

# Active Learning, Curriculum Learning, & Reinforcement Learning

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Spring 2020



# 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/>
  - can schedule four individual 45-minutes consultation per month
- Tutoring:
  - <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](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

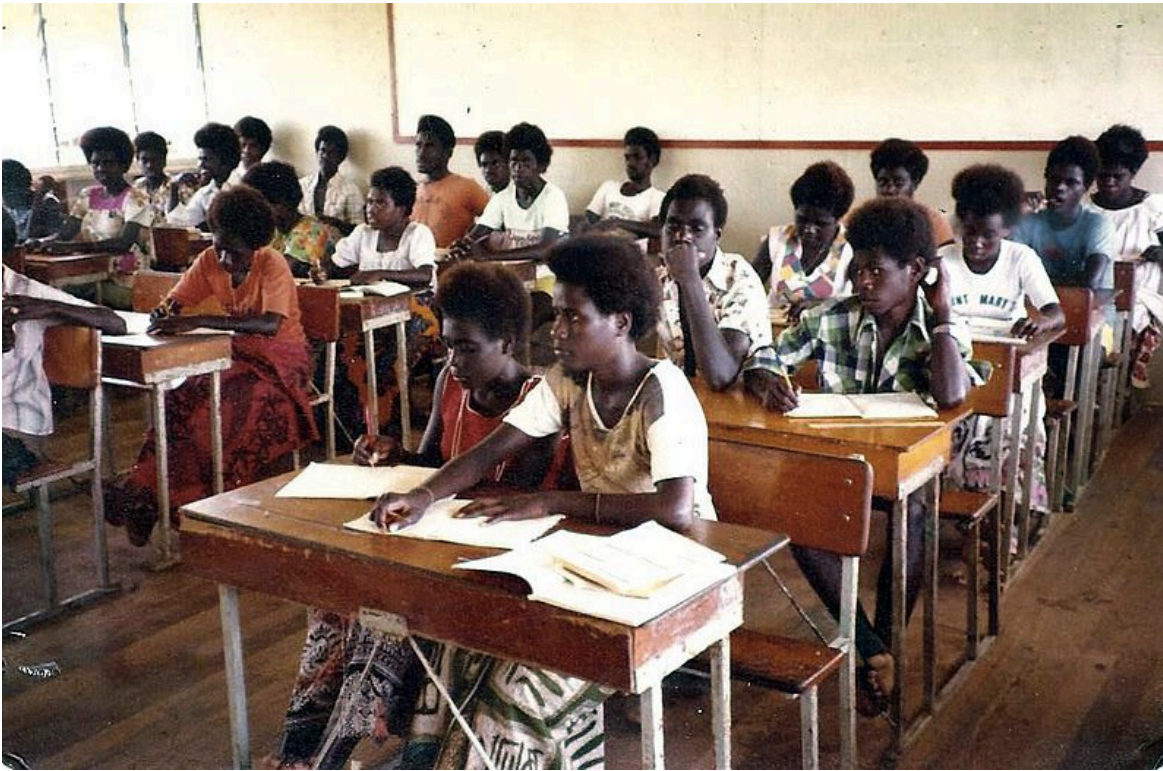
- Active Learning
- Curriculum Learning
- Reinforcement Learning
- Guest: Dr. Cheryl Martin from Alegion

# Today's Topics

- Active Learning
- Curriculum Learning
- Reinforcement Learning
- Guest: Dr. Cheryl Martin from Alegion

# Idea

Passive Learning

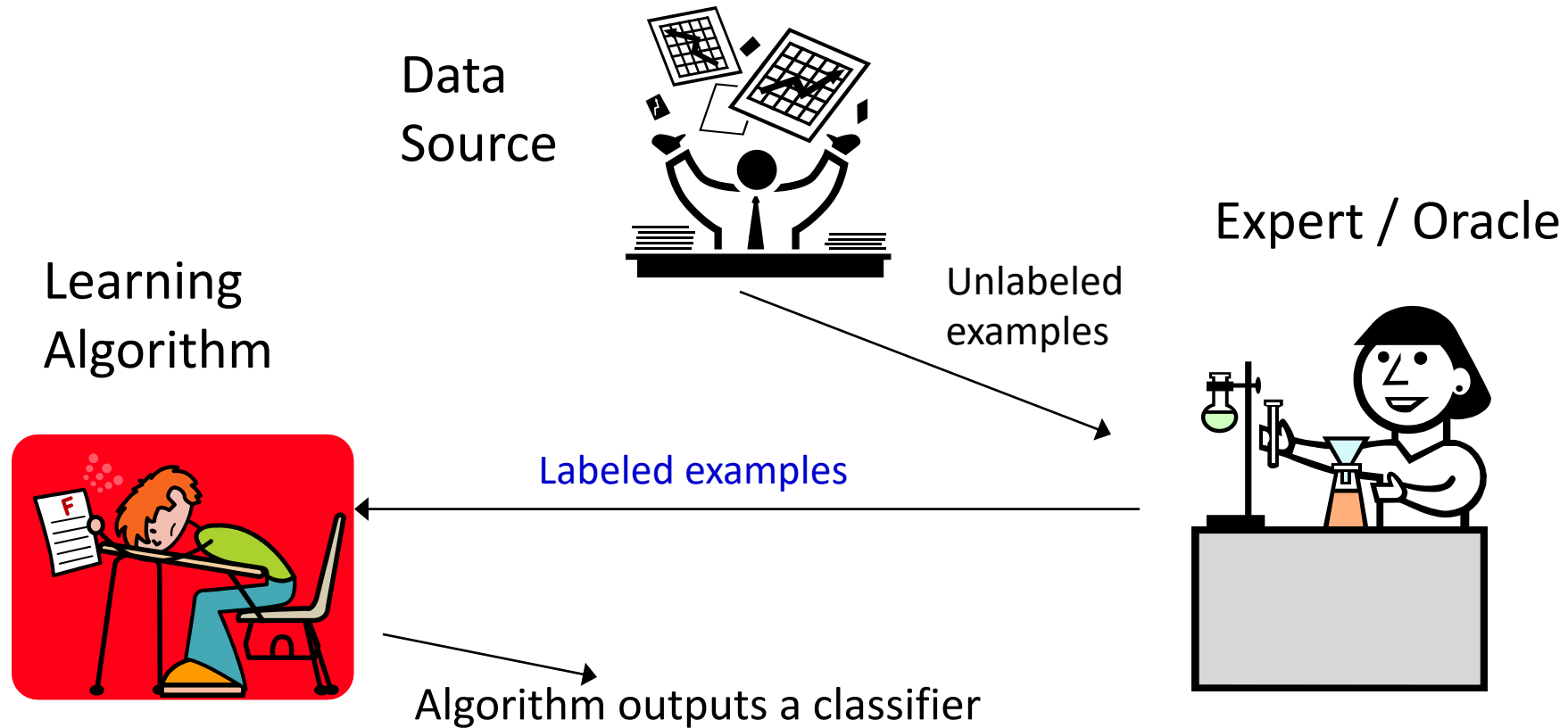


Active Learning

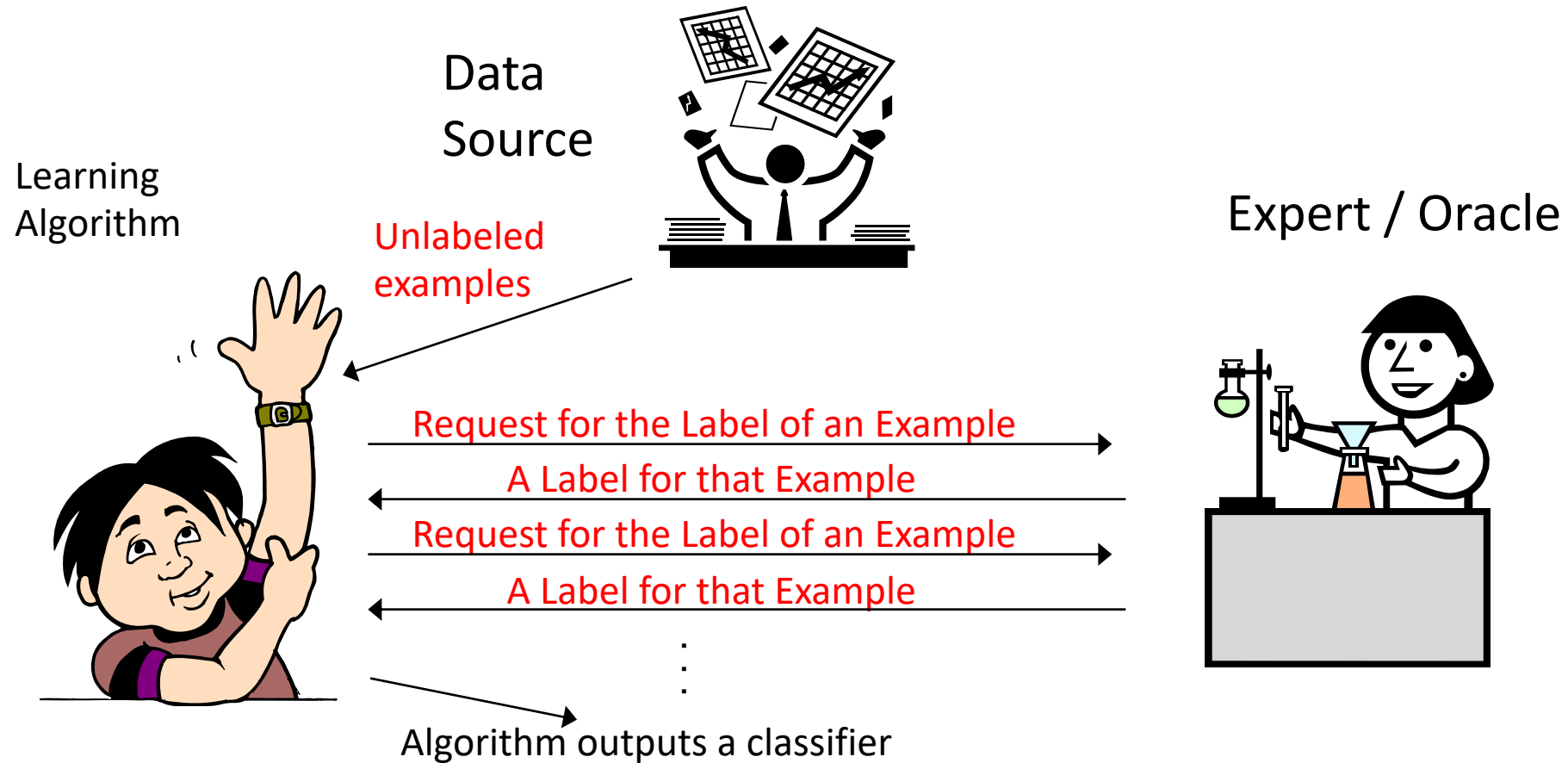


What is the difference between “passive” and “active” learning?

