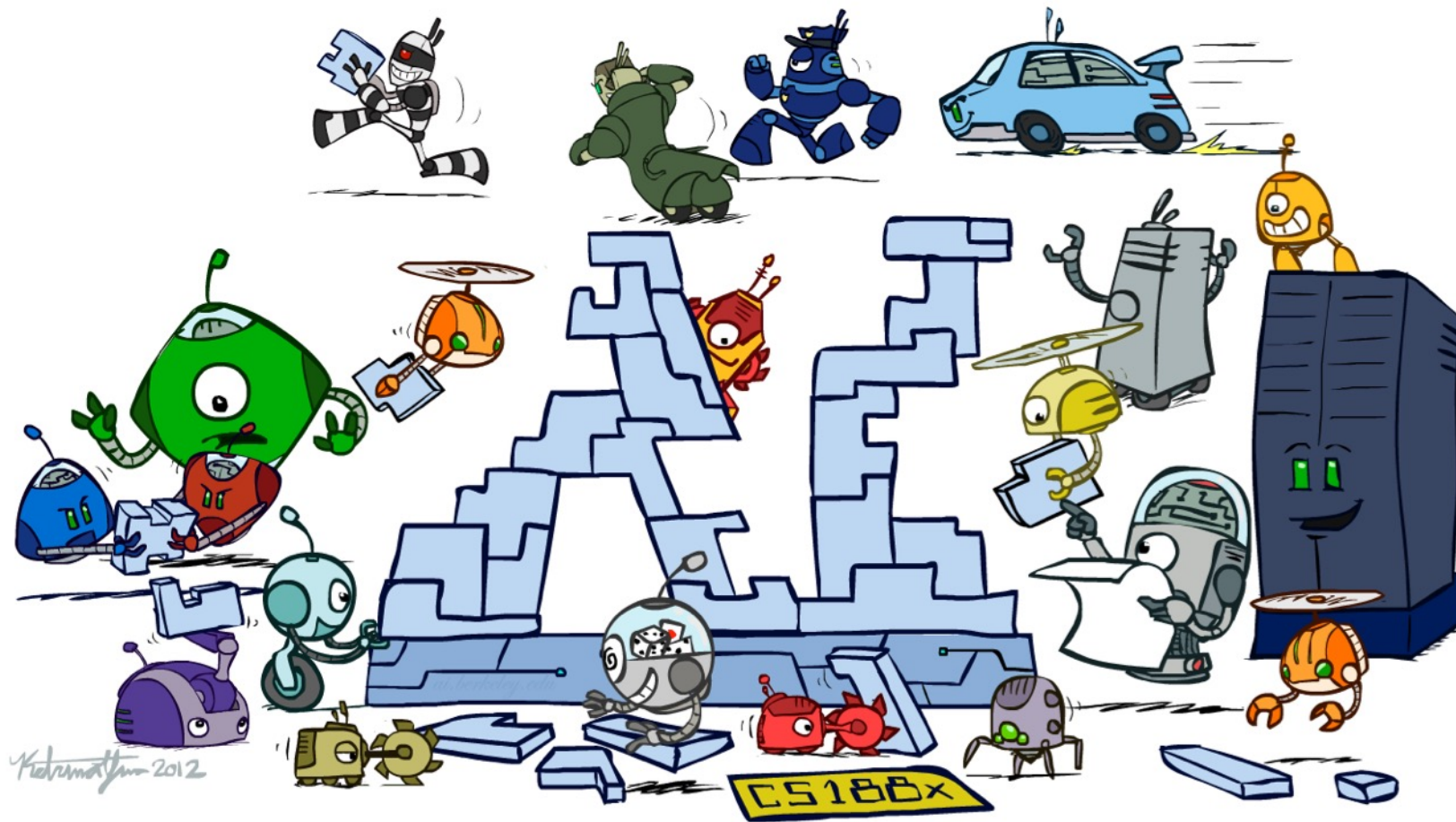
