Engineering Faculty Document No. 24-21

October 6, 2020

TO: The Faculty of the College of Engineering

FROM: The Faculty of the School of Biomedical Engineering

RE: New Graduate Course, BME 64600, Deep Learning – Theory and Practice of Deep Neural Networks

The Faculty of the School of Biomedical Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

BME 64600: Deep Learning-Theory and Practice of Deep Neural Networks
Term Offered: Spring or Fall, Lecture 3, Cr. 3
Requisites, Restrictions, and Attributes. None

Description: This course teaches the theory and practice of deep neural networks from basic principles through state-of-the-art methods. The class blends hands-on programming, using a variety of state-of-the-art programming frameworks, with theoretical treatment based on current literature. Implementation will emphasize the use of the Pytorch language and the use of dynamic computational graphs. Some previous experience with optimization techniques is important for success in the course.

Reason: The course is unique at the university and at a national level in that it teaches the theory and practice of deep neural networks from fundamental principles through state-of-the-art methods and it blends hands-on programming using a variety of state-of-the-art programming frameworks with theoretical treatment based on current research literature. Advanced students in engineering and computer science need this course in order to learn both the theoretical and software methods that are widely used and have become crucial background for careers in science and engineering. This course has been taught as BME 69500 for more than 6 terms in 2010, 2012, 2014, 2016, 2017 and 2019 with 10, 14, 16, 16, 15 and 35 students respectively.

George R Wodicka

George R. Wodicka,
Dane A. Miller Head and Professor
Weldon School of Biomedical Engineering

Course Information:

BME 69500DL - Deep Learning
CRN: 21307;
Meeting time: Tues/Thurs 12-1:15
Meeting location: MJIS 1001
Course credit hours: 3
Course prerequisites: None

Information About the Instructors:

Prof. Avinash Kak
Office: EE 340
Phone: 765 49-43551
Email: kak@purdue.edu

Prof. Charles A. Bouman
Office: MSEE 320
Phone: 765 494-0340
Email: bouman@purdue.edu

Course Description:

The purpose of this course is to teach the theory and practice of deep neural networks from basic principles through state-of-the-art methods. The class is unique at a national level in that it blends hands-on programming using a variety of state-of-the-art programming frameworks with theoretical treatment based on current literature. Implementation will emphasize the use of the Pytorch language and the use of dynamic computational graphs. Competency in multivariate calculus and linear algebra, some previous experience with optimization techniques along with some programming experience is important for success in the course.

Approximate Schedule:

- Week 1: Overview of Deep Learning and Its Relation to Machine Learning in General
- Week 2: Object-Oriented Python for DL Software Structures
- Week 3: Basic Concept of Neural Processing for Classification and Regression
- Week 4: Introduction to Convolutional Networks
- Week 5: Static versus Dynamic Computational Graphs
- Week 6: Residual Learning with Skipped Connections
- Week 7: Recurrent Networks
- Week 8: Neural Processing of Textual Information
- Week 9: Theory of back-propagation and automated differentiation
- End of Week 9: Midterm exam
- Week 10: Convergence of GD and SGD
- Week 11: Local Minima and Saddle-Point Problems
- Week 12: SGD using Momentum and Adaptive Gradients (Adam)
- Week 13: Equilibrium solutions and adversarial methods
- Week 14: Generative models
- Week 15: Recurrent models
- Week 16: Reinforcement learning

Learning Outcomes:

A student successfully completing this course will be able to:

- *Understand how to design a neural network architecture that is appropriate for a wide range of specific applications.*
- *Be able to create an efficient implementation of a wide range of standard neural network architectures in Pytorch.*
- *Be able to use neural networks to solve applications problems in classification, regression, and data generation.*
- *Understand how the fundamental theory of optimization can be used to efficiently train neural networks.*
- *Understand the trade-offs between optimization techniques and how these techniques can be selected to achieve the best neural network training.*
- *Understand and use current theory of neural network performance.*
- *Understand the limitations of existing neural network theory and the likely directions of future research.*

Learning Resources, Technology, & Texts:

Recommended Books:

- https://www.manning.com/books/grokking-deep-learning
- Deep Learning, http://www.deeplearningbook.org
- Neural Networks and Deep Learning, http://neuralnetworksanddeeplearning.com
- Data Science from Scratch, http://shop.oreilly.com/product/0636920033400.do
- Python Machine Learning, https://www.packtpub.com/big-data-and-business-intelligence/python-machine-learning
- http://machinelearningmastery.com/deep-learning-courses/
- Pytorch tutorials: https://drive.google.com/drive/folders/0B41Zbb4c8HVyUndGdGdJSXd5d3M and videos: https://www.youtube.com/playlist?list=PLlMkM4tgfjnJ3I-dbhO9JTw7gNty6o_2m

Recommended supplementary course material:

