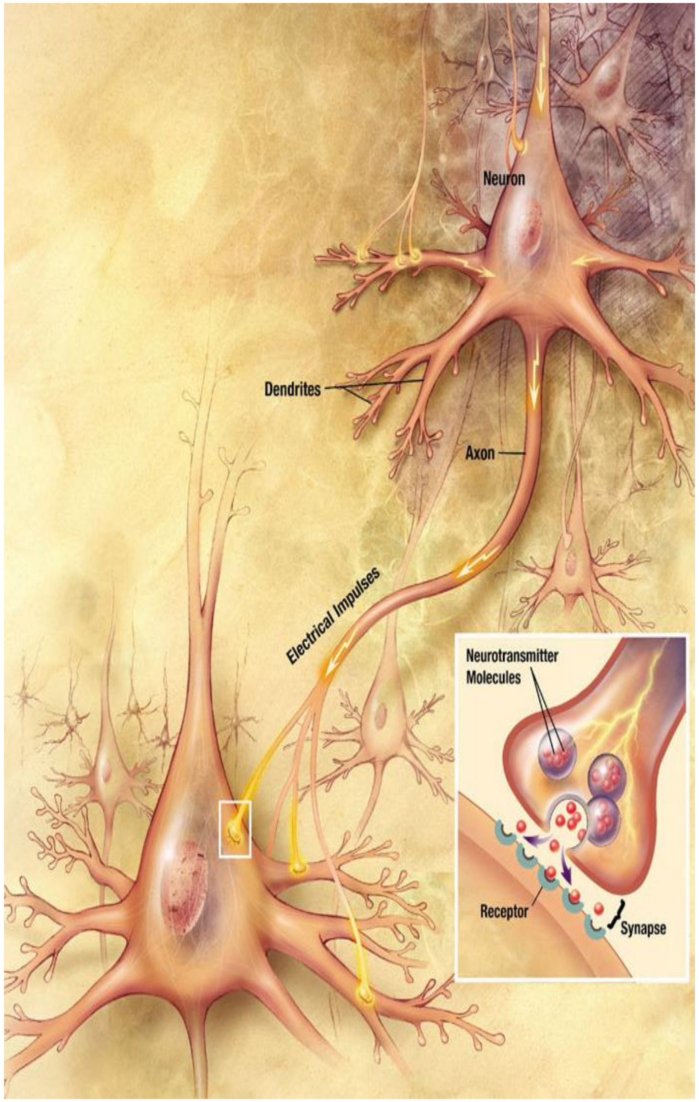
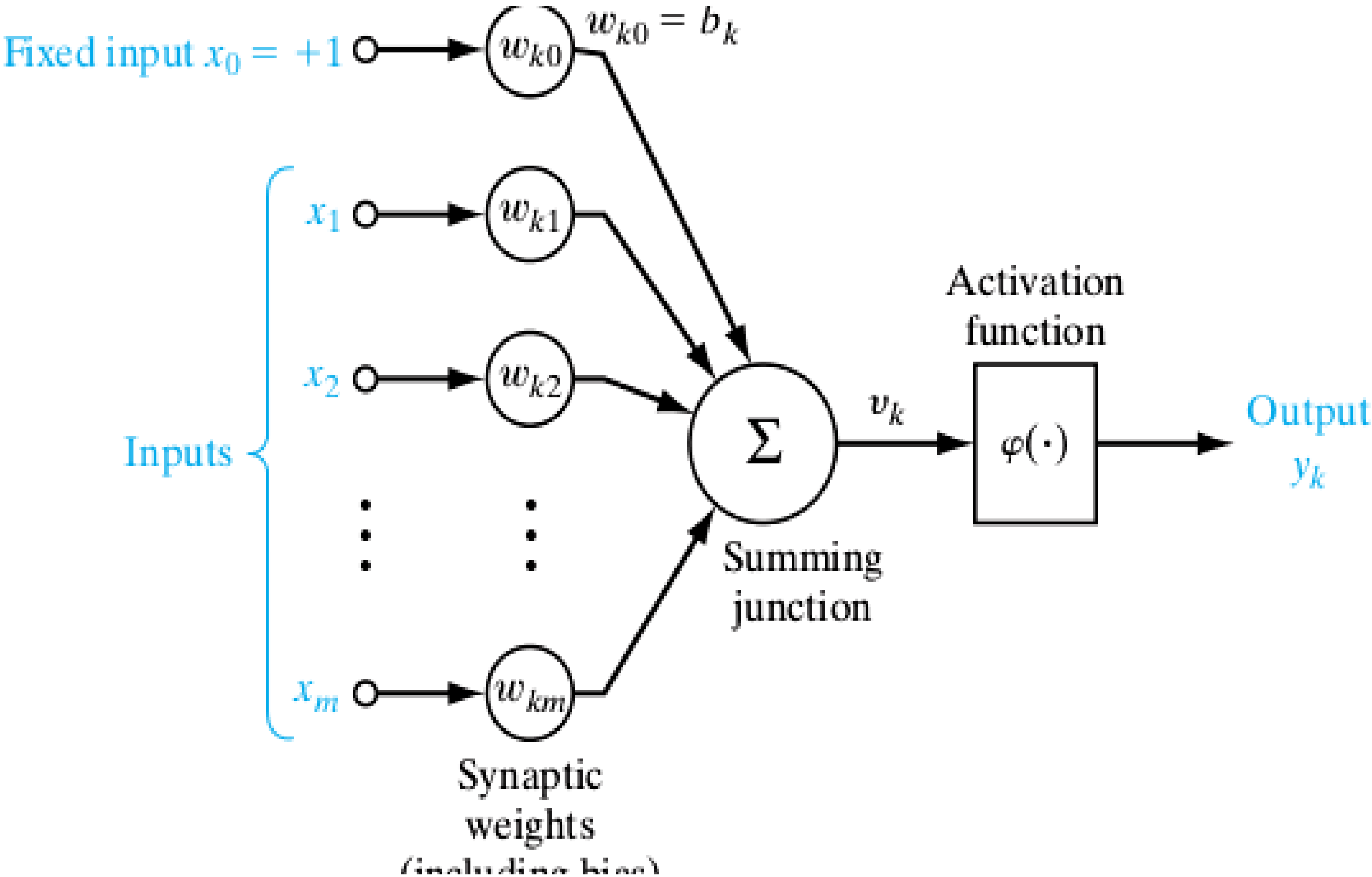
Deep Learning

