**Deep Learning**

### Instructors

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### Goal

This course will cover theory and practice of deep learning, including neural network and structured models, optimization algorithms, and applications to perception and Artificial Intelligence.

### Recommended Textbook

Extensive course notes will be provided, in addition to reading materials from conferences, journals, and book referenced below.

Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville. MIT Press, 2016, http://www.deeplearningbook.org/. 780 pages.

### Grading

40% Homework and 4 assignments

20% Midterm Exam

40% Final Project

### Prerequisites

The course requires the new class Mathematical Foundations of Machine Learning, and an Advanced Machine Learning course CSE6740/ISYE6740/CS6741/CS7641 as prerequisites.

Students should have had exposure to the basics of linear algebra, probability, statistics, optimization, and data structure. Student should also have basic programming skills.

### Learning Objectives

*As part of this course, students …*

1. Become familiar with deep learning and the most commonly used neural network architectures, learning and inference algorithms
2. Gain exposure to the application of deep learning to real world problems
3. Formulate a wide range of problems and design appropriate architectures for them as well as properly optimize them

### Course Educational Outcomes

*Upon successful completion of this course, students should be able to …*

1. Categorize, compare, and contrast various deep learning algorithms and explain which are better suited for particular types of real-world data or problems than others (multilayer perceptrons vs. ConvNets vs RNNs vs. Restricted Boltzmann Machines/Factor Graphs)
2. Derive and implement backprogation-based parameter learning and modern optimization techniques in such models
3. Design and implement various types of neural network architectures for different types of machine learning problems (classification, detection, regression, sequence to sequence)
4. Discuss and critique research papers on these topics
5. Design and carry out a project within their area of interest, apply the learned techniques to new types of data within this area, and analyze the performance of the algorithms within it
6. Identify open research questions in these areas

### Academic Integrity

Academic dishonesty will not be tolerated. This includes cheating, lying about course matters, plagiarism, or helping others commit a violation of the Honor Code. Plagiarism includes reproducing the words of others without both the use of quotation marks and citation. Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at [www.honor.gatech.edu](http://www.honor.gatech.edu).

### Learning Accommodations

If needed, we will make classroom accommodations for students with documented disabilities. These accommodations must be arranged in advance and in accordance with the Office of Disability Services ([http://disabilityservices.gatech.edu](http://disabilityservices.gatech.edu/)).

Excused Absence Policy

### <http://www.catalog.gatech.edu/rules/4/>

### Outline of Topics

1. Machine Learning Background and History
   1. Machine Learning Background
   2. Features and Non-Linear Spaces
   3. Elements of ML: Loss Functions, regularization, etc.
2. Neural Networks
   1. Perceptrons
   2. Multi-layer Perceptrons
   3. Non-linear approximation, SGD, Backpropagation
   4. Universal Function Approximation
3. Deep Learning Models
   1. Common Basic Layers (ReLU, Batch Normalization, etc.)
   2. Regularization: Dropout, ensembling, etc.
   3. Convolutional Neural Networks (CNNs)
   4. Applications of CNNs: Classification, Detection, Segmentation, Visualization
   5. Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTMs)
   6. Applications of RNNs: Text, Multi-modal, etc.
4. Generative Models
   1. Boltzmann and Restricted Boltzmann Machines (RBMs)
   2. Deep Belief Nets
   3. Stacked/Deep RBMs
5. Novel Architectures
   1. Distillation and model compression
   2. Memory Networks
   3. Deep Reinforcement Learning