Active Learning, Curriculum Learning, & Reinforcement Learning

Danna Gurari
University of Texas at Austin
Spring 2020

https://www.ischool.utexas.edu/~dannag/Courses/IntroToMachineLearning/CourseContent.html
Review

• Last week:
  • Machine Learning for Unlabeled Data
  • Autoencoders
  • Clustering

• Assignments (Canvas):
  • Project outline with ML system prototype due yesterday
  • Final project video due in two weeks
  • Final project report due in three weeks

• Questions?
Paper Writing: Support

• Writing center: [http://uwc.utexas.edu/](http://uwc.utexas.edu/)
  - can schedule four individual 45-minutes consultation per month

• Tutoring:
  - [https://utdirect.utexas.edu/apps/ugs/my/tutoring/student/tutoring-agreement/](https://utdirect.utexas.edu/apps/ugs/my/tutoring/student/tutoring-agreement/)
Plagiarism: Definition

• Material from: https://legacy.lib.utexas.edu/services/instruction/avoidplagiarism.html

University of Texas
Definition of Plagiarism:
“the appropriation of, buying, receiving as a gift, or obtaining by any means material that is attributable in whole or in part to another source, including words, ideas, illustrations, structure, computer code, and other expression or media, and presenting that material as one's own academic work being offered for credit.”
Plagiarism: Definition

• Material from: https://legacy.lib.utexas.edu/services/instruction/avoidplagiarism.html

Plagiarism in Plain English:

Using someone else's work in your own academic work without giving proper credit. Click a button below to see some examples.

Intentional Plagiarism

Unintentional Plagiarism
Plagiarism: Play It Safe, Give Credit Generously

- Material from: https://legacy.lib.utexas.edu/services/instruction/avoidplagiarism.html

Intentional Plagiarism:

- Copying a friend's or classmate's work
- Buying or borrowing papers
- Cutting and pasting blocks of text without providing documentation of the original source
- Borrowing images and other media without documentation of the original source
- Publishing work on the Web without the permission of the creator
Plagiarism: Play It Safe, Give Credit Generously

- Material from: https://legacy.lib.utexas.edu/services/instruction/avoidplagiarism.html

*Unintentional Plagiarism:*
- Careless paraphrasing
- Poor documentation of sources
- Quoting excessively
- Failure to use your own ideas or words
Plagiarism: Play It Safe, Give Credit Generously

- Material from: https://legacy.lib.utexas.edu/services/instruction/avoidplagiarism.html

During the course of your research, you come across an idea that you use in your paper. You don't use the author's exact words or even paraphrase -- just the idea. Cite it?

Other people's words aren't the only thing you need to cite. You also need to cite ideas. So in this case, you should give the author credit for the idea by citing them.
Plagiarism: Play It Safe, Give Credit Generously

- Material from: https://legacy.lib.utexas.edu/services/instruction/avoidplagiarism.html

You are doing a presentation for your Chemistry class and use an image of the Periodic Table you found on a government web site. Cite it?

You should cite images. Even government websites in the public domain need to be cited.
Plagiarism: Play It Safe, Give Credit Generously

• What can happen if you are accused of plagiarism?
  • Redo assignment
  • Receive a failing grade
  • Be suspended
  • Be expelled

• What resources can help you to avoid plagiarism?
  • Review: https://legacy.lib.utexas.edu/services/instruction/avoidplagiarism.html
  • Review: https://legacy.lib.utexas.edu/d7/sites/default/files/services/instruction/AvoidingPlagiarism_guide.pdf
  • Visit writing center: http://uwc.utexas.edu/

• Neither you (I believe) nor I have any desire to talk about plagiarism 😊
• Play it safe and give credit generously!!!
Give Credit Generously

• Idea: add credit page to your presentation for resources used
  • e.g., Microsoft Azure
  • e.g., freely-shared code/libraries
  • e.g., links to all images
  • ...