# Passive Learning: Classical ML Approach

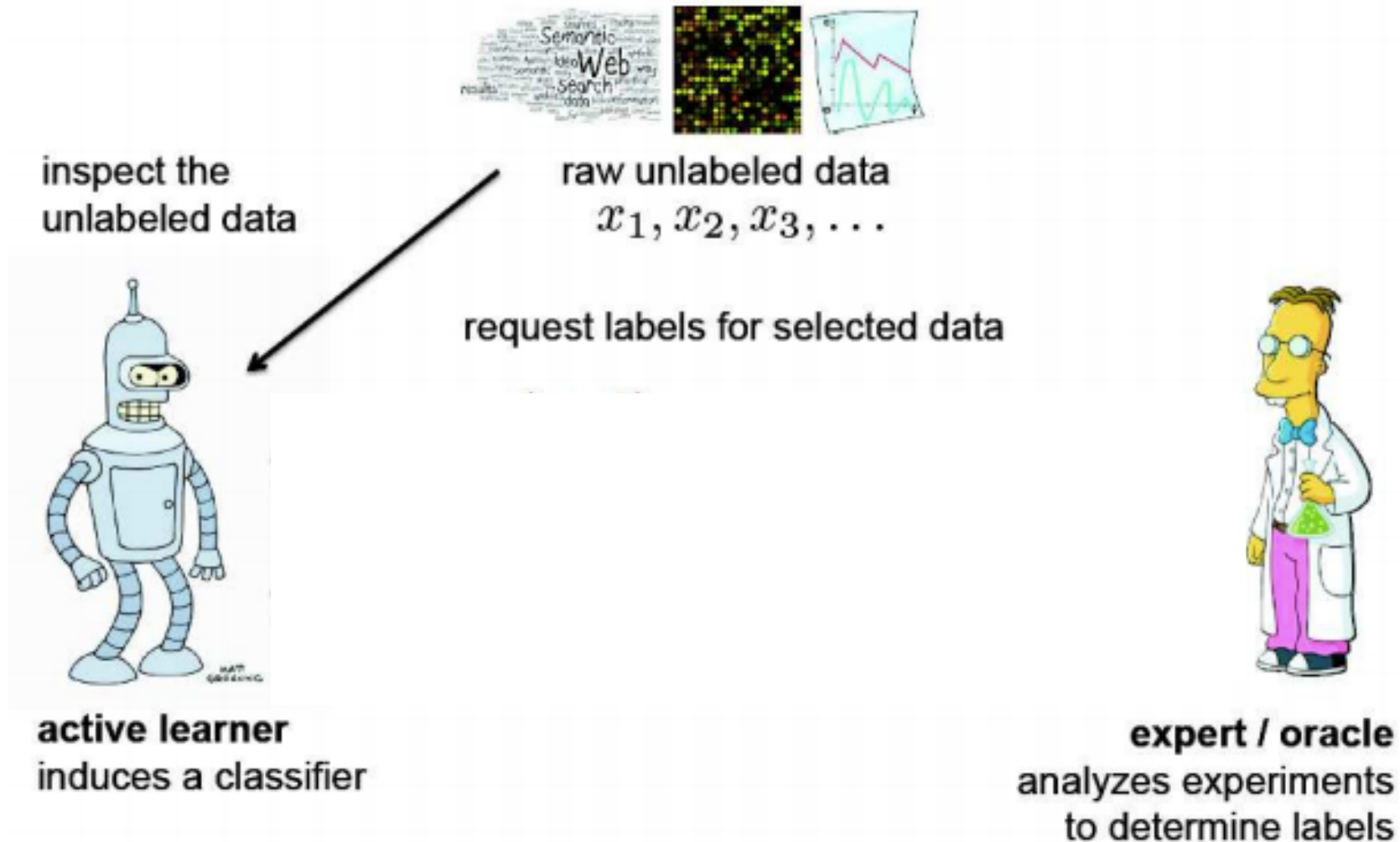


# Active Learning

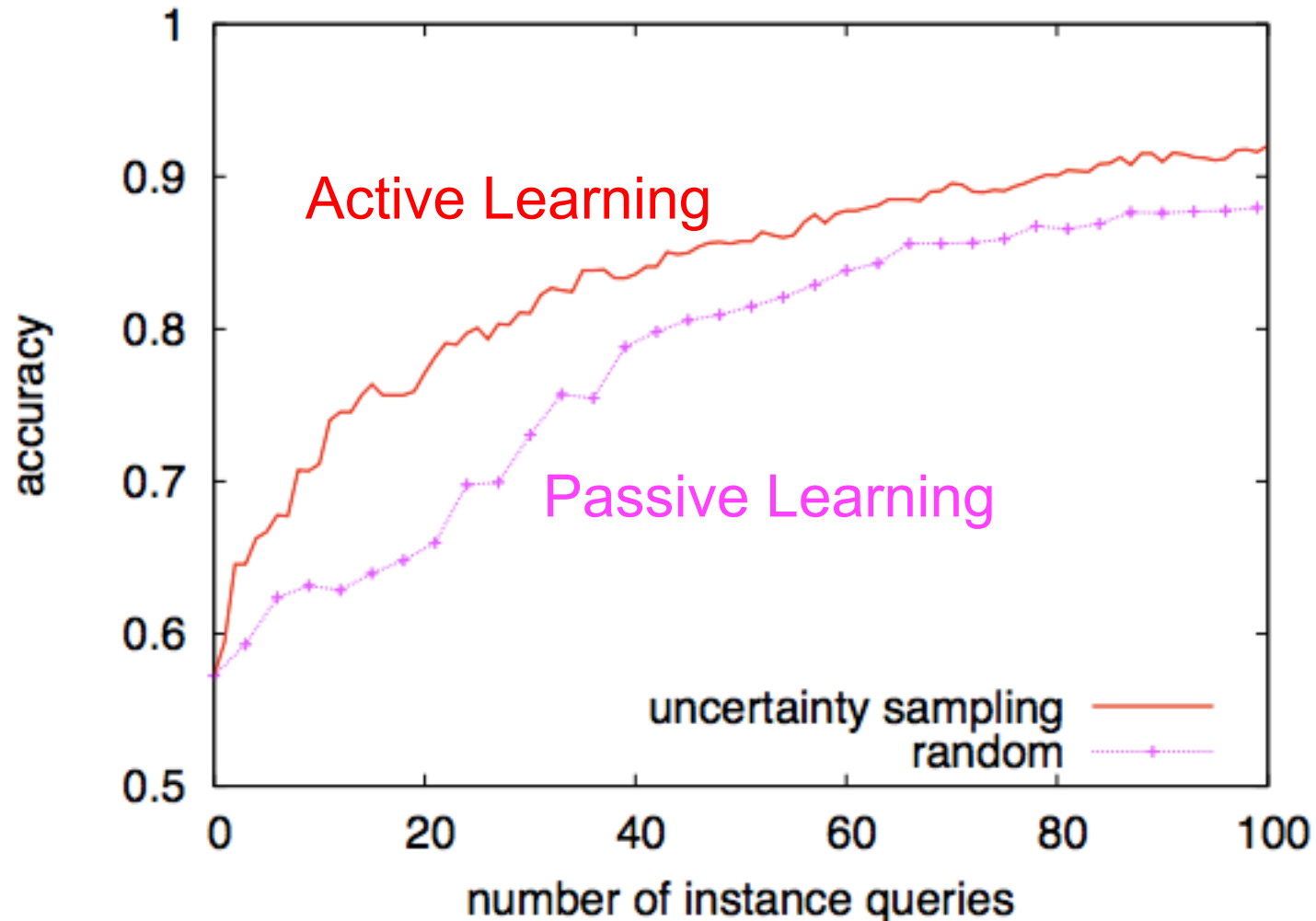




# Active Learning

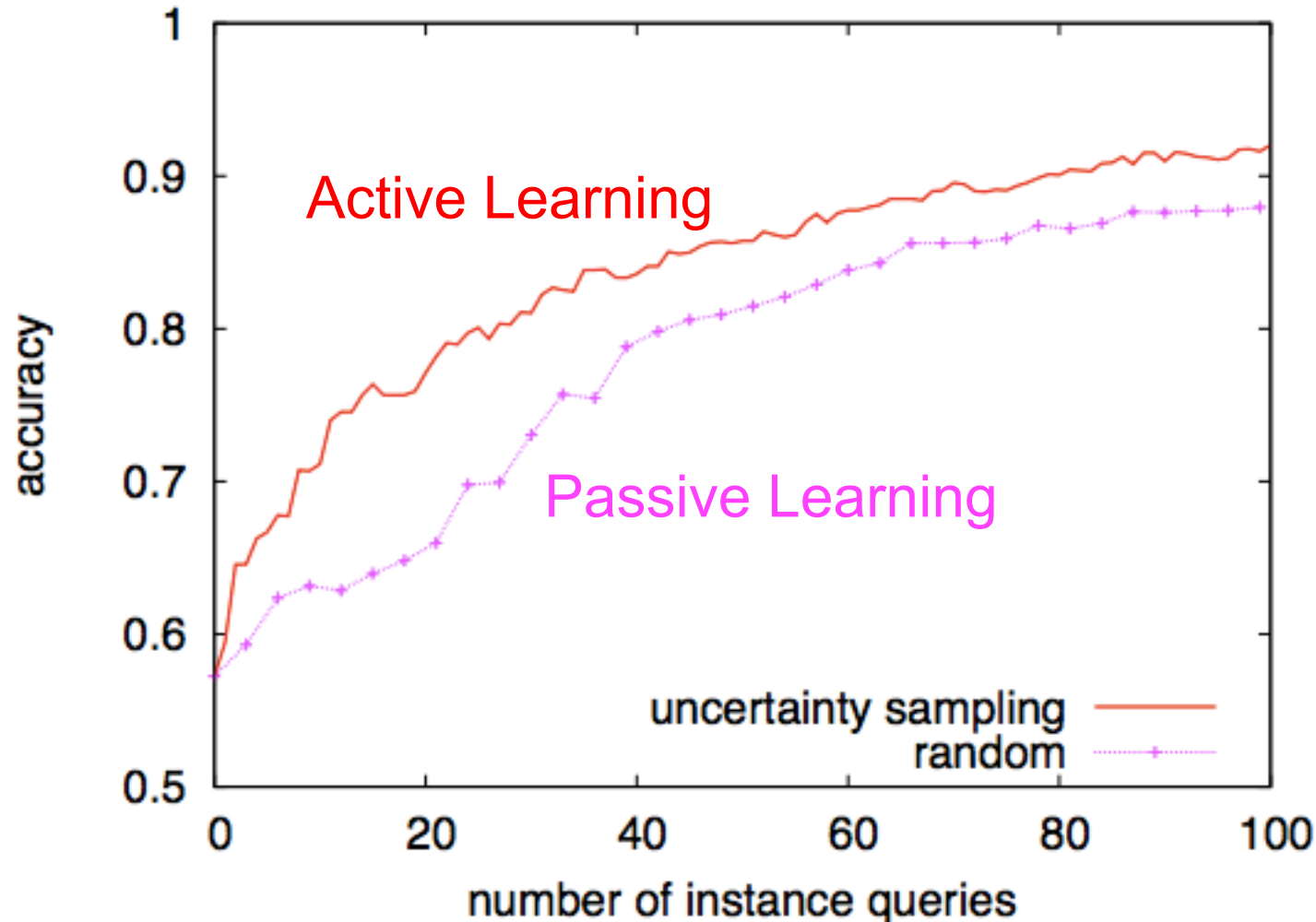