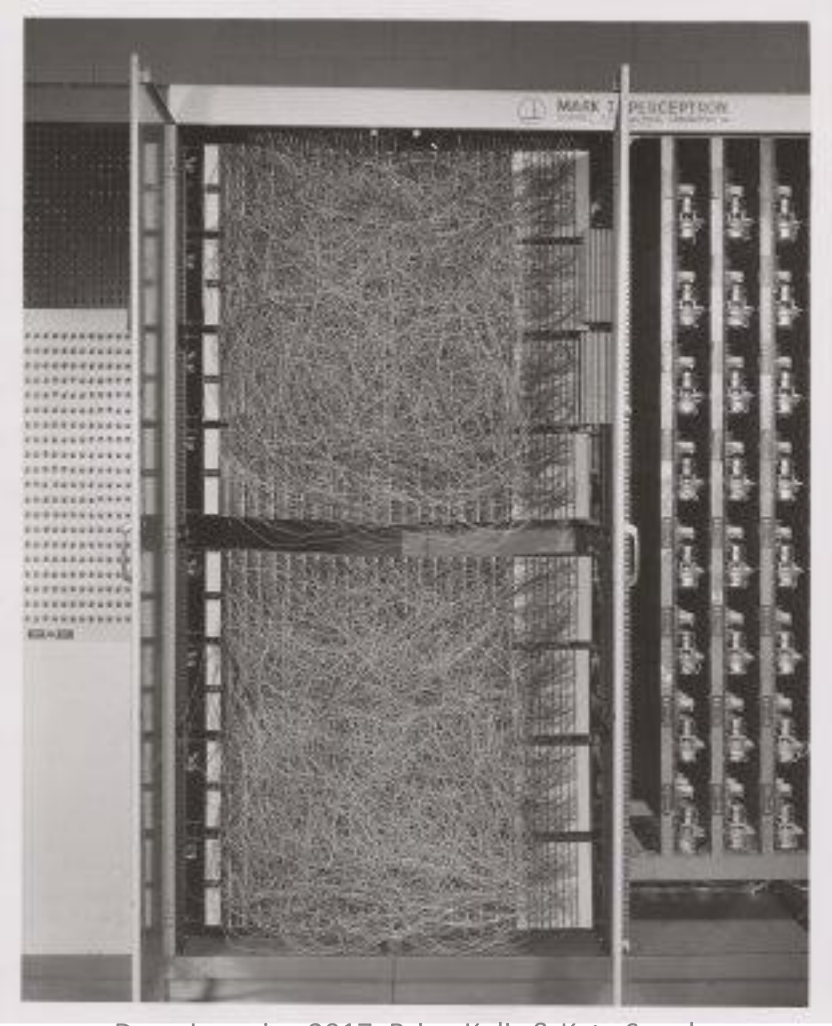
Motivation


Neuron
Dendrites
Axon
Electrical Impulses
Neurotransmitter
Molecules
Receptor
Synapse



$w_{k0} = b_k$
Fixed input $x_0 = +1$
w_{k0}
x_1
w_{k1}
x_2
w_{k2}
Inputs
x_m
w_{km}
Σ
v_k
Activation function
$\varphi(\cdot)$
Output y_k
Summing junction
Synaptic weights

Perceptron



Brief Timeline

- 1943: McCulloch and Pitts
- 1957: Rosenblatt’s Perceptron
- 1969: Minsky and Papert’s *Perceptrons*
- ‘70s/’80s: Symbolic AI
- 1986: Backpropagation takes hold
- Late 80s –Mid 90s: Resurgence of NNs
- 1992: Kernel Methods (Support Vector Machines)
- Mid 90s – 2010: Statistical AI / Graphical Models
- 2006: Hinton’s Deep Belief Nets
- 2010+: Deep Learning Gains Popularity
- 2029: Skynet

IMAGENET

14,197,122 images, 21841 synsets indexed

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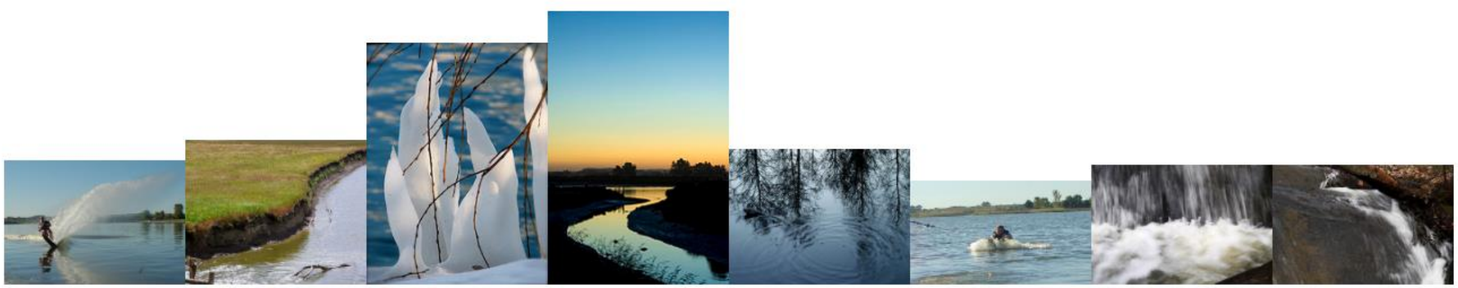
ImageNet is an image database organized according to the WordNet hierarchy (currently only the nouns), in which each node of the hierarchy is depicted by hundreds and thousands of images. Currently we have an average of over five hundred images per node. We hope ImageNet will become a useful resource for researchers, educators, students and all of you who share our passion for pictures.

