Computer Science EN.601.482/682
Machine Learning: Deep Learning
Fall 2024 (4 credits, E)

Instructor
Mathias Unberath, mathias@jhu.edu, https://arcade.cs.jhu.edu/
Office hours: Thursdays, 3:00 – 4:00 pm
Office hour location: Malone Hall 327

Teaching Assistants
Jan Mangulabnan,

Catalina Gomez Caballero

Meetings

Attendance <u>in person</u> is strongly recommended to achieve the best learning outcomes.
The Zoom virtual presence option is provided exclusively for increased accessibility, and
in extraordinary circumstances (such as acute illness). Lecture *recordings are not an*
adequate substitution for in person attendance. Recordings are made available to
facilitate recollection and working through the materials after class.
If you are feeling sick, or have reason to believe you may be sick, please do not come to
class and make use of this option.

Mask Policy
Deep Learning is a large class and ventilation of and air quality in auditoriums is limited;
prosperous conditions for the spread of diseases. Nobody wants to get sick – If you are
experiencing symptoms (such as a runny nose, coughing, etc.) first ask yourself if you
have to come to class or whether making use of the virtual presence option is adequate. If
you have to be in person, make sure you wear a mask so that others do not feel
uncomfortable around you, and to curb the spread of communicable diseases. Your
serious consideration of this request is highly appreciated.

Textbook
This course does not explicitly follow a specific textbook, though many good textbooks
on the topic are available. A fairly exhaustive list of additional reading material
(including textbooks, blog articles, tutorials, and scientific articles) will be made
available in the "Resource" section of Piazza.

Online Resources

Please log in to Piazza for all materials related to this course.

Course Information

Synopsis: Deep learning (DL) has emerged as a powerful tool for solving data-intensive learning problems such as supervised learning for classification or regression, dimensionality reduction, and control. As such, it has a broad range of applications including language processing, computer vision, medical imaging, and perception-based robotics. The goal of this course is to introduce the basic concepts of DL. The course will include a brief introduction to the basic theoretical and methodological underpinnings of machine learning, commonly used architectures for DL, current challenges including ethics and fairness, and specialized applications with a particular focus on computer vision. Students will be expected to solve several DL problems on standardized data sets and will be given the opportunity to pursue team projects on topics of their own interest.

Prerequisites: (AS.110.201 or AS.110.212 or EN.553.291) and (EN.553.310 EN.553.311 or EN.553.420 or EN.560.348) and (EN.601.475 or equivalent); Calc III and numerical optimization recommended. Recommended co-req: EN.601.382.

Communication Plan: In Fall 2024, this course will be held in person. Virtual presence through zoom is possible in case of need (accommodations, illness, higher power). No prior approval is required to attend virtually. Sessions will be recorded to facilitate recollection and in preparation for assignments and exams. *Watching the recordings is not an acceptable substitute for in person attendance.*

Where do I find course material? The course's home is on Piazza. On **Piazza** you will find lecture slides, assignments, and other relevant course material and resources. You are encouraged to post any questions and discussions on Piazza and contribute to answering questions your peers have posted. Please note that, while you can remain anonymous to peers, posting anonymously to instructors is disabled.

What about homework assignments? We will offer recitations, homework orientation, and Q/A sessions during the Friday slot. Attending these sessions is highly recommended. Questions about homework assignments should be posted to Piazza (again, ideally as a public post so that everyone can benefit from our answers) and can also be discussed in greater detail during office hours. Homework assignments are submitted through **Gradescope**.

Any other communication platforms? Yes – We may use **Google Forms** for specific activities and will share the links as needed.

Course Goals

Specific Outcomes for this course are that
- Students will learn fundamental concepts of machine learning
- Students will learn the theoretical underpinnings of deep learning
- Students will learn contemporary architectures, applications, and challenges of deep learning
- Students will learn to design, implement, and validate deep learning-based solutions to machine learning problems

This course will address the following CSAB ABET Criterion 3 Student Outcomes

Graduates of the program will have an ability to:

1. Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
2. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
3. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.
4. Apply computer science theory and software development fundamentals to produce computing-based solutions.

Course Topics
Homework assignments are released / are due Wednesdays (latest submission 11.59pm).