Today’s Topics

• Active Learning

• Curriculum Learning

• Reinforcement Learning

• Guest: Dr. Cheryl Martin from Alegion
Today’s Topics

• Active Learning

• Curriculum Learning

• Reinforcement Learning

• Guest: Dr. Cheryl Martin from Alegion
What is the difference between “passive” and “active” learning?
Passive Learning: Classical ML Approach

- **Data Source**
  - Labeled examples
  - Unlabeled examples

- **Learning Algorithm**
  - Outputs a classifier

- **Expert / Oracle**

Slide Credit: http://www.cs.cmu.edu/~learning/talks-2007-spring/slides/mll0319.active_learning.ppt
Active Learning

Learning Algorithm

Data Source

Unlabeled examples

Request for the Label of an Example

A Label for that Example

Expert / Oracle

Algorithm outputs a classifier

Request for the Label of an Example

A Label for that Example

: 

Slide Credit: http://www.cs.cmu.edu/~learning/talks-2007-spring/slides/mll0319.active_learning.ppt
Active Learning

- inspect the unlabeled data
- raw unlabeled data: \(x_1, x_2, x_3, \ldots\)
- request labels for selected data
- active learner induces a classifier
- expert/oracle analyzes experiments to determine labels

Slide Credit: https://www.cs.utah.edu/~piyush/teaching/10-11-slides.pdf
Learning Curves: Active versus Passive Learning

What are benefits of active learning?

Learning Curves: Active versus Passive Learning

Machines can learn with fewer training instances if they ask questions.

Types of Active Learning

1. Stream-Based

Consider one example at a time

Image Credit: https://www.cs.utah.edu/~piyush/teaching/10-11-slides.pdf
Types of Active Learning

2. Pool-Based

Consider many examples at a time

Image Credit: https://www.cs.utah.edu/~piyush/teaching/10-11-slides.pdf
Types of Active Learning

Stream-Based

- Consider one example at a time

Pool-Based

- Consider many examples at a time

Image Credit: https://www.cs.utah.edu/~piyush/teaching/10-11-slides.pdf
Active Learning Approach

- Active Learning **proceeds in rounds**
- Each round has a **current model** (learned using the labeled data seen so far)
- The current model is **used to assess informativeness** of unlabeled examples
  - .. using one of the query selection strategies
- The **most informative example(s) is/are selected**
- The **labels are obtained** (by the labeling oracle)
- The (now) labeled example(s) is/are included in the training data
- The **model is re-trained** using the **new training data**
Active Learning Approach

- Active Learning proceeds in rounds.
- Each round has a current model (learned using the labeled data seen so far).
- The current model is used to assess informativeness of unlabeled examples.

Approach: query instances based on past queries and their responses (labels)

- The most informative example(s) is/are selected.

Problem: how to choose most informative examples to query?

- The labels are obtained (by the labeling oracle).
- The (now) labeled example(s) is/are included in the training data.
- The model is re-trained using the new training data.

Slide Credit: https://www.cs.utah.edu/~piyush/teaching/10-11-slides.pdf
Uncertainty Sampling: e.g., Logistic Classifier

Query instance(s) the classifier is most uncertain about.

True Representation (Assume Labels Are Not Known)

Passive Learner (Random Selection)

Active Learner (Uncertainty Sampling)

Uncertainty Sampling: e.g., SVM Classifier

Query instance(s) the classifier is most uncertain about.

e.g., strategy 1: request the label of the example closest to the current separator.
Query By Committee

Query instance(s) different classifiers disagree most about.
Group Discussion:

Assume you are hired to build a new face recognition service. How would you design an active learning approach to train an accurate machine learning algorithm while collecting training data efficiently?

Today’s Topics

• Active Learning

• Curriculum Learning

• Reinforcement Learning

• Guest: Dr. Cheryl Martin from Alegion
How to teach machines to learn faster?
e.g., How to Teach a Child Math?

Random Order of Examples

Meaningful Order of Examples

Big Book of Math; Dinah Zike
e.g., How to Teach a Child To Read?

Random Order of Examples

Meaningful Order of Examples
Idea: Teach Machines As We Teach Humans

**Curriculum**

Train with simpler examples first and progressively harder examples over time.