Click here to learn more about ImageNet, Click here to join the ImageNet mailing list.



What do these images have in common? *Find out!*

Check out the ImageNet Challenge 2016

ImageNet Classification with Deep Convolutional Neural Networks

Alex Krizhevsky
University of Toronto
kriz@cs.utoronto.ca

Ilya Sutskever
University of Toronto
ilya@cs.utoronto.ca

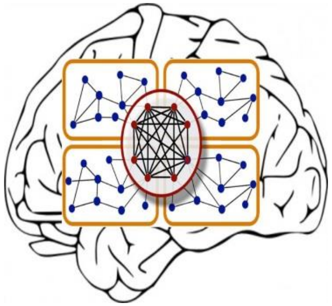
Geoffrey E. Hinton
University of Toronto
hinton@cs.utoronto.ca

Abstract

We trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images in the ImageNet LSVRC-2010 contest into the 1000 different classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0% which is considerably better than the previous state-of-the-art. The neural network, which has 60 million parameters and 650,000 neurons, consists of five convolutional layers, some of which are followed by max-pooling layers, and three fully-connected layers with a final 1000-way softmax. To make training faster, we used non-saturating neurons and a very efficient GPU implementation of the convolution operation. To reduce overfitting in the fully-connected layers we employed a recently-developed regularization method called "dropout" that proved to be very effective. We also entered a variant of this model in the ILSVRC-2012 competition and achieved a winning top-5 test error rate of 15.3%, compared to 26.2% achieved by the second-best entry.