Week 1 (Aug 26): Introduction and Basics
    L-1)   Welcome, Course Logistics and Topic Overview
    L-2)   Basics Part I: Image Features, Regression, and Classification
    Recitation: L3) Basics Part II and Homework 1 review
    Wednesday, Aug 28: Homework 1 released

Week 2 (Sep 02): Basics
    ~~L-3)   Basics Part II: Regularization and Optimization~~ Labor Day
    L-4)   Computational Graphs and Backpropagation Part I
    <u>Voluntary review</u>: Intro to Python video
    Recitation: Previous weeks and homework 2
    Wednesday, Sep 04: Homework 1 due, Homework 2 released

Week 3 (Sep 09): Convolutional Neural Networks
    L-5)   History of and Introduction to Neural Networks
    L-6)   Convolutional Neural Networks
    Recitation: Previous week and homework 2

Week 4 (Sep 16): Training Neural Networks
    L-7)   Training Part I: Activation, Initialization, Preproc., Dropout, Batch norm
    L-8)   Training Part II: Updates & Momentum, Augmentation, Transfer Learning
    Recitation: Previous week and homework 3
    Wednesday, Sep 18: Homework 2 due, Homework 3 released

Week 5 (Sep 23): Architectures
    L-9)   **Inverse Classroom**: It's not working! Help!
    L-10) Network Architectures: AlexNet, VGG, ResNet, U-Net, …
    Recitation: Previous week and homework 4
    Wednesday, Sep 25: Homework 3 due, Homework 4 released

Week 6 (Sep 30): Architectures continued – **Form project groups**
    L-11) **Inverse Classroom**: What does this network do?
    L-12) RNNs and LSTM
    Recitation: Previous week and homework 4

Week 7 (Oct 07): Recitation Week
    Mathias traveling to MICCAI; TAs leading recitation sessions and Q/A
    Recitation: Previous weeks and homework 5
    Wednesday, Oct 09: Homework 4 due, Homework 5 released

Week 8 (Oct 14): Unsupervised Learning and Generative Models
    L-13) Unsupervised and Self-supervised Learning
    L-14) Autoencoders, Variational Autoencoders, and Disentanglement
    Recitation: Fall Break October 17/18
    Wednesday, Oct 16: Homework 5 due, Homework 6 released

Week 9 (Oct 21): Unsupervised Learning and Generative Models
    L-15) Generative Adversarial Networks
    L-16) **Inverse Classroom**: Labeling? Ain't nobody got time for that.
    Recitation: Previous week and homework 6

Week 10 (Oct 28): Advanced Topics – **Start project work**
    L-17) Generalization, domain gaps, and explainable AI
    L-18) Domain gaps and black boxes
    Recitation: Previous week and homework 6

Week 11 (Nov 04): Advanced Topics
    L-19) Character and word embedding
    L-20) Transformers for Language and Vision
    Recitation: Previous week
    Wednesday, Nov 06: Project proposals due**, Homework 6 due, Bonus assignment released

Week 12 (Nov 11): Advanced Topics
    L-21) Neural Radiance Fields
    L-22) Diffusion Models
    Recitation: Midterm Q/A

Week 13 (Nov 18): Midterm and Healthcare Applications
    L-23) DL4Health
    L-24) **Midterm Exam**
    Recitation: Previous week

Fall Recess

L-25)   Human-centered AI, ethics, etc.
L-26)   Wrap Up
Wednesday, Dec 04: Bonus assignment due

TBD: **Final project reports due**

TBD (final exam slot): Synchronous project pitch and breakout rooms

Course Expectations & Grading
The course has 6+1 assignments: 3 are written and the remaining 3+1 focus on programming. The bulk of the homework assignment workload (1 to 6) is condensed into the first three quarters of the semester to free up time for the final project. Starting in Week 11, most time will be spent on the final project that will be completed in groups of four. Individual grades will be computed as a weighted combination of these factors:
1)   Homework Assignments: 45%
2)   Midterm Exam: 35%
3)   Final Project: 20%
There is an opportunity for bonus points. Bonus points are earned by completing additional assignments that will be released as bonus assignment 7.

For late assignment submissions, you have a total of **5 late days** that you can use at your discretion. However, no smaller quantity than "one day" can be used but you can use multiple days for the same homework. <u>You do not need to request late days but will have to keep track of your remaining quota yourself</u>. Once you run out of late days but submit late anyway, the submission will not award any points.

Assignments & Readings
See above schedule for assigned lectures and materials every week.