# Learning Curves: Active versus Passive Learning



What are benefits of active learning?

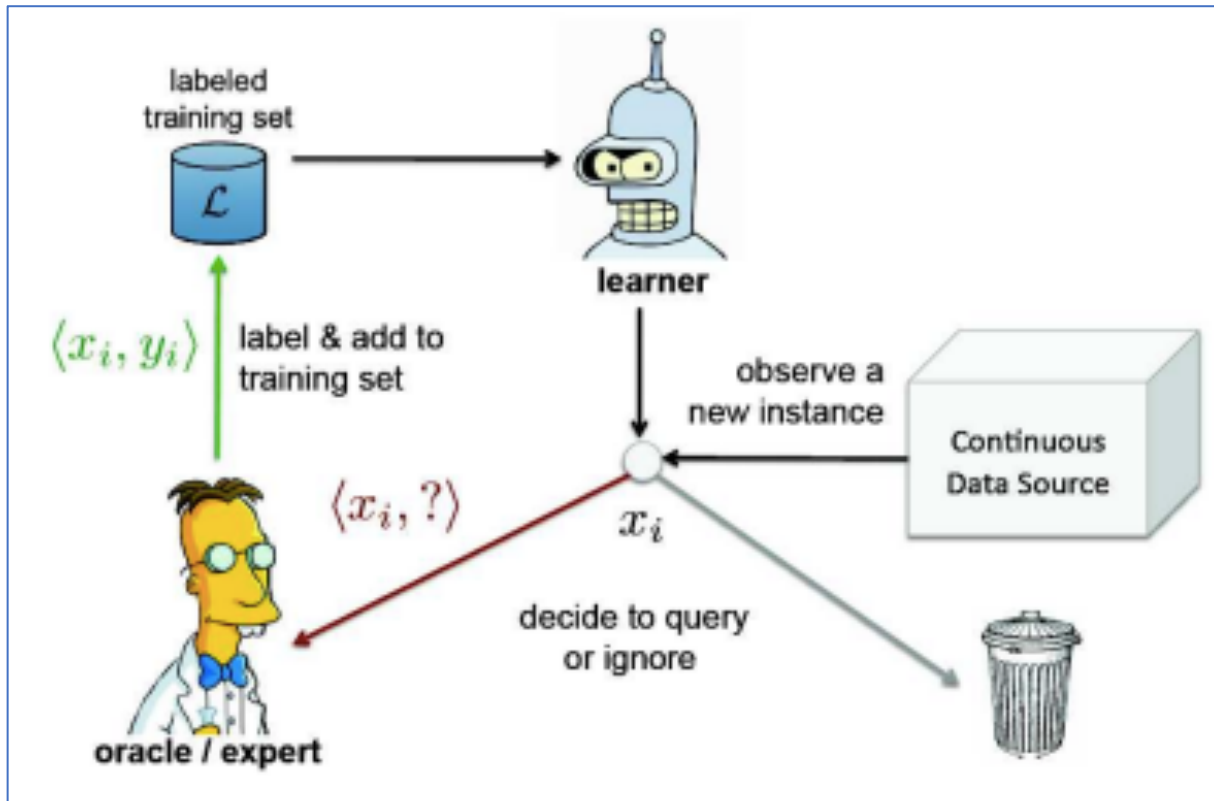
# Learning Curves: Active versus Passive Learning