Learning Curves: Shape Variability

*Artificial data*: classify images into 3 shapes (rectangle, ellipse, triangle)

*Input*: 32×32 grey-scale image

(Less shape variability)

**Easy:**
(Basic)

**Hard:**
(Geom)

Yoshua Bengio et al.; Curriculum Learning; 2009.
Learning Curves: Shape Variability

Artificial data: classify images into 3 shapes (rectangle, ellipse, triangle)
- Training: 3-layer neural network with BasicShapes or GeomShapes (10,000 examples)
- Testing: GeomShapes

What are benefits of curriculum learning?

How long should the algorithm train with easy examples before switching to difficult examples?

No curriculum

Yoshua Bengio et al.; Curriculum Learning; 2009.
Learning Curves: Word Prediction

Wikipedia: predict next word in a sentence
- Curriculum: grow vocabulary size; 5k most frequent words, then 10k most frequent words, etc
- Target: final vocabulary size is 20,000 words

What are benefits of curriculum learning?

How long should the algorithm train with easy examples before switching to difficult examples?

Yoshua Bengio et al.; Curriculum Learning; 2009.
Group Discussion: Curriculum Learning

Task: train algorithm to read text in images taken by people who are blind

Questions
1. What criteria should be used to order examples?
2. What batches would you use when changing the available data?
3. How often would you make updates?
Today’s Topics

• Active Learning

• Curriculum Learning

• Reinforcement Learning

• Guest: Dr. Cheryl Martin from Alegion
Reinforcement Learning Overview

Agent takes actions in an environment so as to maximize the total reward.

Figure Credit: https://towardsdatascience.com/applications-of-reinforcement-learning-in-real-world-1a94955bcd12
Intuition: Learning to Walk by Trial-and-Error

Reinforcement Learning Applications
Reinforcement Learning Applications

Autonomous reinforcement learning on raw visual input data in a real world application

Sascha Lange, Martin Riedmiller
Department of Computer Science
Albert-Ludwigs-Universität Freiburg
D-79110, Freiburg, Germany
Email: [slange,riedmiller]@informatik.uni-freiburg.de

Arne Voigtländer
Shoogee GmbH & Co. KG
Krögerweg 16a
D-48155 Münster, Germany
Email: arne@shoogee.com

Fig. 1. The visual slot car racer task. The controller has to autonomously learn to steer the racing car by raw visual input of camera images.
Reinforcement Learning Applications

https://www.tastehit.com/blog/google-deepmind-alphago-how-it-works/

e.g., Pong Game - Learning Example

Move “up” or “down”

http://karpathy.github.io/2016/05/31/rl/

-1 if missed the ball
+1 reward if ball goes past opponent
0 otherwise
e.g., Pong Game: Policy Network

Implements our player (or “agent”)
e.g., Pong Game: Training Protocol

- Play 100 games of Pong; i.e., policy “rollouts” (200 images/game); Suppose: win 12 games, lose 88
- \# Winning Decisions = 200*12 = 2400 decisions; positive update (fill in a +1.0 in the gradient for the sampled action, do backprop, and parameter update to encouraging the actions)
- \# Losing Decisions: 200*88 = 17600; negative update (as above, but fill in -1.0 in the gradient)
e.g., Pong Game: Trained for Three Nights

Demo: https://www.youtube.com/watch?time_continue=16&v=YOW8m2YGtRg
e.g., Learning Dexterity

• Demo: https://www.youtube.com/watch?v=jwSbzNHGfIM
e.g., Learning to Flip Pancakes

Demo: https://www.youtube.com/watch?v=W_gxLKSsSIE&list=PL5nBAYUyJTrM48dViiyi68urttMIUv7e
e.g., Learning to Walk

• Demo: https://www.youtube.com/watch?v=gn4nRCC9TwQ
Google Form: Guest Speaker & Class Feedback

• Google form:
  
  • Guest: Dr. Cheryl Martin, Chief Data Scientist at Alegion (https://www.alegion.com/company/leadership); list one question for her for today’s visit

• Then, take a short break.

• Class resumes at 4:50pm CST.
Today’s Topics

• Active Learning

• Curriculum Learning

• Reinforcement Learning

• Guest: Dr. Cheryl Martin from Alegion