Machine Learning from Big Data: Achievements

Artificial Neural Network

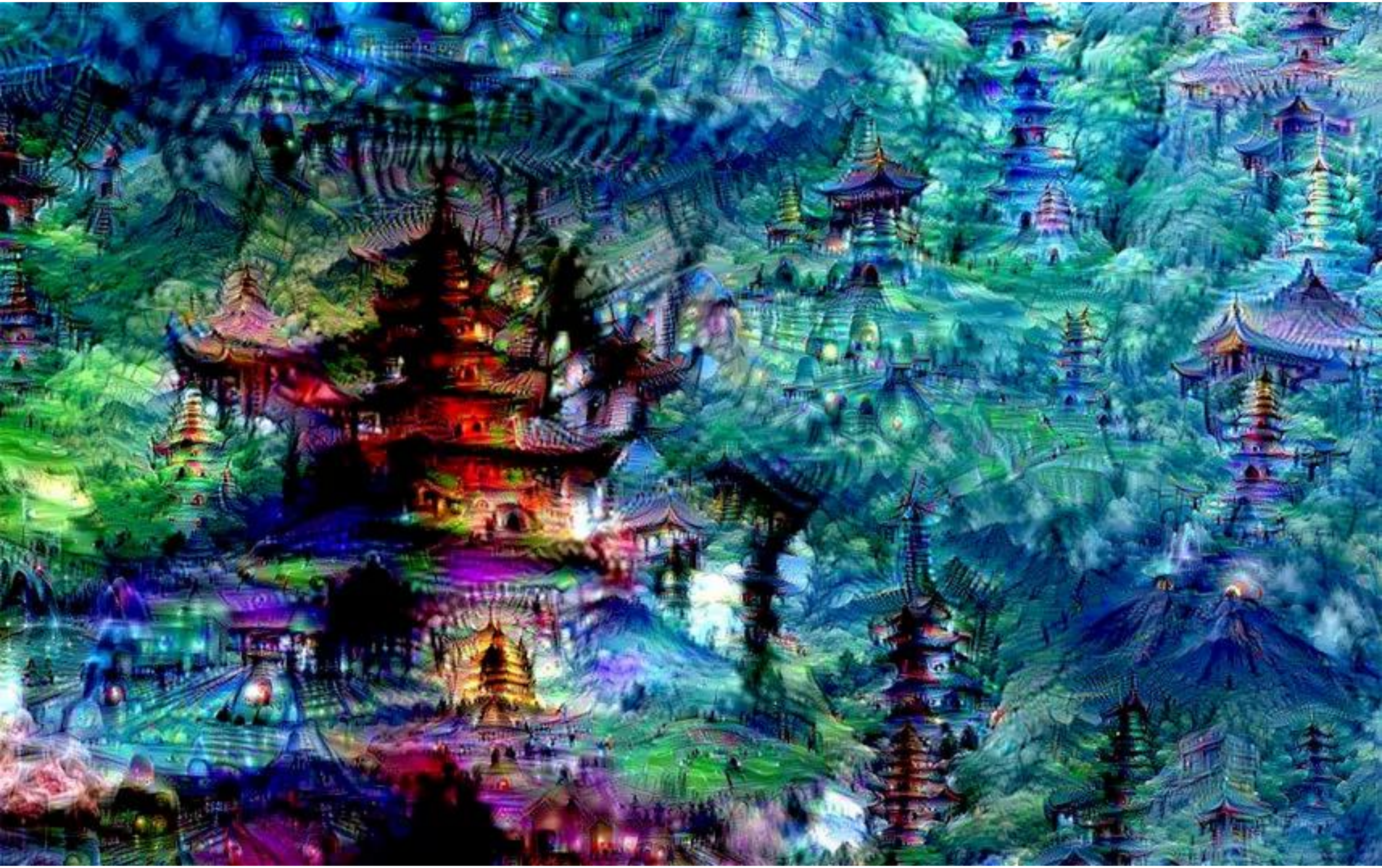


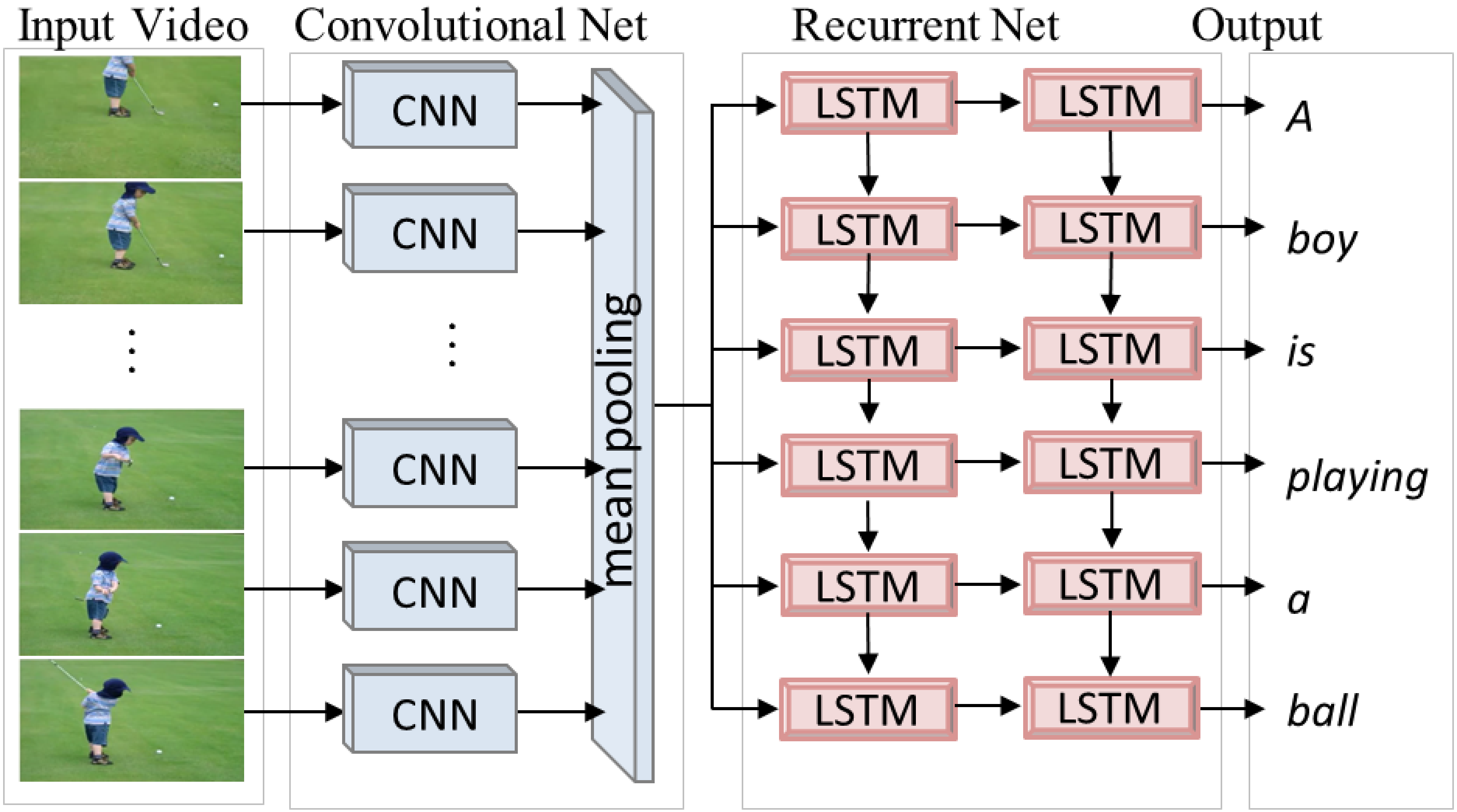
ML watches YouTube for three straight days!
(and learns to recognize cats?!)

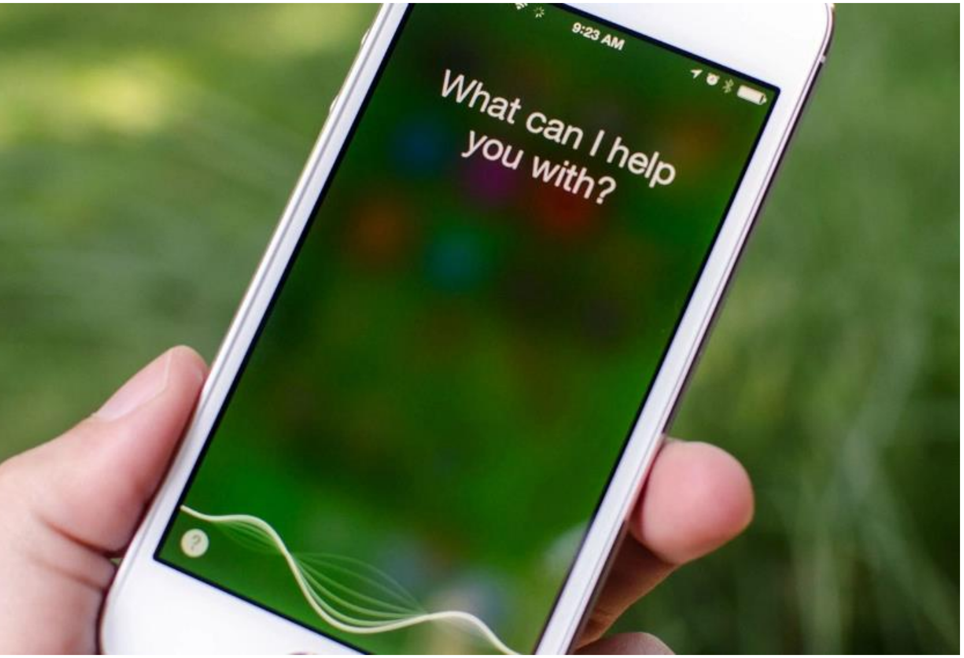
http://www.npr.org/2012/06/26/155792609/a-massive-google-network-learns-to-identify

Building High-level Features Using Large Scale Unsupervised Learning

Quoc V. Le, Marc'Aurelio Ranzato, Rajat Monga, Matthieu Devin, Kai Chen, Greg S. Corrado, Jeffrey Dean, and Andrew Y. Ng



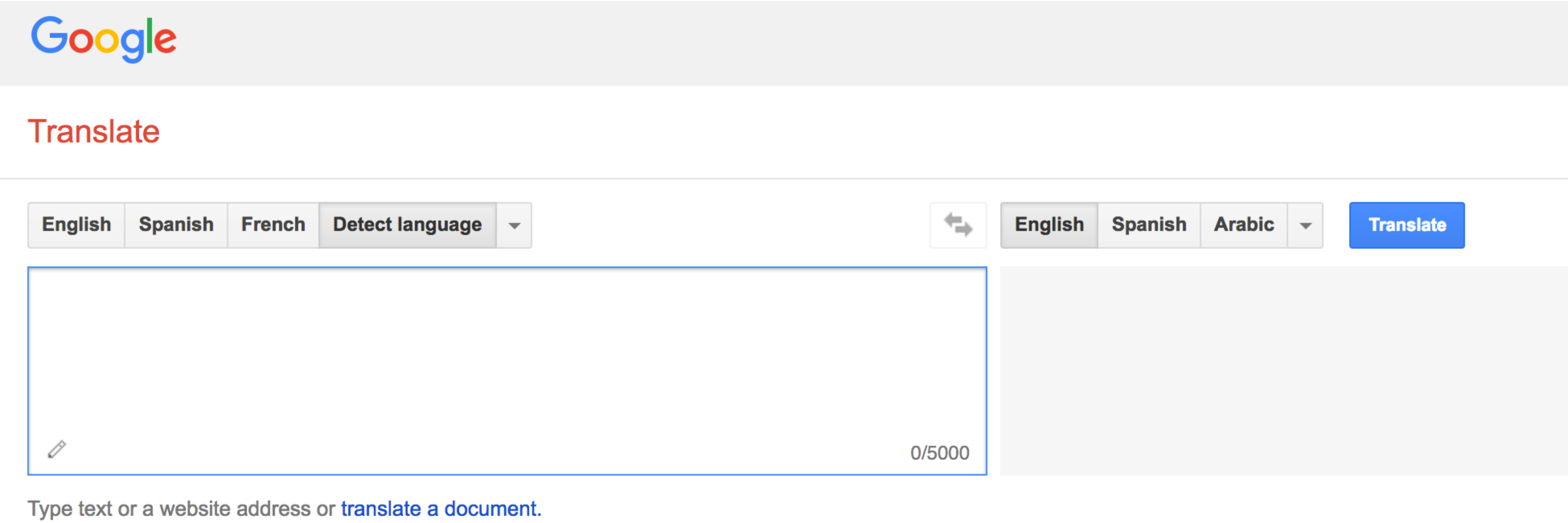

Input Video
Convolutional Net
Recurrent Net
Output
CNN
CNN
CNN
CNN
CNN
mean pooling
LSTM
A
boy
is
playing
a
ball


9:23 AM
What can I help you with?

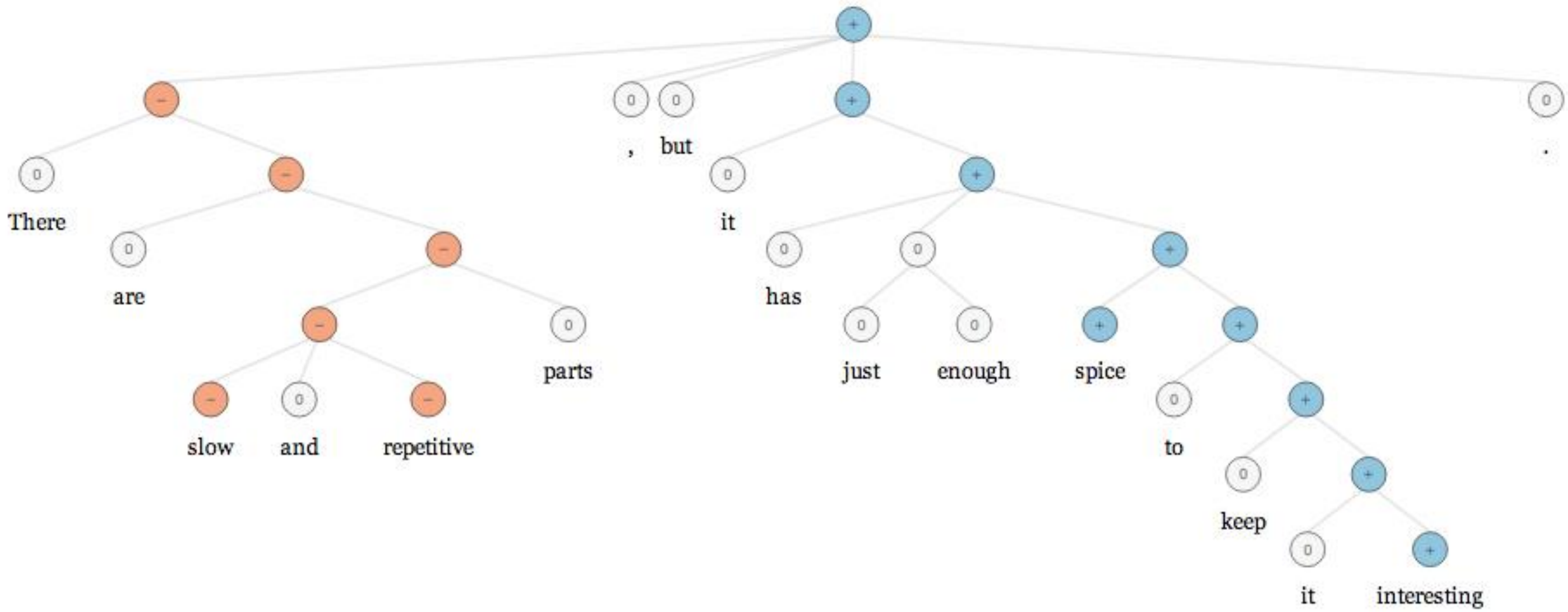

amazon

WaveNet

- https://deepmind.com/blog/wavenet-generative-model-raw-audio/


Google
Translate
English
Spanish
French
Detect language
English
Spanish
Arabic
Translate
0/5000
Type text or a website address or translate a document.

Sentiment analysis




LEE SEDOL

Deep Reinforcement Learning for Atari Games

- https://www.youtube.com/watch?v=V1eYniJ0Rnk

In a ***recent study in Nature****, we introduce a form of memory-augmented neural network called a differentiable neural computer, and show that it can learn to use its memory to answer questions about complex, structured data, including artificially generated stories, family trees, and even a map of the London Underground. We also show that it can solve a block puzzle game using reinforcement learning.*

Plato likened memory to a wax tablet on which an impression,

Deep Learning

Course information

Outline

- Course website & logistics
- Syllabus
  - Problem sets
  - Projects
  - Grading
- Pre-Quiz

Course logistics

Time/Location: Tue/Thu 2-3:15pm in room TBD

Sections: EC500 K1 / CS591 S2

Instructors:

Brian Kulis, bkulis@bu.edu; office hours: TBD

Kate Saenko, saenko@bu.edu; office hours: TBD in MCS296

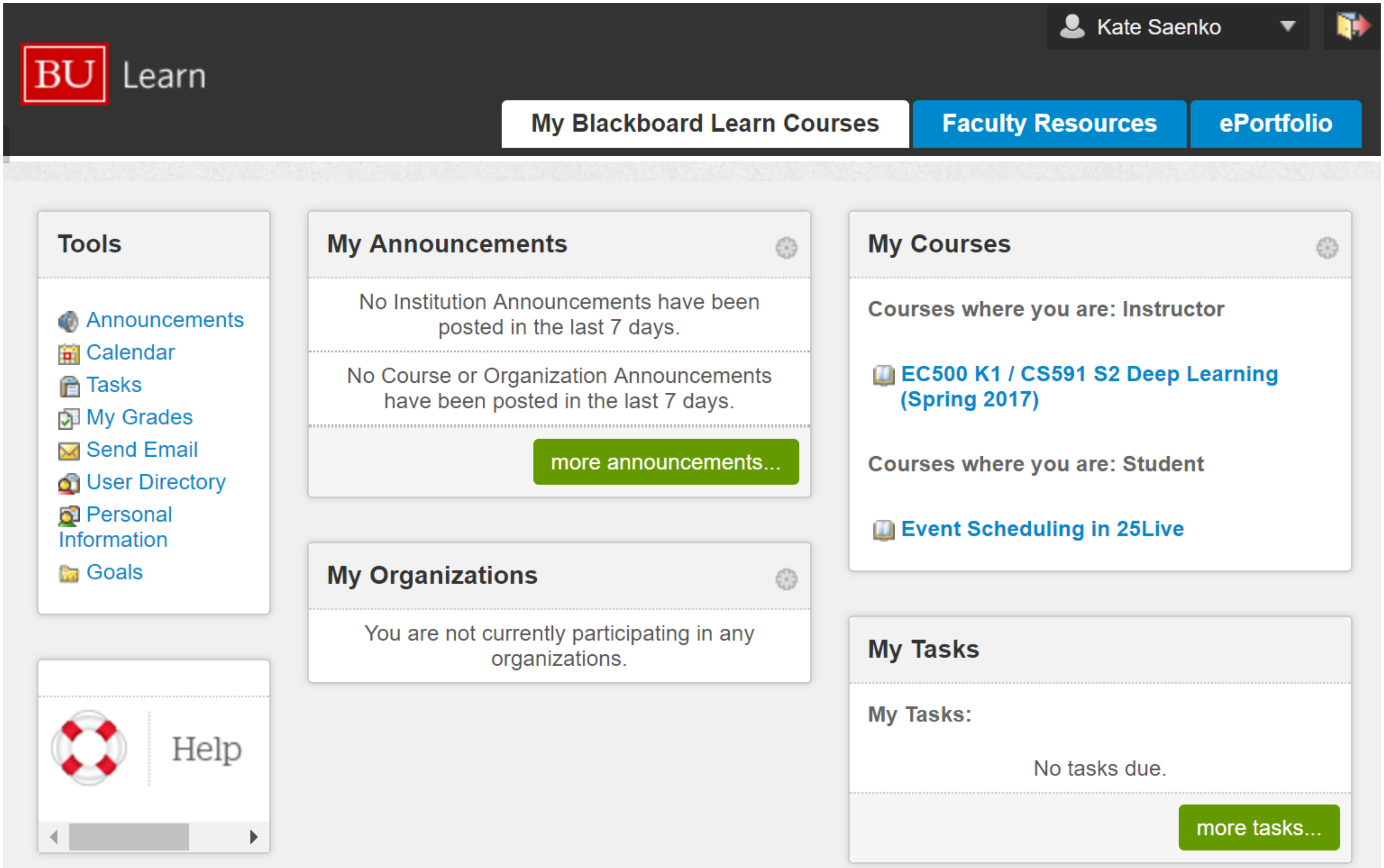
Teaching Assistants:

Kun He, hekun@bu.edu, office hours: Tue 11am-noon, Wed 3-4pm in CS undergrad lab

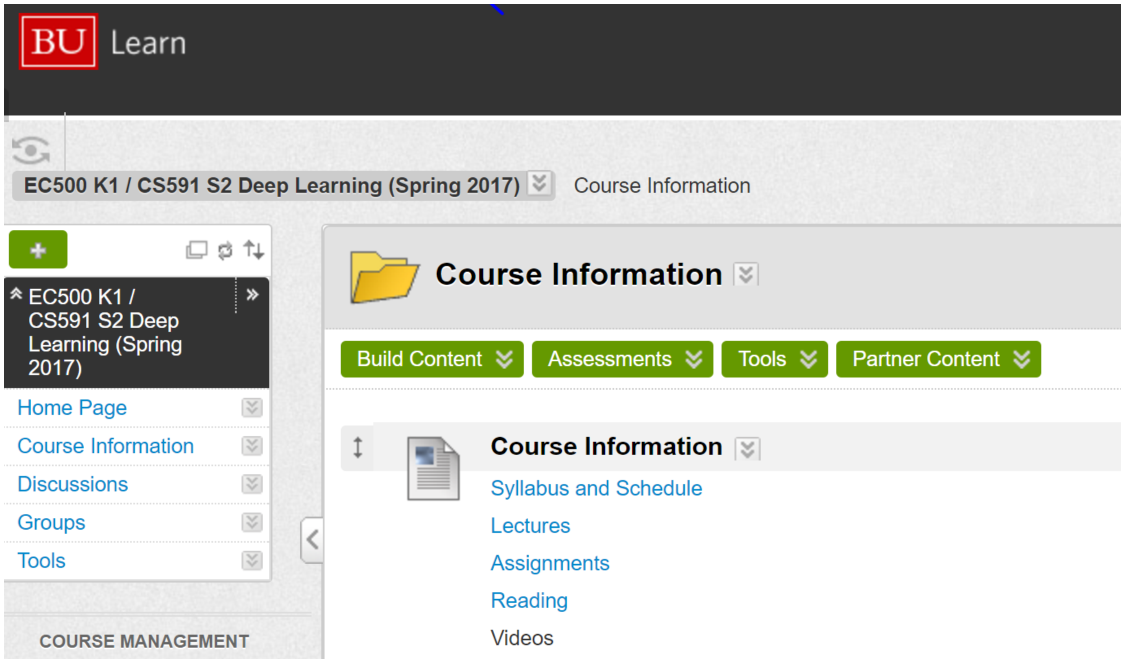
Ben Usman, usmn@bu.edu and Sarah Bargal, sbargal@bu.edu

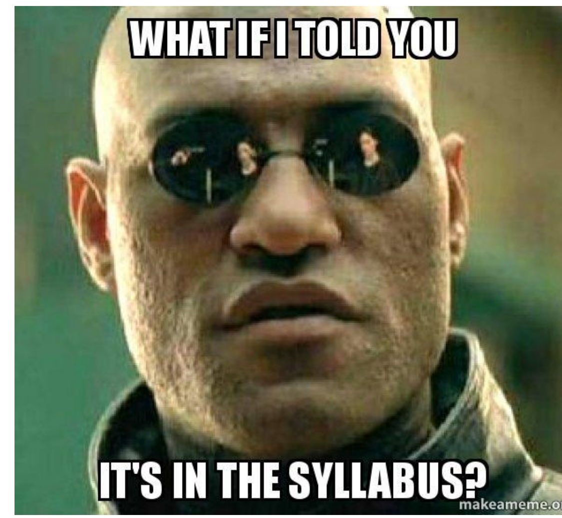
Blackboard: registered students can access via https://learn.bu.edu

Blackboard website



Blackboard website





Pre-requisites

Course Pre-requisites

This is an upper-level undergraduate/graduate course. All students should have the following skills:

- Calculus, Linear Algebra
- Probability & Statistics
- Ability to code in Python

In addition, students must complete and pass the

Pre-Quiz on prerequisite math knowledge. Students who cannot pass the Pre-Quiz must drop the class.

(more on this later)

