

ECE/CS/CSE 497/597: AI/MACHINE LEARNING HARDWARE AND SYSTEMS

This 3-credit advanced-level course takes a hardware-centric view of AI/machine learning systems from constrained embedded devices to high-level distributed systems. It covers topics like ML design for low-power devices, optimization techniques for real-time processing, and deployment strategies for AI/ML models on embedded devices, bridging the gap between AI theory and practical hardware implementation.

COURSE OUTLINE

COURSE INFORMATION

Course Name	Special Topics: AI/Machine-Learning Hardware and Systems		
Course Code	Lecture (hr/week)	Days	Total Credit
ECE/CSE/CS: 497/597	2.5	2	3

Course Instructor	Omiya Hassan	omiyahassan@boisestate.edu
Teaching Assistant	Ikteder Akhand Uday	iktederakhandudo989@u.boisestate.edu
Office Hours	<ul style="list-style-type: none"> Monday: 4:00 PM – 5:00 PM (can be available both in Zoom/in person) Friday: 12:00 PM – 1:00 PM (can be available both in Zoom/in person) 	

Course Objectives & Learning Outcomes	<ul style="list-style-type: none"> Demonstrate an understanding of how machine learning algorithms are implemented on different hardware systems. Apply key optimization techniques, including pruning, quantization, and binarization, to improve the efficiency of machine learning algorithms on various hardware platforms. Analyze and evaluate the performance and efficiency of hardware platforms with and without optimizations, understanding the trade-offs between efficiency and accuracy. Deploy and infer optimized AI/ML models on microcontrollers, specifically within the context of TinyML.
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COURSE OUTLINE

	Topic	Description
Week 1-4	Introduction to AI, Machine Learning (ML), and Deep Learning (DL) Models	Introduction to AI/ML/DL: background, training vs inference, embedded vs cloud, ML/DL algorithm.
		Structure of AI/ML/DL: Attributes of connections within and between layers, types of DL modes.

		Code Structure: Coding basic ML and DL models, exploring popular benchmarked models used for computer vision and natural language processing. (all will be done using Python/Pytorch)
Week 5-9	Design of Hardware and Systems for Processing AI/ML/DL models	ML Hardware: Performance metrics, roofline analysis, Dataflow paradigms, and Hardware efficiency.
		Advanced/speculative hardware technologies ML Compilers: Mapping convolutions and matrix multiplications to hardware, Kernel transformations e.g.: Winograd, FFT-based computation, Domain-specific compilation (ML).
		Model-level Optimizations: Matrix decomposition Quantization, Knowledge distillation, Hardware-aware AutoML and Pruning.
		ML Systems: Preprocessing and postprocessing in ML systems, Distributed training, Federated learning, Ethical, environmental, and societal concerns related to ML systems
Week 10-16	Co-Design of ML Hardware and TinyML Applications	Fundamentals of TinyML: ML Paradigm, building blocks of DL, Building Computer Vision Models.
		Project I: Keyword Spotting Project II: Person Detection with Keyword Spotting Project III: Gesturing Magic Wand
		Final Project: Open-ended

Suggested Textbook (Optional)	<ul style="list-style-type: none"> “Efficient Processing of Deep Neural Networks,” Vivienne Sze, Yu-Hsin Chen, Tien-Ju Yang, and Joel S. Emer. Morgan & Claypool publishers. 2020.
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EVALUATION SYSTEM

Semester Requirement	Percentage
Attendance	5
Assignment	20
Quizzes	25
Class Project	25
Final Project	25
Total	100

- **Quizzes:** There will be two Quizzes throughout the semester based on Module 1 and Module 2.
- **Assignment:** There will be two assignments based on Module 1 and Module 2.
- **Class Project:** There will be three class projects based on Module 1 and Module 3.
- **Final Project:** There will be one final group project.

GRADE DISTRIBUTION

A/A+	93-100%	A-	90-92%	B+	87-89%
B	83-86%	B-	80-82%	C+	77-79%
C	73-76%	C-	70-72%	D+	67-69%
D	63-66%	D-	60-62%	F	0-59%

COURSE REGULATIONS

ACADEMIC INTEGRITY

Boise State's core [Shared Value](#) of **Academic Excellence** states that we must “engage in our own learning and participate fully in the academic community’s pursuit of knowledge.” Upholding academic integrity in all work allows you to fully engage with the investigated material and assert your evidence-based findings. Behaving with integrity and honesty is a hallmark of a Boise State graduate, demonstrating the commitment to learning and preparation necessary for a successful future. When you receive your degree, the University will indicate that you have engaged in academic work that is representative of your efforts and completed your work with integrity and honesty.