Ethics
The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful, abiding by the *Computer Science Academic Integrity Policy*:

Cheating is wrong. Cheating hurts our community by undermining academic integrity, creating mistrust, and fostering unfair competition. The university will punish cheaters with failure on an assignment, failure in a course, permanent transcript notation, suspension, and/or expulsion. Offenses may be reported to medical, law or other professional or graduate schools when a cheater applies.

Violations can include cheating on exams, plagiarism, reuse of assignments without permission, improper use of the Internet and electronic devices,

unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition. Ignorance of these rules is not an excuse.

Academic honesty is required in all work you submit to be graded. Except where the instructor specifies group work, you must solve all homework and programming assignments without the help of others. For example, you must not look at anyone else's solutions (including program code) to your homework problems. However, you may discuss assignment specifications (not solutions) with others to be sure you understand what is required by the assignment.

To clarify, any work submitted to this course must be the student's own, original work. We understand that "another individual" in the Computer Science Academic Integrity Policy and Homewood Undergraduate Ethics Policy includes artificial intelligence (AI) assistants such as ChatGPT and GitHub Copilot. Therefore, use of such AI assistants is considered a form of unauthorized collaboration and is not allowed in this course. To ensure the integrity of the academic work submitted, we will not accept any assignments that have been written with the assistance of AI.

If your instructor permits using fragments of source code from outside sources, such as your textbook or on-line resources, you must properly cite the source. Not citing it constitutes plagiarism. Similarly, your group projects must list everyone who participated.

Falsifying program output or results is prohibited.

Your instructor is free to override parts of this policy for particular assignments. To protect yourself: (1) Ask the instructor if you are not sure what is permissible. (2) Seek help from the instructor, TA or CAs, as you are always encouraged to do, rather than from other students. (3) Cite any questionable sources of help you may have received.

On every exam, you will sign the following pledge: "I agree to complete this exam without unauthorized assistance from any person, materials or device. [Signed and dated]". Your course instructors will let you know where to find copies of old exams, if they are available.

Report any violations you witness to the instructor.

You can find more information about university misconduct policies at these sites:
- For   undergraduates: http://e-catalog.jhu.edu/undergrad-students/student-life-policies/
- For   graduate   students: http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/

Personal Wellbeing

- If you are sick please notify me by email so that we can make appropriate accommodations should this affect your ability to attend class, complete assignments, or participate in assessments. The [Student Health and Wellness Center](#) is open and operational for primary care needs. If you would like to speak with a medical provider, please call 410-516-8270, and staff will determine an appropriate course of action based on your geographic location, presenting symptoms, and insurance needs. Telemedicine visits are available only to people currently in Maryland. See also https://studentaffairs.jhu.edu/student-life/student-outreach-support/absences-from-class/illness-note-policy/
- The Johns Hopkins COVID-19 Call Center (JHCCC), which can be reached at 833-546-7546 seven days a week from 7 a.m. to 7 p.m., supports all JHU students, faculty, and staff experiencing COVID-19 symptoms. Primarily intended for those currently within driving distance of Baltimore, the JHCCC will evaluate your symptoms, order testing if needed, and conduct contact investigation for those affiliates who test positive. More information on the JHCCC and testing is on the [coronavirus information website](#).
- All students with disabilities who require accommodations for this course should contact me at their earliest convenience to discuss their specific needs. If you have a documented disability, you must be registered with the JHU Office for Student Disability Services (385 Garland Hall; 410-516-4720; http://web.jhu.edu/disabilities/) to receive accommodations.
- Students who are struggling with anxiety, stress, depression or other mental health related concerns, please consider connecting with resources through the JHU Counseling Center. The Counseling Center will be providing services remotely to protect the health of students, staff, and communities. Please reach out to get connected and learn about service options based on where you are living this fall at 410-516-8278 and online at http://studentaffairs.jhu.edu/counselingcenter/.
- Student Outreach & Support will be fully operational (virtually) to help support students. Students can self-refer or refer a friend who may need extra support or help getting connected to resources. To connect with SOS, please email deanofstudents@jhu.edu, call 410-516-7857, or students can schedule to meet with a Case Manager by visiting the Student Outreach & Support website and follow "Schedule an Appointment".