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

# Types of Active Learning

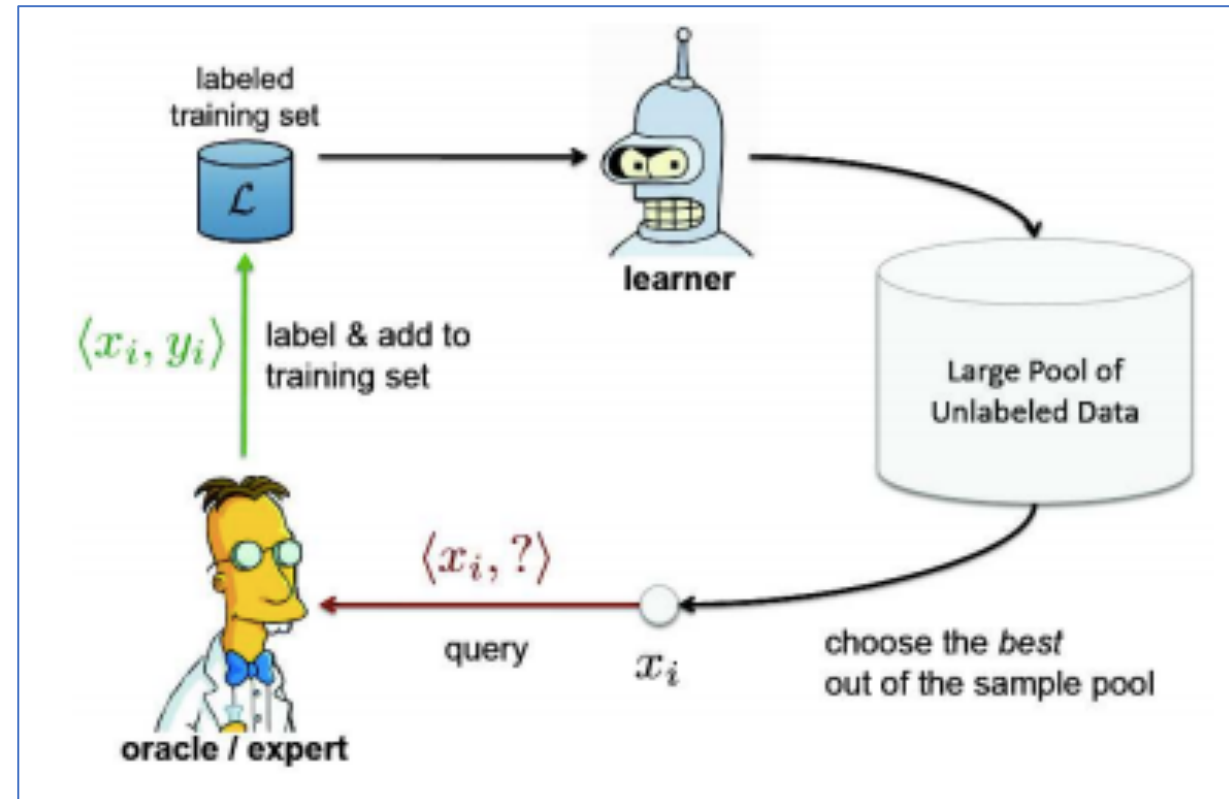
## 1. Stream-Based



Consider one example at a time

# Types of Active Learning

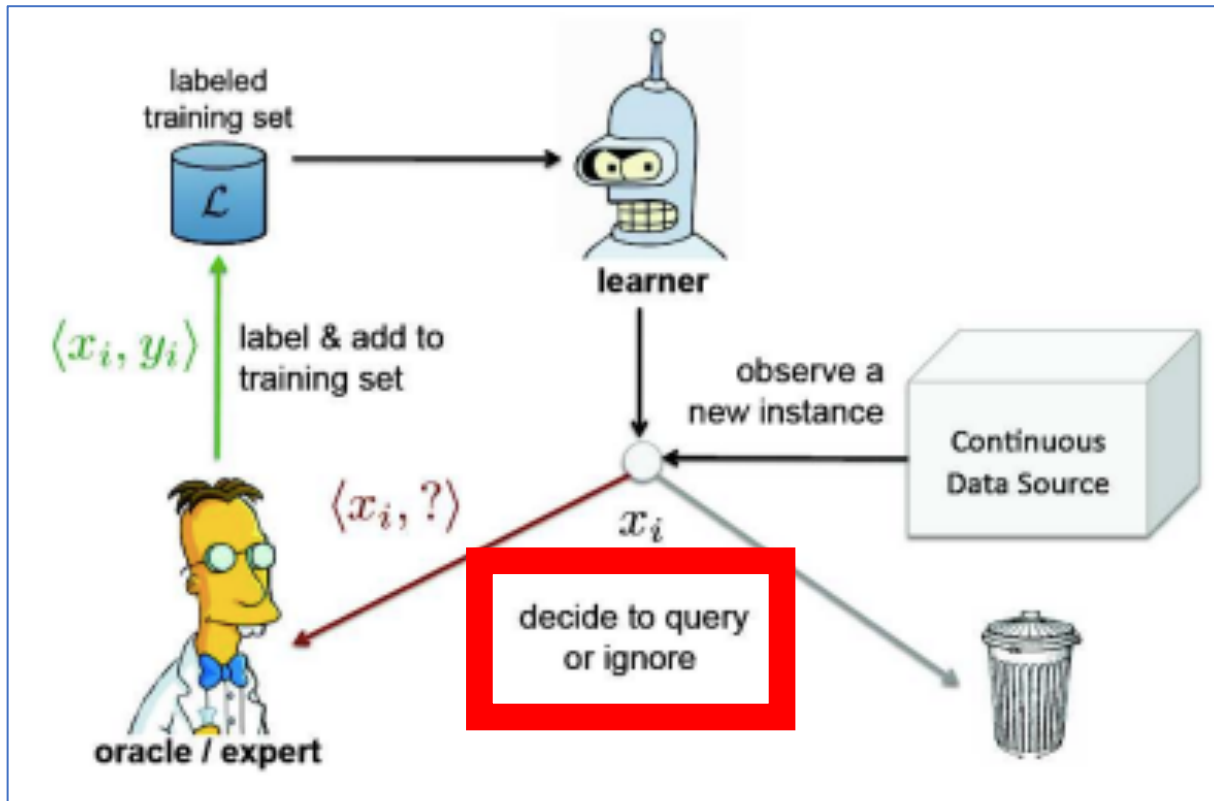
## 2. Pool-Based



Consider many examples at a time

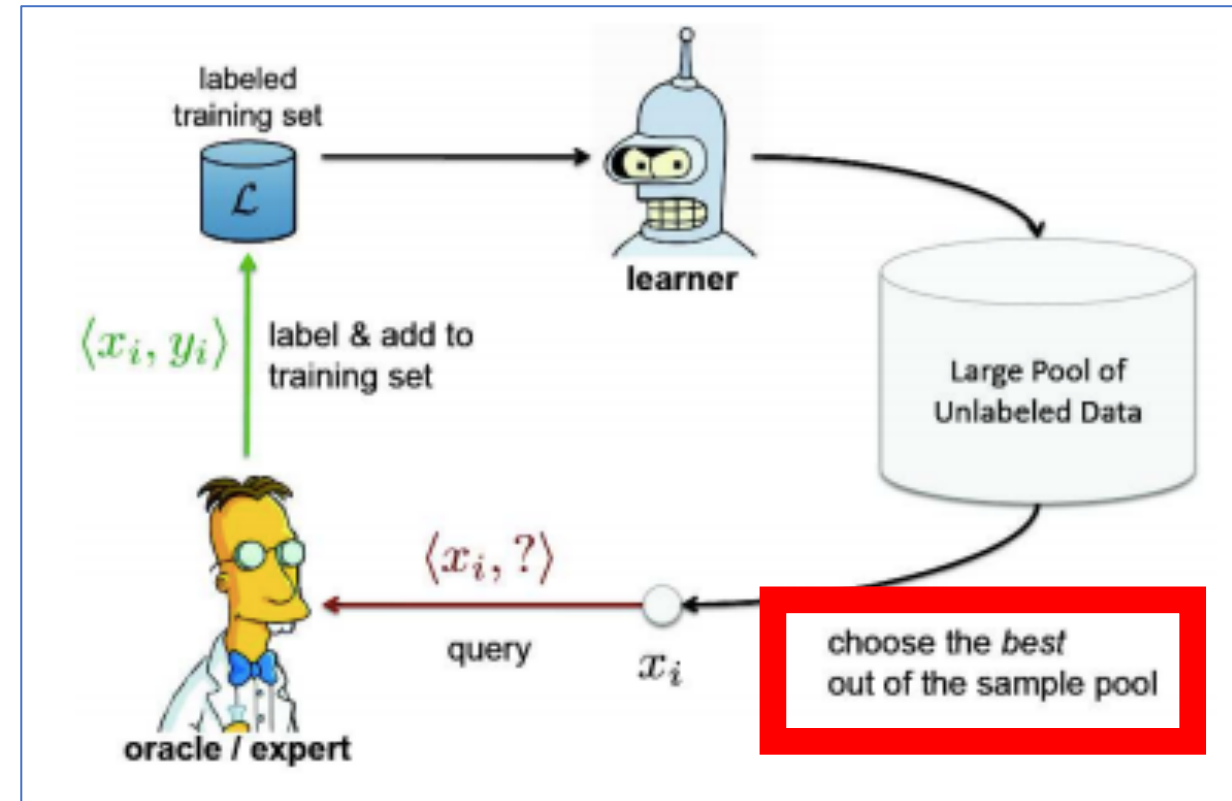
# Types of Active Learning

## Stream-Based



Consider one example at a time

## Pool-Based



Consider many examples at a time

# 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
- using one of the query selection strategies

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

**Problem: how to choose most informative examples to query?**

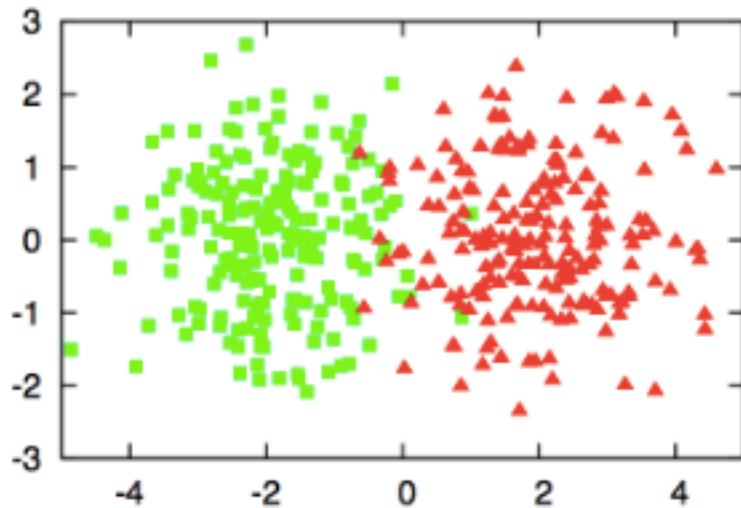
- The **labels are obtained** (by the labeling oracle)
- The (now) labeled example(s) is/are included in the training data
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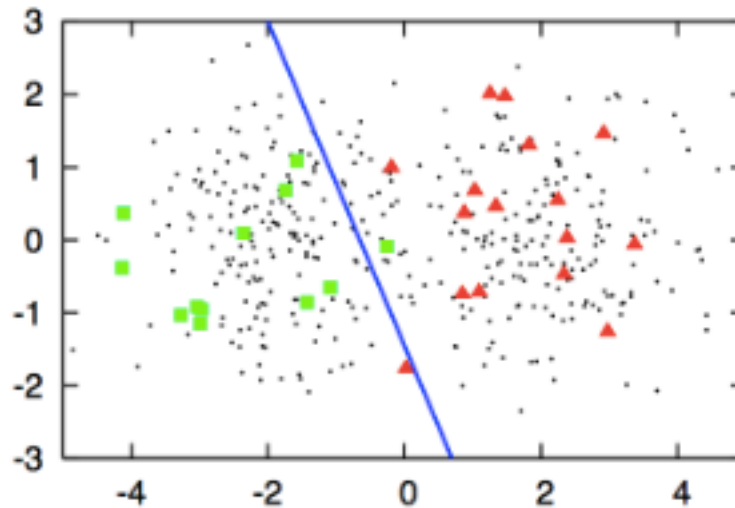
# Uncertainty Sampling: e.g., Logistic Classifier

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

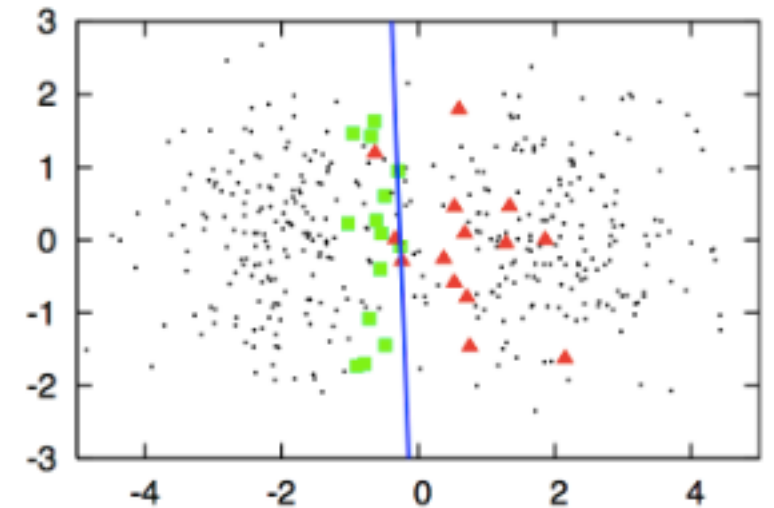
True Representation  
(Assume Labels Are  
Not Known)



