which academic dishonesty can occur. In addition, all engineering students are expected to adhere to both the ASU Academic Integrity [Honor Code](#) and the Fulton Schools of Engineering (FSE) [Honor Code](#). All academic integrity violations will be reported to the FSE Academic Integrity Office (AIO). The AIO maintains record of all violations and has access to academic integrity violations committed in all other ASU college/schools.

Specific academic integrity announcements for this class are...[\* When discussing sanctions please use language like, *recommended sanctions for these violations will be...*this allows for the fact that the AIO may want to discuss the sanction with you and it also improves the ability to increase the penalty when it is a multiple violation]

#### 13. Copyright

All course content and materials, including lectures (**Zoom recorded lectures included**), are copyrighted materials and students may not share outside the class, upload to online websites not approved by the instructor, sell, or distribute course content or notes taken during the conduct of the course (see [ACD 304-06](#), “Commercial Note Taking Services” and ABOR Policy [5-308 F.14](#) for more information).

You must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the students first comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement.

#### **14. Policy against threatening behavior, per the Student Services Manual, [SSM 104-02](#)**

Students, faculty, staff, and other individuals do not have an unqualified right of access to university grounds, property, or services. Interfering with the peaceful conduct of university-related business or activities or remaining on campus grounds after a request to leave may be considered a crime. All incidents and allegations of violent or threatening conduct by an ASU student (whether on- or off-campus) must be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students.

#### **15. Disability Accommodations**

Suitable accommodations will be made for students having disabilities. Students needing accommodations must register with the ASU Disabilities Resource Center and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in sufficient time for it to be properly arranged. See [ACD 304-08](#) Classroom and Testing Accommodations for students with disabilities.

#### **16. Harassment and Sexual Discrimination**

Arizona State University is committed to providing an environment free of discrimination, harassment, or retaliation for the entire university community, including all students, faculty members, staff employees, and guests. ASU expressly prohibits discrimination, harassment, and retaliation by employees, students, contractors, or agents of the university based on any protected status: race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, and genetic information.

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at <https://sexualviolenceprevention.asu.edu/faqs>.

**Mandated sexual harassment reporter:** As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, <https://eoss.asu.edu/counseling>, is available if you wish discuss any concerns confidentially and privately.

#### **17. Syllabus Changes**

Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice.