CS 410: Intro to Software Engineering

Introduction to Deep Learning

thras@deepcure.ai
Overview

Introduction (~5 mins)

Deep Learning 101 (~25 mins)

Notable Applications (~15 mins)

Hands-on coding (~30 mins)

Discussion (@Piazza, after class)
Historical Overview

1958 Perceptron
1974 Backpropagation
1969 Perceptron criticized
1998 Convolution Neural Networks for Handwritten Recognition
2006 Restricted Boltzmann Machine
2012 Google Brain Project on 16k Cores
2012 AlexNet wins ImageNet

awkward silence (AI Winter)
1995 SVM reigns

Slide adapted from: https://www.slideshare.net/LuMa921/deep-learning-the-past-present-and-future-of-artificial-intelligence
Big Data (Digitalization)

Computation (Moore’s Law, GPUs)

Algorithmic Progress

14 mil. images

IMDb
25k movie reviews

Twitter
40 mil. tweets

> 100 datasets

Amazon web services

Google Cloud Platform

$700 for 1 TeraFlop

Geoffrey Hinton: University of Toronto & Google
Yann LeCun: New York University & Facebook
Andrew Ng: Stanford & Baidu
Yoshua Bengio: University of Montreal
Jürgen Schmidhuber: Swiss AI Lab & NNAISENSE

facebook
Microsoft
Yahoo!
Google
IBM
NVIDIA
Baidu
An AI-Driven Genomics Company Is Turning to Drugs

Deep Genomics aims to develop drugs by using deep learning to find patterns in genomic and medical data.

by Will Knight May 3, 2017

GEN News Highlights

GSK Launches Up-to-$43M AI-Focused Collaboration with Exscientia

How AI And Deep Learning Are Now Used To Diagnose Cancer

Automating Breast Cancer Detection with Deep Learning

Will artificial intelligence help to crack biology?

Silicon Valley has the squishy worlds of biology and disease in its sights

Deep learning for regulatory genomics

Yongjin Park & Manolis Kellis
1000s of startups on top and around DL Tech

Slide adapted from: https://www.slideshare.net/LuMa921/deep-learning-the-past-present-and-future-of-artificial-intelligence
Machine Learning Tasks - Classification

Supervised Learning

Dog, Dog, Dog → Cat

Cat, Dog, Cat
Machine Learning Tasks - Classification

Unsupervised Learning
Unsupervised Learning
Machine Learning Tasks - Regression

165 CM

182 CM

177 CM

??? CM
Machine Learning Tasks - Generative Modeling
Machine Learning Tasks - Reinforcement Learning
Deep Learning V. Machine Learning

Input → Feature Engineering → Prediction Model
Deep Learning V. Machine Learning

Input

Feature Extraction + Prediction
Deep Learning V. Machine Learning

LogP
MWT

\[ \phi \]

\[ X_1 \]
\[ X_2 \]
\[ X_3 \]
Multi-Layer Perceptrons (MLPs)

Impulses carried toward cell body

dendrite

presynaptic terminal

Impulses carried away from cell body

axon

cell body

This image by Felipe Peruchio is licensed under CC-BY-3.0

sigmoid activation function

\[
\frac{1}{1 + e^{-x}}
\]

Multi-Layer Perceptrons (MLPs)

The “3” detector

Demo: 2D Classification with MLPs

https://cs.stanford.edu/people/karpathy/convnetjs/demo/classify2d.html
Convolutional Neural Networks (CNNs)
Demo: Large scale scene classification with CNNs

drawNet

http://people.csail.mit.edu/torralba/research/drawCNN/drawNet.html
Recurrent Neural Networks (RNNs)

... Lorem Ipsum is simply dummy text of the printing and typesetting industry ...

... Lorem Ipsum es simplemente un texto de relleno de la industria de impresión y tipografía ...

![Diagram of RNNs](image-url)
Recurrent Neural Networks

Long Short Term Memory (LSTM)

Vanishing Gradients!
Demo: Speech & Text translation with LSTM RNNs

https://distill.pub/2016/augmented-rnns/
Evaluation Mechanisms - Data Splits

Train Data  Test Data

Fold 1  Fold 2  Fold 3  Fold 4  Validation  Test Data
Evaluation Mechanisms - Metrics

Classification

- Classification accuracy
- Cross entropy
- $CE = -y \log \hat{y} - (1 - y) \log (1 - \hat{y})$
- ROC AUC
- PRC AUC

Regression

- Mean Squared Error
  \[ MSE = \frac{1}{n} \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \]
- Explained Variance
- R2 Score
Train a DNN to learn the error distribution of the experiment

https://academic.oup.com/bioinformatics/article/33/14/i225/3953958
Complex of bacteria-infecting viral proteins modeled in CASP 13. The complex contains four separate subunits that were modeled individually. PROTEIN DATA BANK

Google's DeepMind aces protein folding

By Robert F. Service | Dec. 6, 2018, 12:05 PM

Turns out mastering chess and Go was just for starters. On 2 December, the Google-owned artificial intelligence firm DeepMind took top honors in the 13th Critical Assessment of Structure Prediction (CASP), a biannual competition aimed at predicting the 3D structure of proteins.

https://deepmind.com/blog/alphafold/
Deep Learning Software - Tools

Frameworks

TensorFlow   theano   PYTorch   Caffe2

Web extensions

TensorFlow.js   ConvNetJS

Mobile

Core ML 2   TensorFlow Lite

Deep Learning Software - Common Features

- Automatic Differentiation
- Parallelism (support for OpenMP, OpenCL, CUDA)
- Distributed Execution (CPU/GPU, cloud)
- Agile Development
- Fast Execution (compilation, optimizations)
- Portability, Export/Import models and parameters
Deep Learning Software - DataFlow Programming
CS 410: Intro to Software Engineering

Rapid hands-on tutorial

https://github.com/thrakar9/dl_bio_workshop