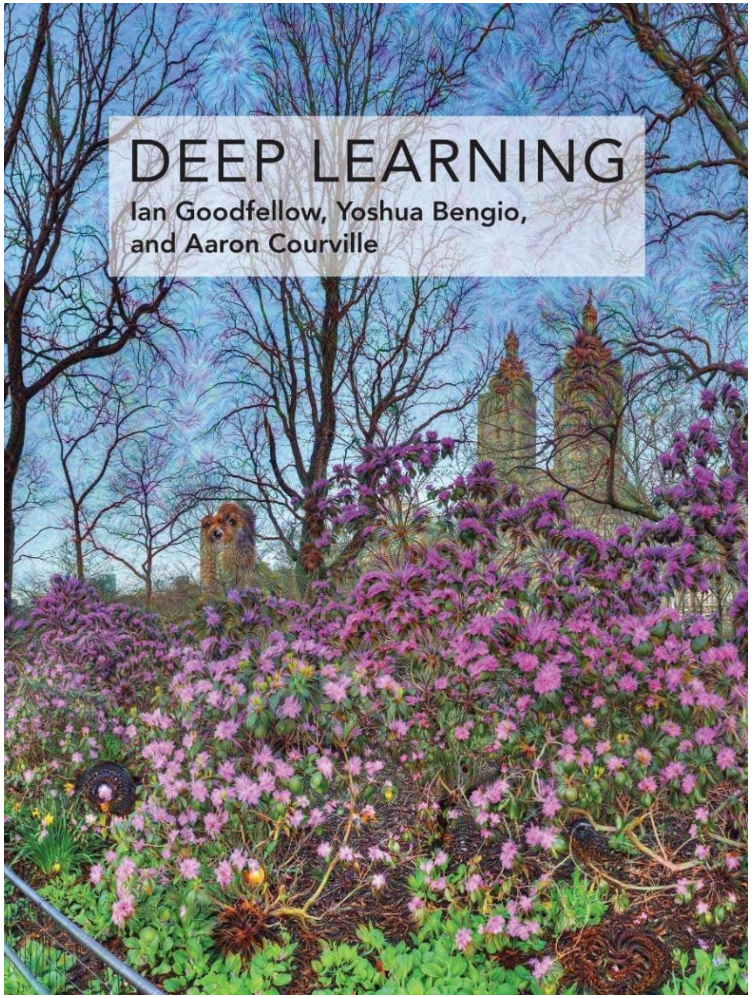
Topics and tentative schedule

1. Course overview
   Math Prerequisite Quiz
2. Math review I
3. Math review II
4. Intro to neural networks
5. Training neural networks
6. Deep neural networks
7. Deep learning strategies I
8. Deep learning strategies II
9. Computing cluster/TensorFlow
10. CNNs I
11. CNNs II

SPRING RECESS

12. Deep Belief Nets I
13. Deep Belief Nets II
14. RNNs I
15. RNNs II
16. Other DNN variants
17. Neural Turing Machines
18. Unsupervised deep learning I
19. Unsupervised deep learning II
20. Deep reinforcement learning
21. Vision applications I
22. Vision applications II

Textbook (required)



Ian Goodfellow, Yoshua Bengio, Aaron Courville. Deep Learning.

Deliverables/Graded Work

- There will be six homework assignments, each consisting of written and/or coding problems, and a final project.
- The course grade consists of the following:

Math prerequisite quiz	5%
Homeworks, best 5 of 6	45%
Project (including all components)	45%
Class participation	5%

Late policy & academic honesty

- Please see syllabus

Homeworks

- Six homeworks
- Roughly every two weeks
- A mix of written questions and coding

Project

- The project will be done in teams of 3-4 students
- Projects will have several deliverables including
  - a proposal
  - progress update(s)
  - final report
  - Github repository
  - in-class presentation
- Project grade is based on all of the above components

BU Shared Computing Cluster/

Sample projects

http://cs231n.stanford.edu/reports2016.html

Supporting humanitarian mapping with deep learning

Lars Roemheld

The Game Imitation: A Portable Deep Learning Model for Modern Gaming AI

Zhao Chen, Darvin Yi

Sample projects

Image Colorization with Deep Convolutional Neural Networks

Jeff Hwang
jhwang89@stanford.edu

You Zhou
youzhou@stanford.edu

Abstract

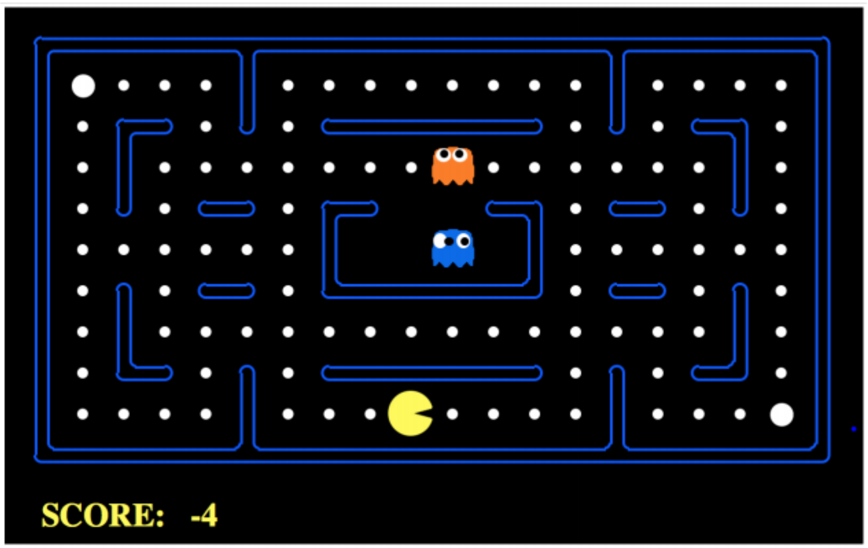
We present a convolutional-neural-network-based system that faithfully colorizes black and white photographic images without direct human assistance. We explore various network architectures, objectives, color spaces, and problem formulations. The final classification-based model we build generates colorized images that are significantly more aesthetically-pleasing than those created by the baseline regression-based model, demonstrating the viability of our methodology and revealing promising avenues for future work.

Figure 1. Sample input image (left) and output image (right).

http://cs231n.stanford.edu/reports2016/219_Report.pdf

Sample projects

Recurrent Deep Q-Learning for PAC-MAN



- train deep neural networks to play the game PAC-MAN,
- using no specific game knowledge, only features extracted from raw-pixel images

- using a convolutional neural network paired with recurrent neural network layers.
- experiment with several architectures and learning strategies

http://cs231n.stanford.edu/reports2016/106_Report.pdf

Deep Learning

Math pre-requisite quiz

Math Pre-Quiz

- Tue January 24 in class (75 min)
- Must pass to continue in the course
- No make-up quiz
- Topics include
  - Calculus: limits, multivariate differentiation, chain rule, convex functions, etc.
  - Linear algebra: vectors, matrices, matrix decomposition, eigenvalues, etc.
  - Probability and statistics: basic rules of probability, multivariate Gaussian distribution, maximum likelihood estimates, etc.

Waitlist

- There is a very long waitlist for this course
- If you are on the waitlist, you
  - May attend lectures and do homeworks
  - Must take and pass the Pre-Quiz
  - May only get into the course if space frees up

Questions?