Classroom Climate

As your instructor, I am committed to creating a classroom environment that values the diversity of experiences and perspectives that all students bring. Everyone here has the right to be treated with dignity and respect. I believe fostering an inclusive climate is important because research and my experience show that students who interact with peers who are different from themselves learn new things and experience tangible educational outcomes. Please join me in creating a welcoming and vibrant classroom climate. Note that you should expect to be challenged intellectually by me, the TAs, and your peers, and at times this may feel uncomfortable. Indeed, it can be helpful to be pushed sometimes in

order to learn and grow. But at no time in this learning process should someone be singled out or treated unequally on the basis of any seen or unseen part of their identity.

If you ever have concerns in this course about harassment, discrimination, or any unequal treatment, or if you seek accommodations or resources, I invite you to share directly with me or the TAs. I promise that we will take your communication seriously and to seek mutually acceptable resolutions and accommodations. Reporting will never impact your course grade. You may also share concerns with the Department Head (Randal Burns, randal@cs.jhu.edu), the Director of Undergraduate Studies (Joanne Selinski, joanne@cs.jhu.edu), the Assistant Dean for Diversity and Inclusion (Darlene Saporu, dsaporu@jhu.edu), or the Office of Institutional Equity (oie@jhu.edu). In handling reports, people will protect your privacy as much as possible, but faculty and staff are required to officially report information for some cases (e.g. sexual harassment).

Family Accommodations Policy
You are welcome to bring a family member to class on occasional days when your responsibilities require it (for example, if emergency childcare is unavailable, or for health needs of a relative). In fact, you may see my children in class on days when no other accommodations are possible. Please be sensitive to the classroom environment, and if your family member becomes uncomfortably disruptive, you may leave the classroom and return as needed.

University Policy on Incompletes
Teaching staff recognizes that some students may find themselves in unexpected situations where study is difficult if not impossible. Students who are confronted with extraordinary circumstances that interfere with their ability perform their academic work may request an incomplete grade from the instructor. While approval of such a request is not automatic, we will make every effort to accommodate students dealing with illness in the family and other significant hardships.

Deadlines for Adding, Dropping and Withdrawing from Courses
Students may add a course up to **February 3, 2023**. They may drop courses up to **March 5, 2023** provided they remain registered for a minimum of 12 credits. Between **March 5 and April 14, 2021**, a student may withdraw from a course with a W on their academic record. A record of the course will remain on the academic record with a W appearing in the grade column to indicate that the student registered and then withdrew from the course.

For more information on these and other academic policies, see
https://e-catalogue.jhu.edu/engineering/full-time-residential-programs/undergraduate-policies/academic-policies/grading-policies/

The Office of Academic Support at JHU

All programs are free to students, please see below for specifics:
- **PILOT Learning** – Peer-Led Team Learning

- o   Students are organized into small study teams who meet weekly to collaborate on faculty-developed problems-sets. Students work together as a team to solve problems.
- o   A trained student leader acts as captain and facilitates the weekly meetings using various strategies to foster a collaborative learning environment.
- o   Registration opens on August 31st at 9pm EST; registration will remain open throughout the semester if space allows.
- o   Contact: Ariane Kelly - ariane.kelly@jhu.edu
- o   Instagram: @jhupilot
- **Learning Den Tutoring Program** - Small Group Tutoring
  - o   Small group, tailored tutoring of 4 students or less which is headed by one tutor. Visit the website (above) to access zoom links for drop-in sessions
  - o   Tutors can assist with but are not limited to:
    - ▪   Review and strengthening of subject-specific material knowledge
    - ▪   Assist with homework-like problems
    - ▪   Course-specific study skills and exam preparation
    - ▪   Contact: Kaitlin Quigley – quigley@jhu.edu
    - ▪   Instagram: @jhulearningden
- **The Study Consulting Program**
  - o   Students work one-on-one with a study consultant to set academic goals and develop customized strategies for success. Areas addressed include but are not limited to:
    - ▪   Time management
    - ▪   Note taking and test preparation
    - ▪   Mastering large amounts of information
  - o   Contact: Dr. Sharleen Argamaso – sharleen.argamaso@jhu.edu
  - o   Instagram: @jhustudyconsulting
- **The Writing Center**
  - o   Undergraduate and graduate students in KSAS/Whiting School of Engineering can schedule 50-min sessions with a Writing Center tutor to look over a draft of written work (up to 10 pages) or a personal statement for graduate study
  - o   Contact: Robert Tinkle – rtinkle1@jhu.edu
  - o   Web Address: https://krieger.jhu.edu/writingcenter/