All work you submit must represent your ideas and efforts or be cited, including any material you wrote for another course; it is academic dishonesty when your work does not. Academic dishonesty may result in additional assignments to learn about academic integrity, requirements to redo or revise work, grade penalties, failure in the course, or dismissal from the Program and the University. [Violations](#) of academic integrity in this course will be addressed following University standards, including submitting an **Academic Dishonesty Report** to the **Office of the Dean of Students**. For more details, see **Boise State’s Academic Integrity** page and the [Student Code of Conduct](#).

RESOURCES

The university has many resources to support you as a learner and human being. Among these are:

[Albertsons Library](#) provides a treasure trove of physical and electronic resources.

- As you enter the library, straight ahead, you’ll find the Reference Desk, where librarians can help you find the information and resources you need.
- The Circulation Desk lets students borrow various technologies.
- The MakerLab on the second floor offers tools for student use, and there are friendly staff in the MakerLab to help you learn how.

[The Writing Center](#) offers individual consultations tailored to your needs, including making sense of writing assignment instructions, brainstorming, crafting a thesis, organizing an essay, revisions, citations, and more.

[Counseling Services](#) helps you tap into your strengths and find resources to deal more effectively with concerns that impact your pursuit of personal and academic goals. It emphasizes prevention and early detection and provides a broad spectrum of short-term counseling, consultative, evaluative, teaching, and training functions. The staff comprises licensed counselors, psychologists, and closely supervised trainees/post-graduate interns.

The Gender Equity Center provides specialized, brief, no-cost, confidential support for campus members affected by:

- Identity-related harassment.
- Sexual harassment, sexual assault, unhealthy relationships, and stalking.
- Life experiences related to gender, sexual orientation, and allyship.
- Life transitions and crises.
- Personal, financial, or academic roadblocks.

Student Equity works with all students interested in equity and social justice from different cultures, countries, and ethnicities. The staff understands cultural differences and perspectives and knows what living in a dominant culture is like. The training and the programs Student Equity provides can help you navigate through political correctness and into respectful dialogue. This center also provides:

- Support and guidance for planning cultural festivals and events.
- In-center tutoring and studying lounge.
- Volunteer opportunities.
- Mentoring and Training.
- Programs and events.

Food assistance: If you are hungry and cannot afford food, the campus has some resources to help you. You can visit the [campus food pantry](#) or [get free meals in the dining hall](#).

COMMUNICATING WITH YOUR INSTRUCTOR

- If you have a conflict and will be unavailable to participate promptly during a particular week, please let me know by email in advance.
- The turnaround time for grading assignments will generally be one week, and charges will be collected via **CANVAS**. I will use rubrics and other tools to comment on your papers and provide feedback.
- If you notice any problems in the course or seek clarification on an assignment, email me through my boisestate.edu ID.
- Please note the posted **Office Hours** and participate whenever you can. **Office Hours** are not structured only to go over course content; they can be used to discuss other topics regarding AI/machine learning for Hardware and Systems. It can be intimidating the first time we meet, but the benefits outweigh any negatives.

BE PART OF THE CLASS COMMUNITY

Students in this class represent a wide variety of backgrounds and perspectives. Boise State University is committed to providing an atmosphere for learning that respects diversity and creates inclusive environments in our courses. While working together to build this community, we ask all members to:

- Share their unique experiences, values, and beliefs if they are comfortable doing so.
- Listen deeply to one another.
- Honor the uniqueness of their peers.

- Appreciate the opportunity we have to learn from each other.
- Use this opportunity to discuss ways to create an inclusive environment in this course and across the campus community.
- Recognize opportunities to invite a community member to exhibit more inclusive, equitable speech or behavior and invite them into further conversation. We also expect members to respond with gratitude and to take a moment of reflection when they receive such an invitation.
- Keep confidential any discussions that the community has of a personal (or professional) nature unless the speaker has given explicit permission to share what they have said.
- Respect students' right to be addressed and referred to by the names and pronouns that correspond to their gender identities, including the use of non-binary pronouns.

WE USE EACH OTHER'S PREFERRED NAMES AND PRONOUNS.

Please let me know of your preferred or adopted name and gender pronoun(s), and I will make those changes to my records and address you that way in all cases.