Passive Learner  
(Random Selection)



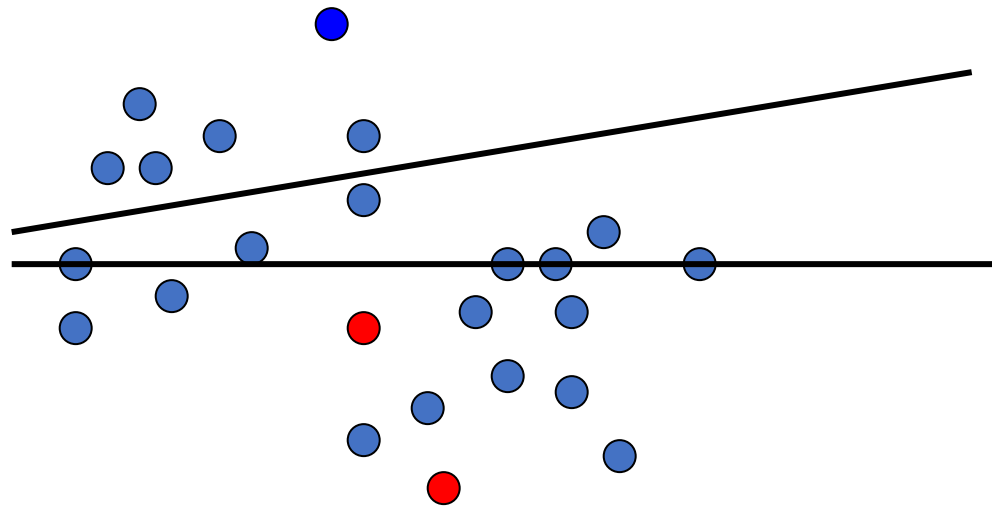
Active Learner  
(Uncertainty Sampling)



# 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.



Prediction Model



Prediction



Prediction Model



Prediction



Prediction Model




Prediction



# 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?



Gfycat's facial recognition software can now recognize individual members of K-pop band Twice, but in early tests couldn't distinguish different Asian faces.  GFYCAT

# Today's Topics

- Active Learning
- Curriculum Learning
- Reinforcement Learning
- Guest: Dr. Cheryl Martin from Alegion

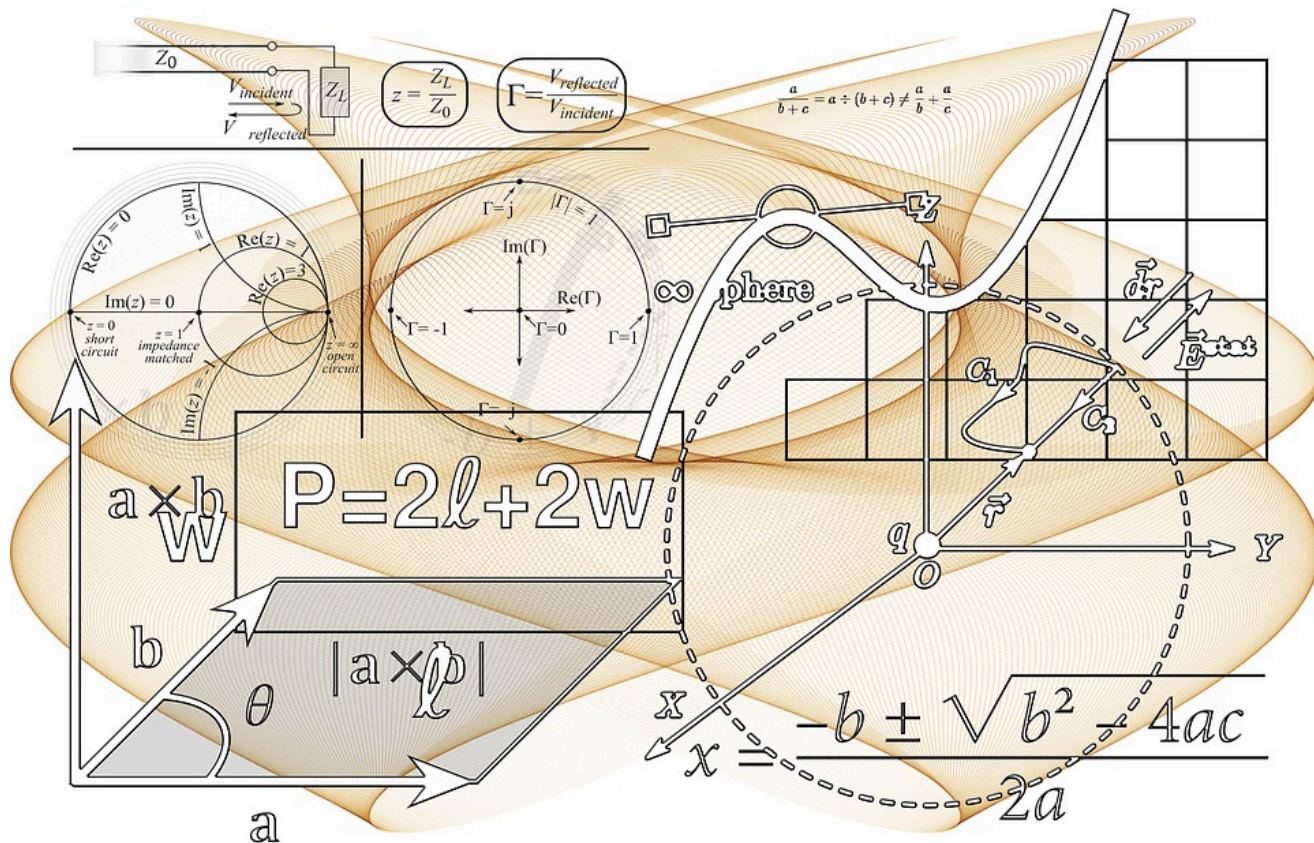
Idea

How to teach machines to learn faster?



# e.g., How to Teach a Child Math?

## Random Order of Examples



## Meaningful Order of Examples

Table of Contents	
Letter from Dinah Zike	ix
Introduction to Foldables	1
Why Use Foldables as Math Tools?	1
Foldable Basics	1
Choosing the Appropriate Foldable	2
Folding Instructions	3
1-Page Foldables	4
Book Book	4
Factor Book	7
Area Book	8
Area Book	8
Area Book	8
2-Page Foldables	10
Area Book	10
Area Book	11
Area Book	12
3-Page Foldables	13
Area Book	13
Area Book	14
Area Book	15
Area Book	16
4-Page Foldables	17
Area Book	17
Area Book	18
Area Book	19
Area Book	20
Area Book	21
Area Book	22
Area Book	23
Area Book	24
Any Number of Pages	25
Area Book	25
Folding into Foldables	26
Folding into Foldables	27
Folding into Foldables	28
Area Book	29
Area Book	30
Area Book	31
Area Book	32
Area Book	33
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Area Book	99
Area Book	100

# 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)



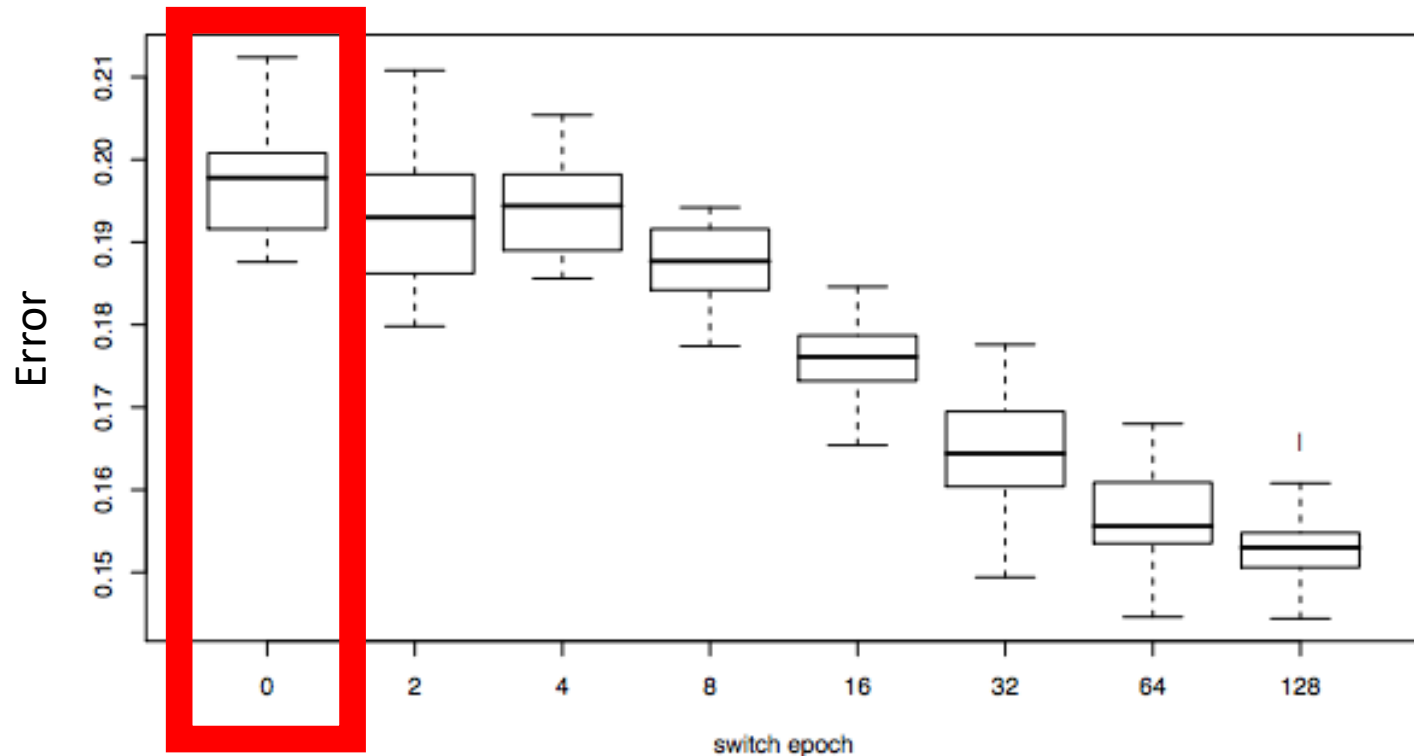
Hard:  
(Geom)



