



Computer Science EN.601.482/682
Machine Learning: Deep Learning
Fall, 2020 (4 credits, E)

Instructor

Mathias Unberath, mathias@jhu.edu, <https://arcade.cs.jhu.edu/>

Office hours: Odd weeks: Wednesdays 8.00 – 9.00 am, and by appointment

Even weeks: Wednesdays 12:00–1:00 pm, and by appointment

Office hours Zoom link: [Zoom](#)

Teaching Assistant

Suzanna Sia, ssia1@jhu.edu

Office hours: Fridays 1:00–2:00 pm

Office hours Zoom link: [Zoom](#)

Hao Ding, hd15@jhu.edu

Office hours: Tuesdays 5.00 – 6.00 am

Office hour Zoom link: [Zoom](#)

Meetings

Asynchronous consumption of lecture recordings

Synchronous Q/A and flipped classroom session (choose one session)

Session 1: Mondays 7.00 to 8.15 am

Session 2: Mondays 12.00 to 1.15 pm

Class Zoom link: [Zoom](#)

Textbook

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 speech and text understanding, 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, and specialized applications to computer vision, speech understanding, and medicine. 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 2020, this course will be held entirely remotely for the first time. It consists of both asynchronous and synchronous elements to enable remote learning in various time zones and schedules while preserving some of the valuable face to face and personalized interactions that distinguish this course from other online material. Because technology-mediated interactions are not quite comparable to in-person events just yet, we will use multiple channels to communicate as effectively as possible.

How does this work? You will find below a list of lectures and/or other material for you to consume during the specified week of the semester. Consuming this material is asynchronous and you can decide your schedule as long as you finish that week. Questions that arise during self-study or homework can be 1) posted on Piazza and/or 2) submitted anonymously via Google Forms as a request for recitation and clarification during our next synchronous session. During our synchronous sessions, we will then review the most important and most frequently requested topics, provide guidance for solving the homework assignments, or discuss flipped classroom tasks.

Where do I find the material? The course's home is on Piazza and you should sign up as soon as possible using this link: piazza.com/jhu/fall2020/cs482682. On **Piazza** you will find links to recorded lectures, 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.

Homework assignments will be submitted through **Gradescope** with course code **M63JEZ**.

In addition, we will use **Google Forms** for quizzes and anonymous recitation requests. Links to the recitation requests are provided together with the semester schedule below. Links to Quizzes will be shared during the synchronous Zoom sessions.

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 Fridays (latest submission 11.59pm).

Week 1 (Aug 31): Introduction and Basics

Synchronous: Welcome and Course Logistics

Asynchronous: Submit questions here <https://forms.gle/9bKupW4U7pamL2DX6>

L-1) Overview

L-2) Basics Part I: Image Features, Regression, and Classification

Friday, Sep 04: Homework 1 released

Week 2 (Sep 07): Basics

Synchronous: Q/A Week 1 and intro to Python

Asynchronous: Submit questions here <https://forms.gle/TgXbDSuHUqBH5R986>

L-3) Basics Part II: Regularization and Optimization

L-4) Computational Graphs and Backpropagation Part I

Friday, Sep 11: Homework 1 due, Homework 2 released

Week 3 (Sep 14): Convolutional Neural Networks

Synchronous: Q/A Week 2

Asynchronous: Submit questions here <https://forms.gle/ABgJQ61HZMFo8Njq7>

L-5) History of and Introduction to Neural Networks

L-6) Convolutional Neural Networks

Friday, Sep 20: Homework 2 due, Homework 3 released

Week 4 (Sep 21): Training Neural Networks

Synchronous: Q/A Week 3

Asynchronous: Submit questions here <https://forms.gle/WUp5vmL1kLXftou79>

L-7) Training Part I: Activation, Initialization, Preprocessing, Dropout, Batch norm

L-8) Training Part II: Update rules (Momentum), Augmentation, Transfer Learning

Friday, Sep 25: Homework 3 due, Homework 4 released

Week 5 (Sep 28): Architectures

Synchronous: Q/A Week 4

Asynchronous: Submit questions here <https://forms.gle/VYhy3YY9ZriycyMY9>

L-9) **Inverse Classroom:** It's not working! Help!

L-10) Network Architectures: AlexNet, VGG, ResNet, U-Net, ...

Week 6 (Oct 05): Architectures continued – Form project groups of 3

Synchronous: Q/A Week 5 and **Inverse Classroom Discussion**

Asynchronous: Submit questions here <https://forms.gle/JPg79nQNc92wrP6v9>

L-11) **Inverse Classroom:** What does this network do?