To change to a preferred name so that it displays on all BSU sites, including Canvas and my course roster, contact the Registrar's Office at (208) 426-4249.

PS: Only a legal name change can alter your name on BSU official and legal documents (e.g., your transcript).

ACCOMMODATIONS

I recognize that navigating your education and life can be more difficult if you have disabilities. I want you to achieve at your highest capacity in this class. If you have a disability, I need to know if you encounter inequitable opportunities in my course related to:

- Accessing and understanding course materials
- Engaging with course materials and other students in the course
- Demonstrating your skills and knowledge on assignments and exams.

If you have a documented disability, you may be eligible for accommodation in your courses. To learn more, make an appointment with the university's [Educational Access Center](#).

***Visit the Educational Access Center website to copy and include the most recent syllabus statement. You can find additional resources/ideas related to inclusivity at this link: [Supporting Students Facing Mental Health Challenges](#).*

CLASS PARTICIPATION

You must attend regular in-person classes every week and complete the assignments and tasks by the scheduled due dates. The amount of learning you get out of this course will depend to a large extent on your preparation and participation. Class participation is a requirement of this course and counts toward your grade.

FACULTY INITIATED WITHDRAWAL FOR NONATTENDANCE

Per Boise State University Policy #4190: **Faculty Initiated Withdrawals**, an instructor can drop you from a course for non-attendance at the beginning of the semester. If unexpected circumstances force you to revise your course schedule, please contact your instructor and advisor immediately to discuss the financial and academic implications. You should expect an instructor to refrain from withdrawing you for nonattendance later in the semester. The primary responsibility for course withdrawal rests with you.

DECREASING THE RISK OF COVID-19 IN CLASSROOMS

At Boise State, we're looking forward to another successful semester. This success depends on us taking small but necessary steps to keep students, faculty, staff, and the local community healthy and safe during the pandemic. For its part, the university has put public health requirements measures in place to support our success. For example, Boise State Public Health staff monitor case rates and perform contact tracing in every class where there may have been a COVID-19 exposure.

As students and faculty, part of this work is understanding and adhering to Boise State's rules and strategies to maintain public health. If you are experiencing any COVID-19 symptoms, you should stay home, test, and wait for the results before attending in-person campus activities. Layered COVID-19 prevention strategies are outlined on this University's [COVID-19 web page](#).

I encourage you to learn about other precautions to keep yourself and your peers safe; you can find the latest recommendations on the [COVID-19 web page](#). Failing to follow these rules and precautions violates Boise State's [Student Code of Conduct](#) and will subject you to university sanctions and discipline.

While facial coverings are not currently required in classrooms and most other campus buildings, students who feel more comfortable wearing a mask are encouraged to do so. The [Centers for Disease Control and Prevention](#) continue to view masking as "a critical public health tool" alongside "vaccination, self-testing, and physical distancing," and Boise State recommends the use of facial coverings to provide an extra layer of protection from COVID-19, especially during periods or in places associated with high transmission. As the University allows students and faculty to choose whether or not to wear a facial covering in classrooms, we will respect one another's decisions in this regard.

Specific protocols may change during the semester, and additional measures may become necessary as the public health situation evolves. The President's Boise State University Office will guide such a change. Further details regarding guidelines, protocols, etc., may be found on the [University's Public Health Response](#) website.

We are taking these and other health precautions so that this course and others can continue to meet in person. Of course, even implementing these strategies can't keep us 100% safe from infection. Because we are breathing standard air in the classroom and sitting close together for entire class meetings, we all remain at risk of potential exposure to the virus. We must all engage in behaviors that protect public health to preserve this learning community for the semester.

This course is designed for in-person learning environments. The face-to-face format of this course offers several benefits that appeal to many students. While I will accommodate the learning needs of students who need to isolate or quarantine, you should expect that this course will continue to meet in person all semester.



Should you prefer a system that meets online or remotely, please talk with me, and we will see if another section of this course or a similar one is available.

STUDENT WELL-BEING

Suppose you are struggling for any reason (COVID, relationship, family, or life's stresses) and believe these may impact your performance in the course. In that case, I encourage you to contact the Dean of Students at (208) 426-1527 or email deanofstudents@boisestate.edu for support. If you are comfortable doing so, please contact me, and I will provide any resources or accommodations I can. If you notice a significant change in your mood, sleep, feelings of hopelessness, or a lack of self-worth, consider connecting immediately with Counseling Services (1529 Belmont Street, Norco Building) at (208) 426-1459 or email healthservices@boisestate.edu.