# 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?

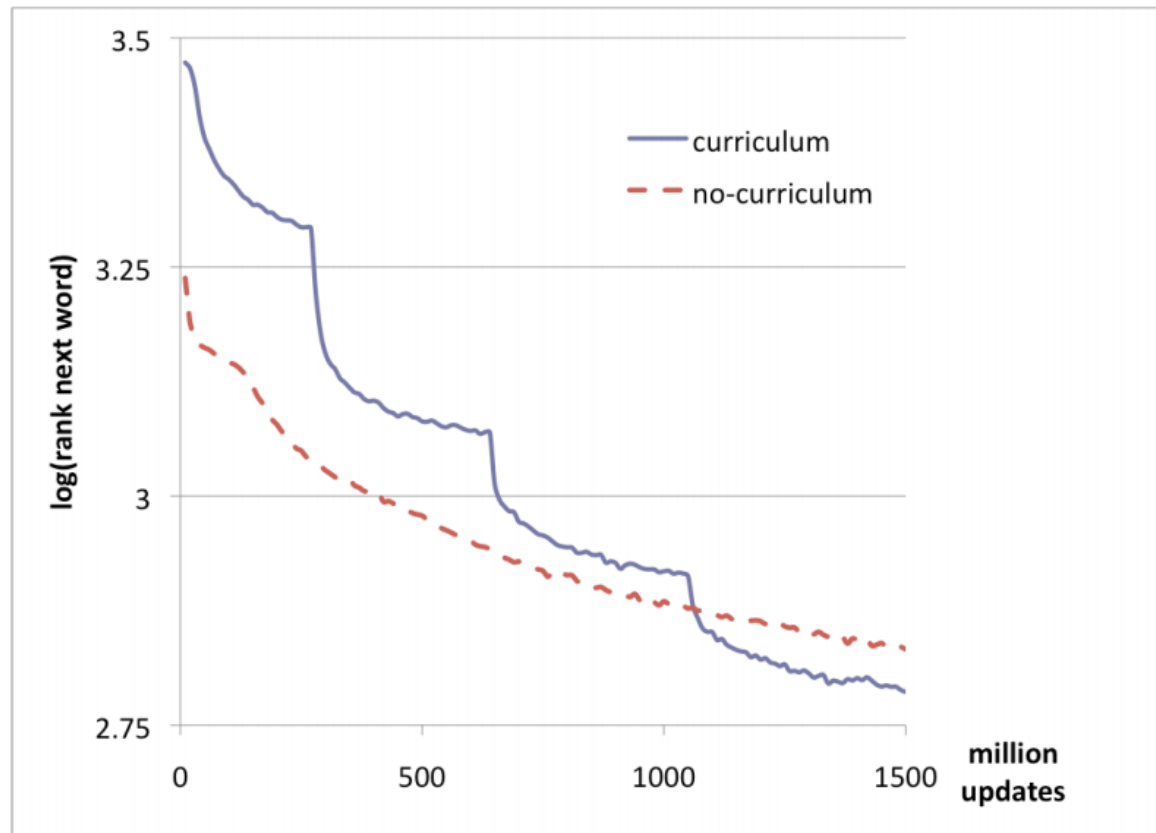
How long should the algorithm train with easy examples before switching to difficult examples?

No curriculum

# 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

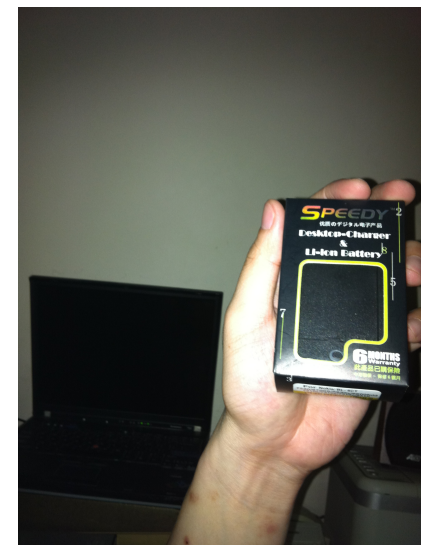


What are benefits of curriculum learning?

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

# Group Discussion: Curriculum Learning

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



## Questions

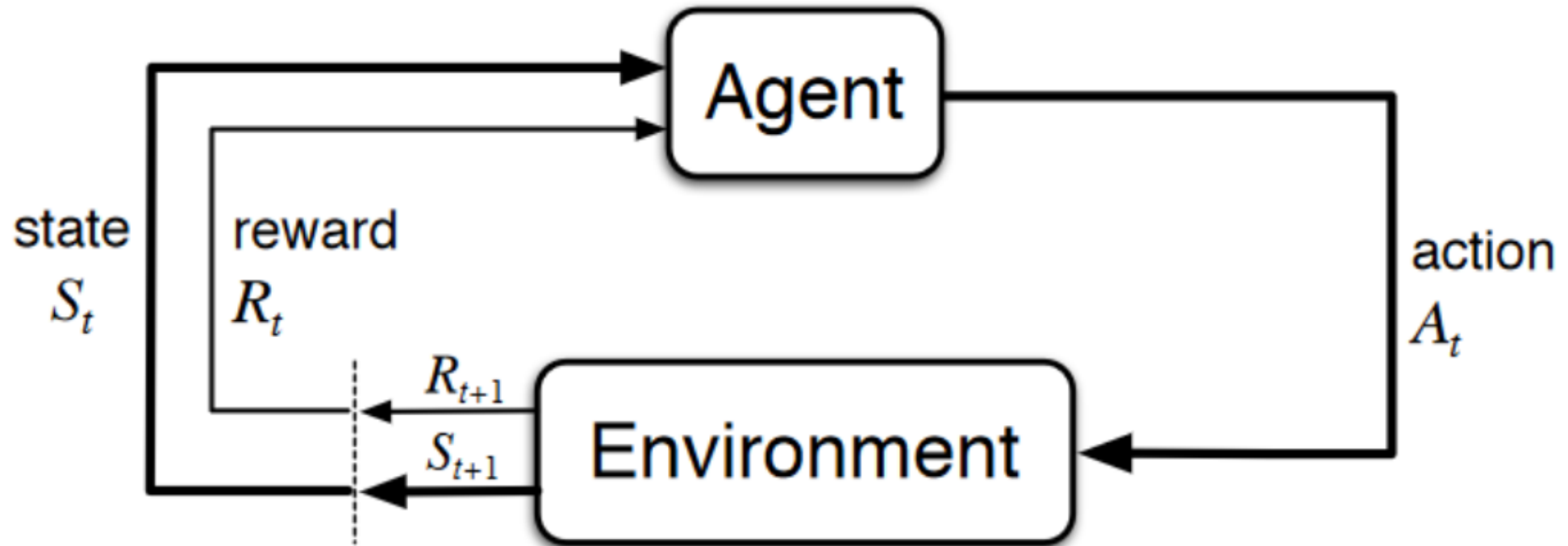
1. What criteria should be used to order examples?
2. What batches would you use when changing the available data?
3. How often would you make updates?

# 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.



# Intuition: Learning to Walk by Trial-and Error



[https://en.wikipedia.org/wiki/Crawling\\_\(human\)](https://en.wikipedia.org/wiki/Crawling_(human))



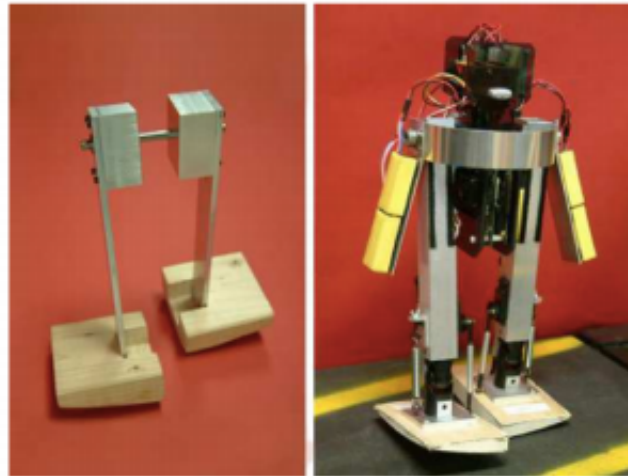
# Reinforcement Learning Applications

## Learning to Walk in 20 Minutes

Russ Tedrake  
Brain & Cognitive Sciences  
Center for Bits and Atoms  
Massachusetts Inst. of Technology  
Cambridge, MA 02139  
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H. Sebastian Seung  
Howard Hughes Medical Institute  
Brain & Cognitive Sciences  
Massachusetts Inst. of Technology  
Cambridge, MA 02139  
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# Reinforcement Learning Applications

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

Sascha Lange, Martin Riedmiller  
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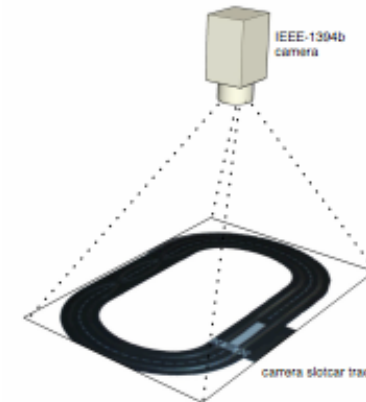
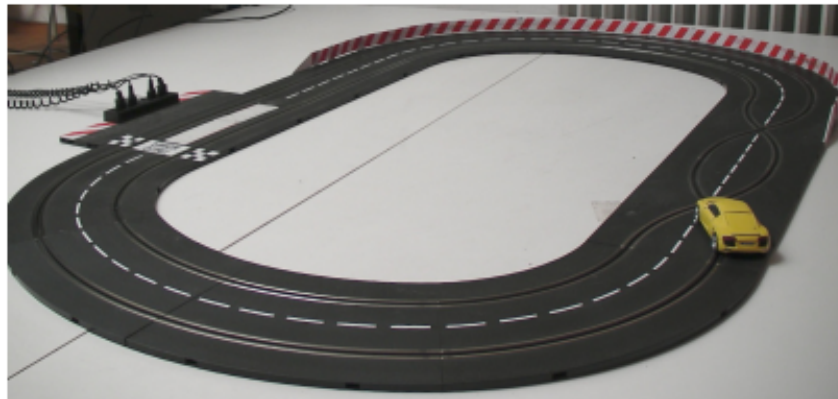
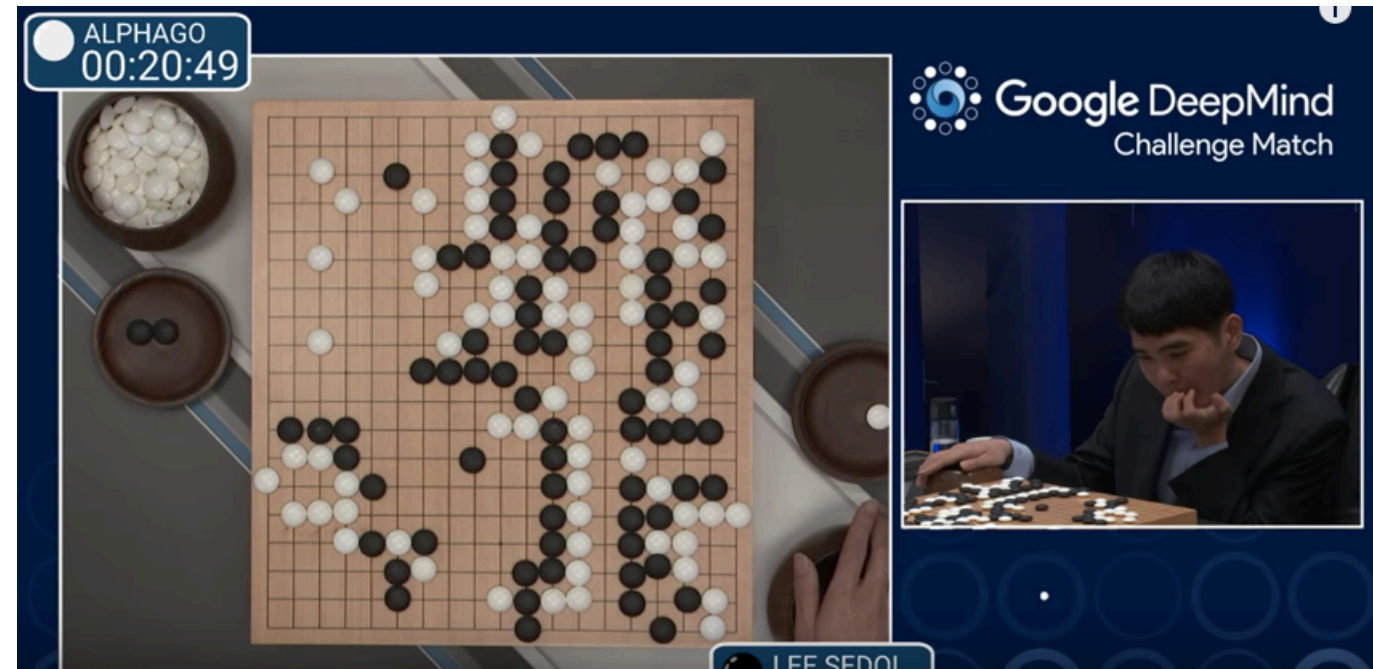
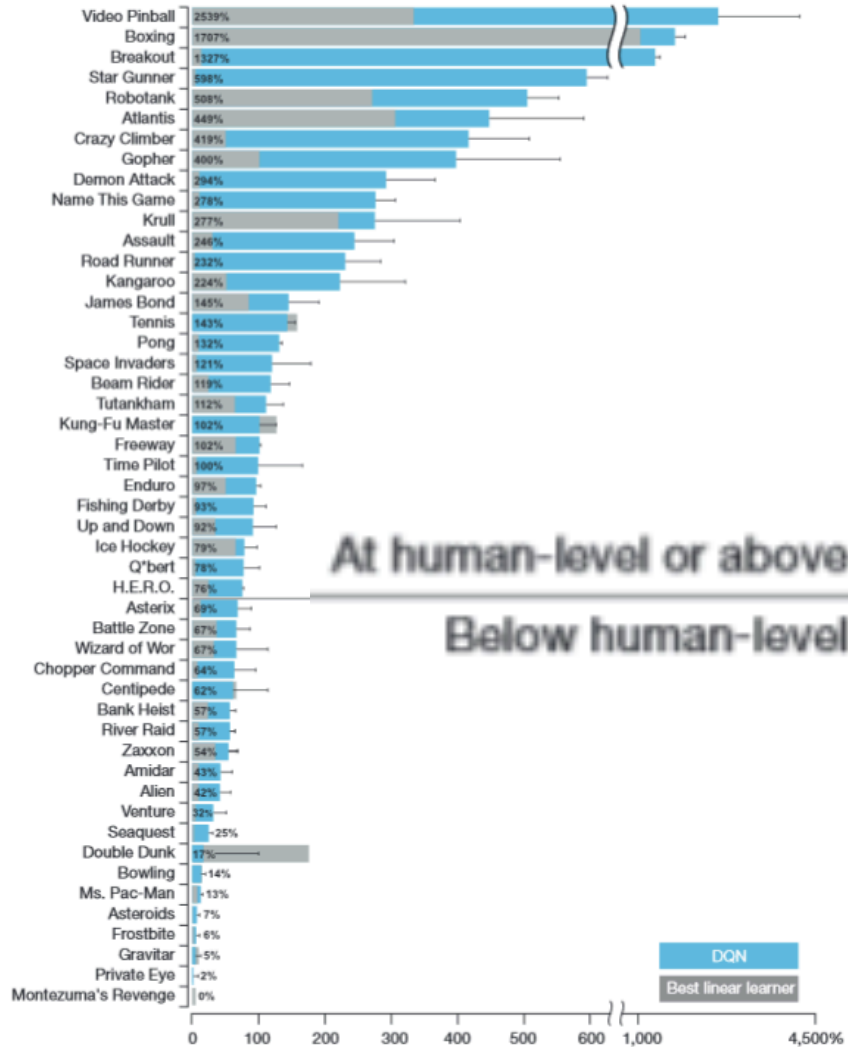


Fig. 1. The visual slot car racer task. The controller has to autonomously learn to steer the racing car by raw visual input of camera images.