Friday, Oct 09: Homework 4 due, Homework 5 released

Week 7 (Oct 12): Sequence Modeling

Synchronous: Q/A Week 6 and **Inverse Classroom Discussion**

Asynchronous: Submit questions here <https://forms.gle/qSZjPQkqqch5yA8eA>

L-12) RNNs and LSTM

Friday, Oct 16: Homework 5 due, Homework 6 released

Week 8 (Oct 19): Unsupervised Learning

Synchronous: Q/A Week 7

Asynchronous: Submit questions here <https://forms.gle/g8csDwkdDSTG2DTv9>

L-13) Unsupervised and Self-supervised Learning

L-14) Autoencoders, Variational Autoencoders, and Disentanglement

Week 9 (Oct 26): Generative Models

Synchronous: Q/A Week 8

Asynchronous: Submit questions here <https://forms.gle/8Qbbo7A8nMe4iara6>

L-15) Generative Adversarial Networks

L-16) **Inverse Classroom:** Labeling? Ain't nobody got time for that.

Friday, Oct 30: Homework 6 due, Homework 7 released

Week 10 (Nov 02): Current Topics – **Start project work**

Synchronous: Q/A Week 9 and **Inverse Classroom Discussion**

Asynchronous: Submit questions here <https://forms.gle/ZohrmWfi6yMaorPB6>

L-17) Generalization, domain gaps, and explainable AI

L-18) Domain gaps and black boxes

Friday, Nov 06: Project proposals due

Week 11 (Nov 09): Current Topics

Synchronous: Q/A Week 10

Asynchronous: Submit questions here <https://forms.gle/gBQd8qqRPNdsXdnL8>

L-19) DL4Health

L-20) Character and word embedding

Week 12 (Nov 16): Current Topics

Synchronous: Q/A Week 11

Asynchronous: Submit questions here <https://forms.gle/9LhqyDvrreCqC73U9>

L-21) Natural Language Processing and Transformers

L-22) Deep Reinforcement Learning
Week 13 (Nov 23): Thanksgiving Vacation

Week 14 (Nov 30): Wrap up

Synchronous: Q/A Week 12

Asynchronous: Submit questions on Piazza for asynchronous clarifications, this is the last week!

L-23) Human-centered AI, ethics, etc.

L-24) Wrap Up

Friday, Dec 04: Homework 7 due

Friday, Dec 11: Final project reports due

Friday, Dec 18, 2.00 to 5.00 pm (we will address time zone concerns): Synchronous project pitch and breakout rooms

Course Expectations & Grading

We will have short weekly quizzes to test your comprehension and recollection of the course material you prepared asynchronously. The link to participate in quizzes will be shared over the zoom link during the respective synchronous session. Further, the course has 7 assignments, 3 of which are written and the remaining 4 focusing on programming. The bulk of the homework assignment workload (1 to 6) is condensed into the first two-thirds in the first two thirds of the semester to free up time for the final project. Starting in Week 10, 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) Quizzes: 10%
- 2) Homework Assignments: 50%
- 3) Final Project: 40%

There is opportunity for bonus points. Bonus points are earned by completing additional assignments that will be described in homework assignment 7.

The **worst quiz score** of every student will be automatically **dropped** from scoring. For late assignment submissions, you have a total of **3 late days** that you can use at your discretion. However, no smaller quantity than “day” can be used but you can use multiple days for the same homework. **Late days must be requested ahead of submission deadline** via private message to instructors on Piazza.

Assignments & Readings

This will be posted on Piazza when applicable.

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.

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 on the web 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 their school is closed. 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

The university recognizes that the Fall 2020 semester is surrounded with uncertainty and many 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, it is expected that faculty will make every effort to accommodate students dealing with illness in the family and other pandemic-related hardships. The instructor and student must establish a timetable for submitting the unfinished work with a final deadline no later than the end of the third week of the Spring 2021 semester (**February 12, 2021**). Exceptions to this deadline require a petition from the instructor to the student's academic advising office by February 12, 2021. When entering an Incomplete grade in SIS, faculty must include a reversion grade which represents the grade the student will receive if s/he does not complete the missing work by the agreed-upon deadline.

Deadlines for Adding, Dropping and Withdrawing from Courses

Students may add a course up to **September 11, 2020**. They may drop courses up to **October 12, 2020** provided they remain registered for a minimum of 12 credits. Between **October 12 and November 13, 2020**, 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
 - 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.
 - A trained student leader acts as captain and facilitates the weekly meetings using various strategies to foster a collaborative learning environment.
 - Registration opens on August 31st at 9pm EST; registration will remain open throughout the semester if space allows.
 - Contact: Ariane Kelly - ariane.kelly@jhu.edu
 - Instagram: @jhupilot
- **Learning Den Tutoring Program** - Small Group Tutoring
 - 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
 - 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**
 - 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
 - Contact: Dr. Sharleen Argamaso – sharleen.argamaso@jhu.edu
 - Instagram: @jhustudyconsulting
- **The Writing Center**
 - 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
 - Contact: Robert Tinkle – rtinkle1@jhu.edu
 - Web Address: <https://krieger.jhu.edu/writingcenter/>