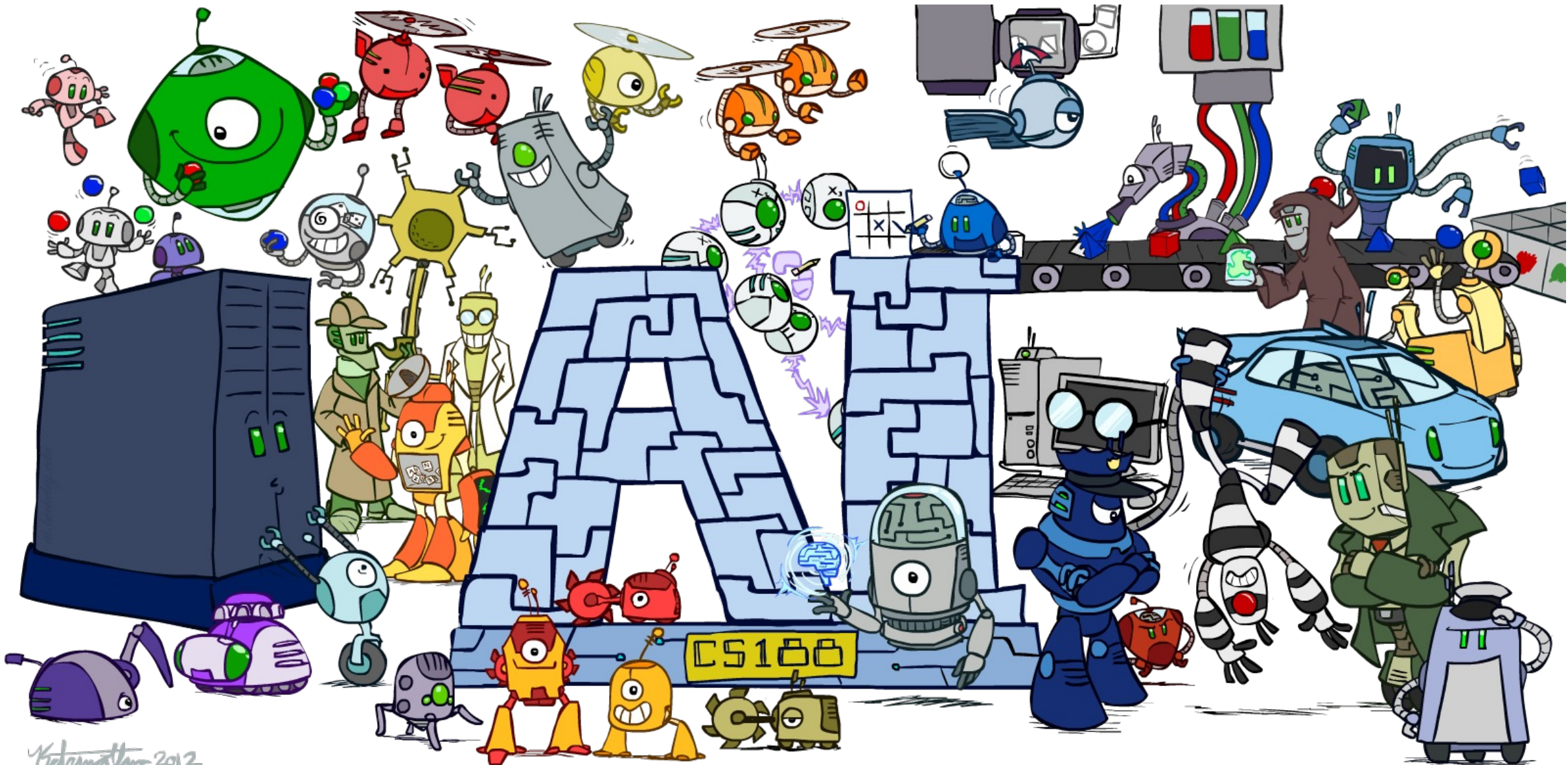