# Reinforcement Learning Applications

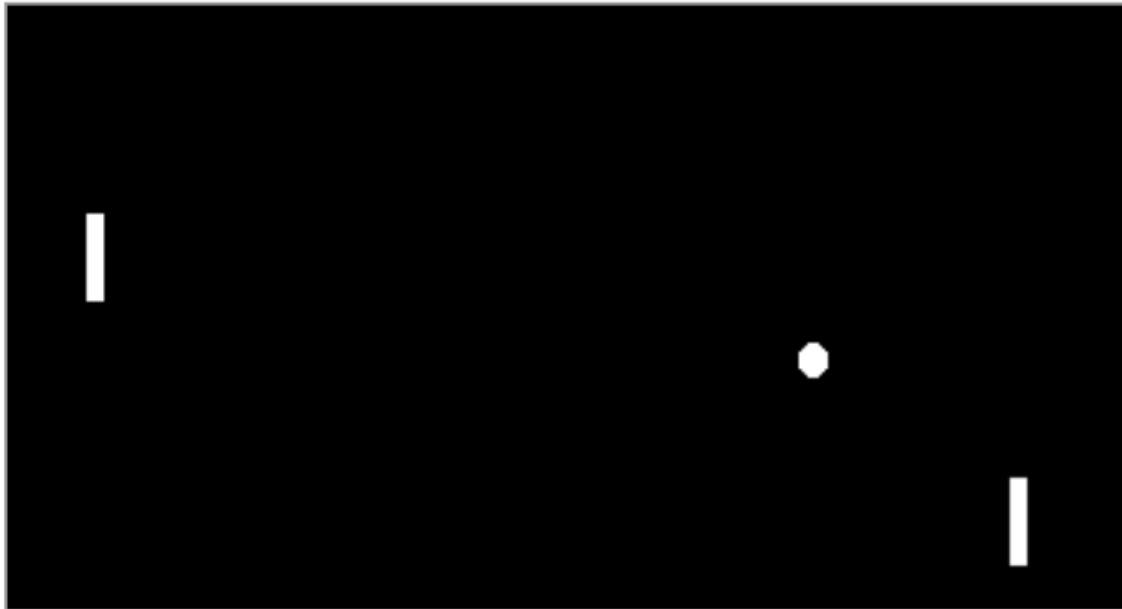


<https://www.tastehit.com/blog/google-deepmind-alphago-how-it-works/>

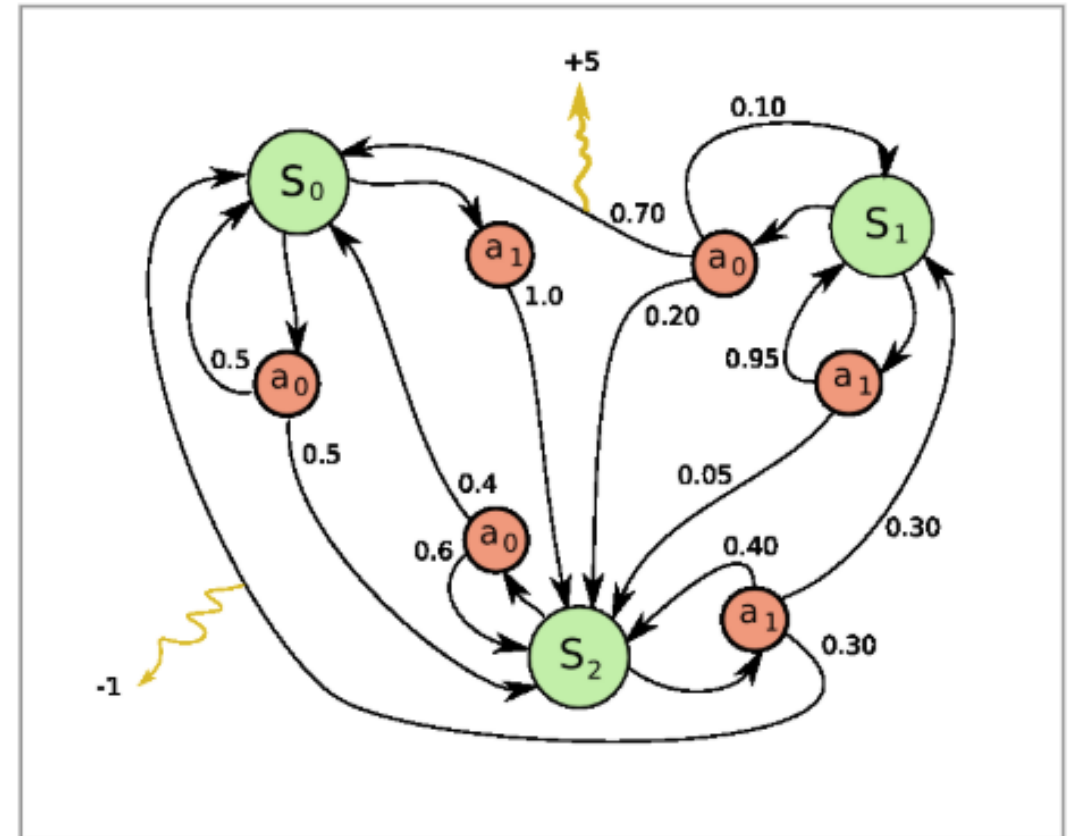
<https://web.stanford.edu/class/psych209/Readings/MnihEtAlHassibis15NatureControlDeepRL.pdf>

# e.g., Pong Game - Learning Example

Move “up” or “down”

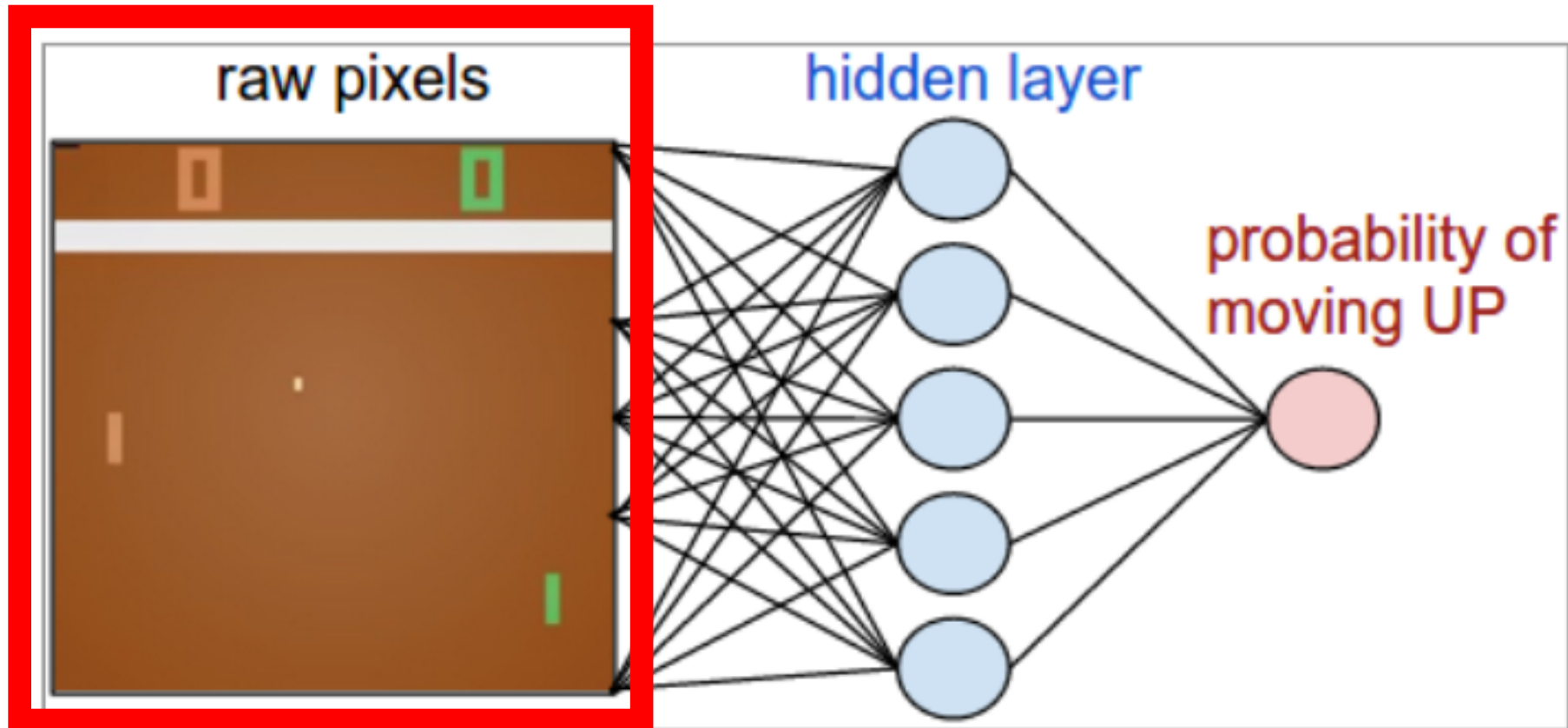


- 1 if missed the ball
- +1 reward if ball goes past opponent
- 0 otherwise



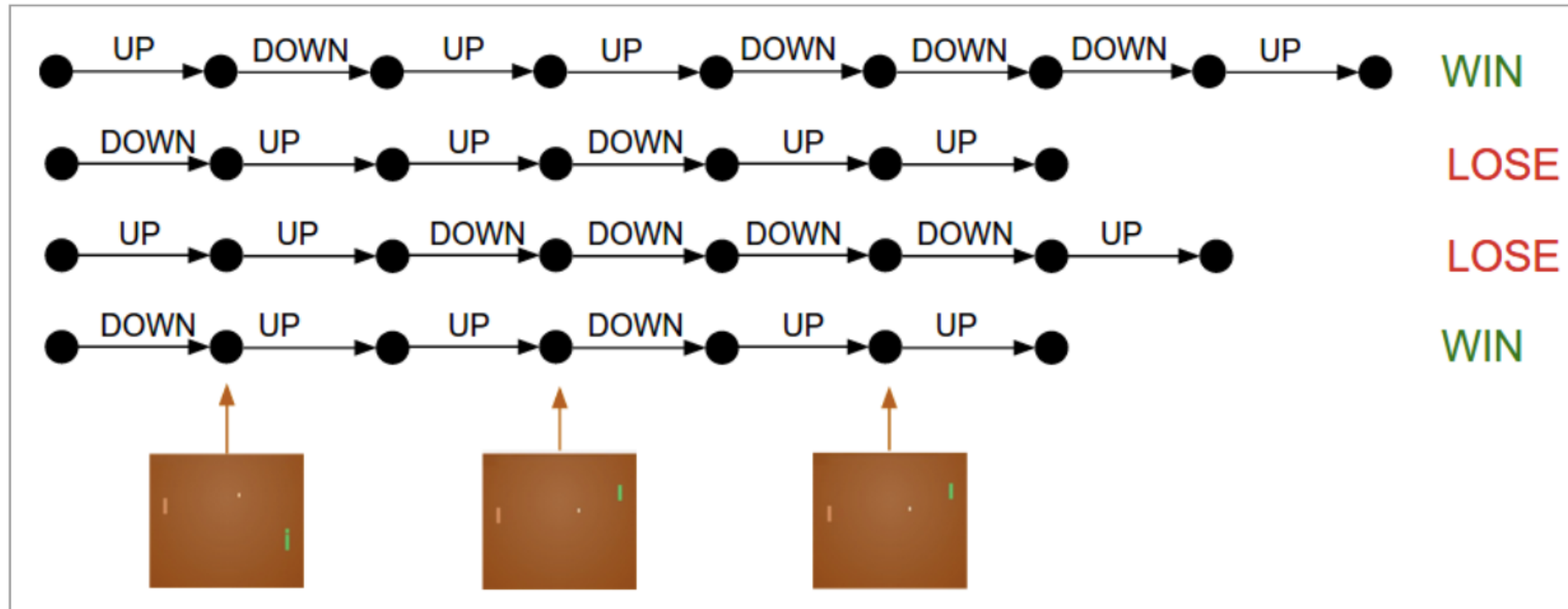
# e.g., Pong Game: Policy Network

Implements our player (or “agent”)



Game State

# 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 =  $200 \times 12 = 2400$  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:  $200 \times 88 = 17600$ ; 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](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=PL5nBAYUyJTrM48dViiby68urttMIUv7e](https://www.youtube.com/watch?v=W_gxLKSsSIE&list=PL5nBAYUyJTrM48dViiby68urttMIUv7e)

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.

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