- https://documents.epfl.ch/users/f/fl/fleuret/www/dlc/ all in pytorch!
- CMU deep learning; https://www.youtube.com/channel/UC8hYZGEkI2dDO8scT8C5UQA/videos
- Oxford DeFreitas complements our course: https://www.cs.ox.ac.uk/people/nando.defreitas/machinelearning/, with Torch7 code, exercises: https://github.com/oxford-cs-ml-2015/
- Stanford FeiFei / Karphaty: excellent material and readings that complement our course: http://cs231n.stanford.edu/ , videos: https://www.youtube.com/playlist?list=PL3FW7Lu3i5JvHM8ljYj-zLfQRF3EO8sYv
- Deep Learning School 2016 Montreal: http://videolectures.net/deeplearning2016_montreal/
- Deep Learning School 2016: http://www.youtube.com/playlist?list=PLrAXtmErZgOfMuxkACrYnD2fTgbzk2THW
- Udacity Deep Learning nano-degree: https://www.udacity.com/course/deep-learning-nanodegree-foundation--nd101

Assignments and Points:

We typically assign approximately 8 or 9 homeworks in which students learn the fundamentals of programing DNN in Pytorch and Python. Homeworks must be performed independently by each student. Violation of this rule will be considered a form of cheating. There will be one midterm exam and a single final exam. Final grades will use the following weighting.

Computer Homeworks	50%
Midterm I	25%
Midterm II	25%

Grading Scale:

This class is graded on a curve. A total score will be computed for each student according to the point weighting above. Then based on the assessment of the professors with input from the teaching assistants, and in consideration of both the overall class performance and individual student performance, cut-offs will be determined separating grade levels, and students will be assigned individual grades based on those cut-offs.

Attendance Policy:

Attendance at lectures is mandatory. No exam makeups will be given, so please check your calendar at the beginning of the semester. Any exam absence due to extreme circumstances will be made up through a weighting of the remaining grades.

Academic Integrity:

We expect every member of the Purdue community to practice honourable and ethical behaviour both inside and outside the classroom. Any actions that might unfairly improve a student's score on homework, quizzes, labs, or examinations will be considered cheating and will not be tolerated. Examples of cheating include (but are not limited to):

- Sharing results or other information during an examination.
- Bringing forbidden material or devices to an examination.
- Working on an exam before or after the official time allowed.
- Requesting a re-grade of answers or work that has been altered.
- Submitting a homework or laboratory report that is not your own work, or engaging
- in forbidden homework or laboratory report collaboration.
- Possession of another person's laboratory solutions or report from the current or previous years.
- Reference to, or use of another person's laboratory solutions or report from the current or previous years.
- Allowing another person to copy your laboratory solutions or work.
- Representing as your own work anything that is the result of the work of someone else.

All homeworks and laboratories must be performed independently by each student. Violation of this rule will be considered a form of cheating. At the professor's discretion, cheating on an assignment, or examination will result in a failing grade for the entire course, or a reduced grade, or a zero score for the particular assignment, or exam. Occurrences of academic dishonesty will be reported to the Assistant Dean of Students and copied to the ECE Assistant Head for Education. If there is any question as to whether a given action might be construed as cheating, please see the professor or the TA before you engage in any such action.

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing or by calling 765-494-8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.

The Honor Pledge Task Force, a student organization responsible for stewarding the mission of the Honor Pledge and encouraging a culture of academic integrity, asks all instructors to prominently include the student-initiated Purdue Honor Pledge on their syllabus, as well as exams and key assignments:

The Purdue Honor Pledge "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue"

Also, you may refer to Purdue's *student guide for academic integrity* for more information.

Nondiscrimination Statement:

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Link to Purdue's nondiscrimination policy statement.

Students with Disabilities:

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: **drc@purdue.edu** or by phone: 765-494-1247.

Purdue has assistance available to help you make learning materials accessible. Some examples include:

- Information on Universal Design for Learning
- Guidance on creating accessible documents

Emergency Preparation:

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances.

In the event of an emergency, students can get information from the following sources:

- The following web page:
  https://www.purdue.edu/ehps/emergency_preparedness/flipchart/index.html
- provides resources in case of emergencies that affect the West Lafayette campus.
- Keep your cell phone on but with the ringer and buzzer off to receive a Purdue ALERT text message.
- Log into a Purdue computer connected to the network to receive any Desktop Popup Alerts.

In an emergency, students are also welcome to contact Prof. Bouman by phone at his office or home.

Mental Health Statement:

- If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.
- If you need support and information about options and resources, please see the Office of the Dean of Students for drop-in hours (M-F, 8 am- 5 pm).
- If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Violent Behavior Policy:

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

See the University's full violent behavior policy for more detail.

Diversity and Inclusion Statement:

In our discussions, structured and unstructured, we will explore a variety of challenging issues, which can help us enhance our understanding of different experiences and perspectives. This can be challenging, but in overcoming these challenges we find the greatest rewards. While we will design guidelines as a group, everyone should remember the following points:

- We are all in the process of learning about others and their experiences. Please speak with me, anonymously if needed, if something has made you uncomfortable.
- Intention and impact are not always aligned, and we should respect the impact something may have on someone even if it was not the speaker's intention.
- We all come to the class with a variety of experiences and a range of expertise, we should respect these in others while critically examining them in ourselves.

Course Evaluation:

During the last two weeks of the course, you will be provided with an opportunity to evaluate this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system.