Announcements

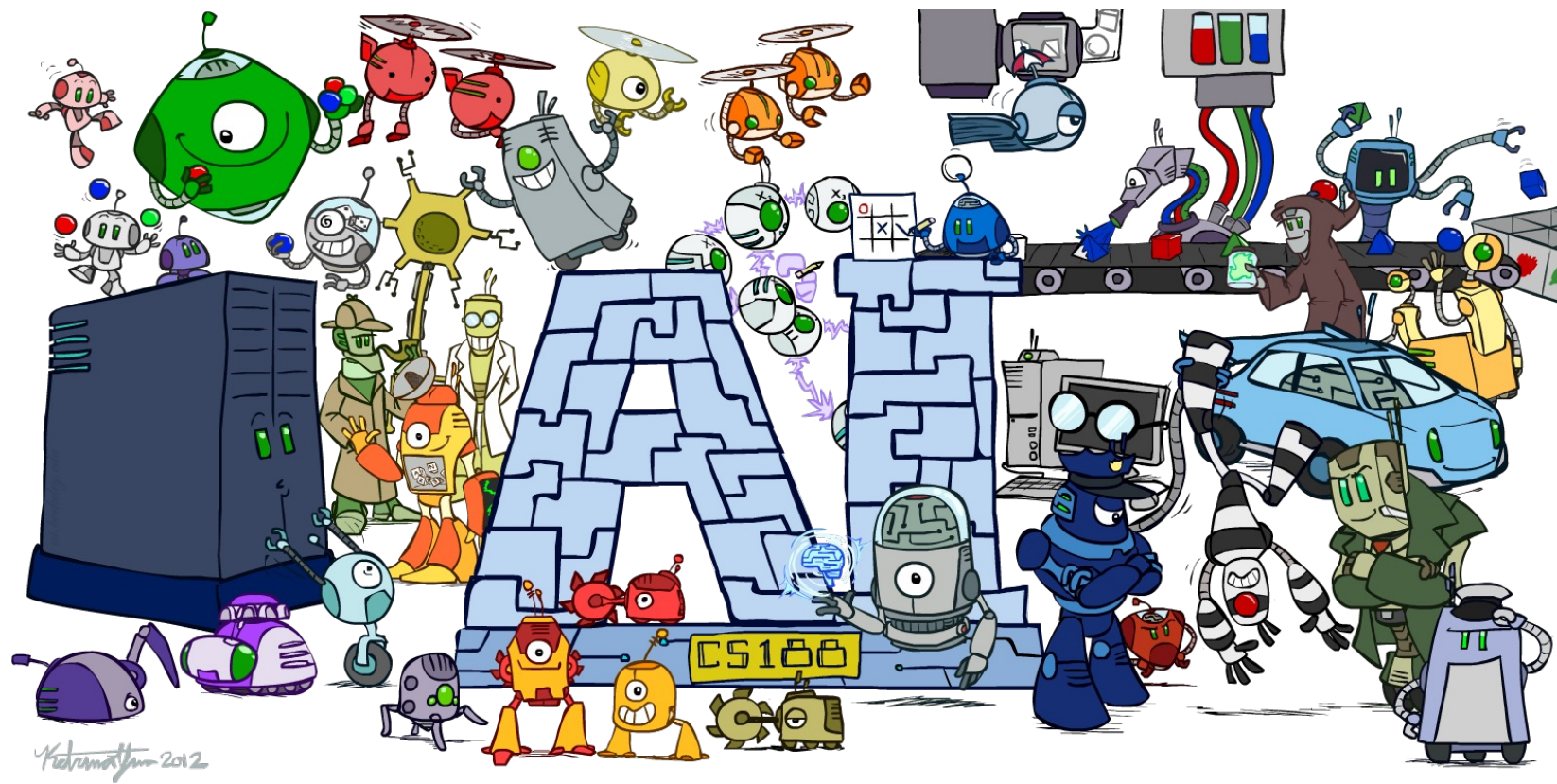
- **Homework 9** due **today** (Tuesday, Nov 29) at 11:59pm PT
- **Project 5** due **Thursday, Dec 1** at 11:59pm PT
 - Q1 unchanged, Q2 & Q3 now have hyperparameters, Q4 is **optional**
- **Homework 10** will be released this week and is **optional**
- Online office hours:
 - 5:00-6:30pm M/W
 - 6:30-8:00pm Tu/Th
- **Final exam** will be held **as planned**
- Thursday lecture will be review session

CS 188: Artificial Intelligence Applications & Conclusion





Kidrobot 2012



Ketrina Yim
CS188 Artist

Recap of Key Neural Network Ideas

Optimize probability of label given input $\max_w ll(w) = \max_w \sum_i \log P(y^{(i)} | x^{(i)}; w)$

Continuous optimization

Gradient ascent: take step in steepest uphill direction

Backpropagation computes gradient efficiently (out of scope)

Deep neural nets

Last layer = logistic regression

Many layers before this last layer: learns “features” of input

Universal function approximation theorem:

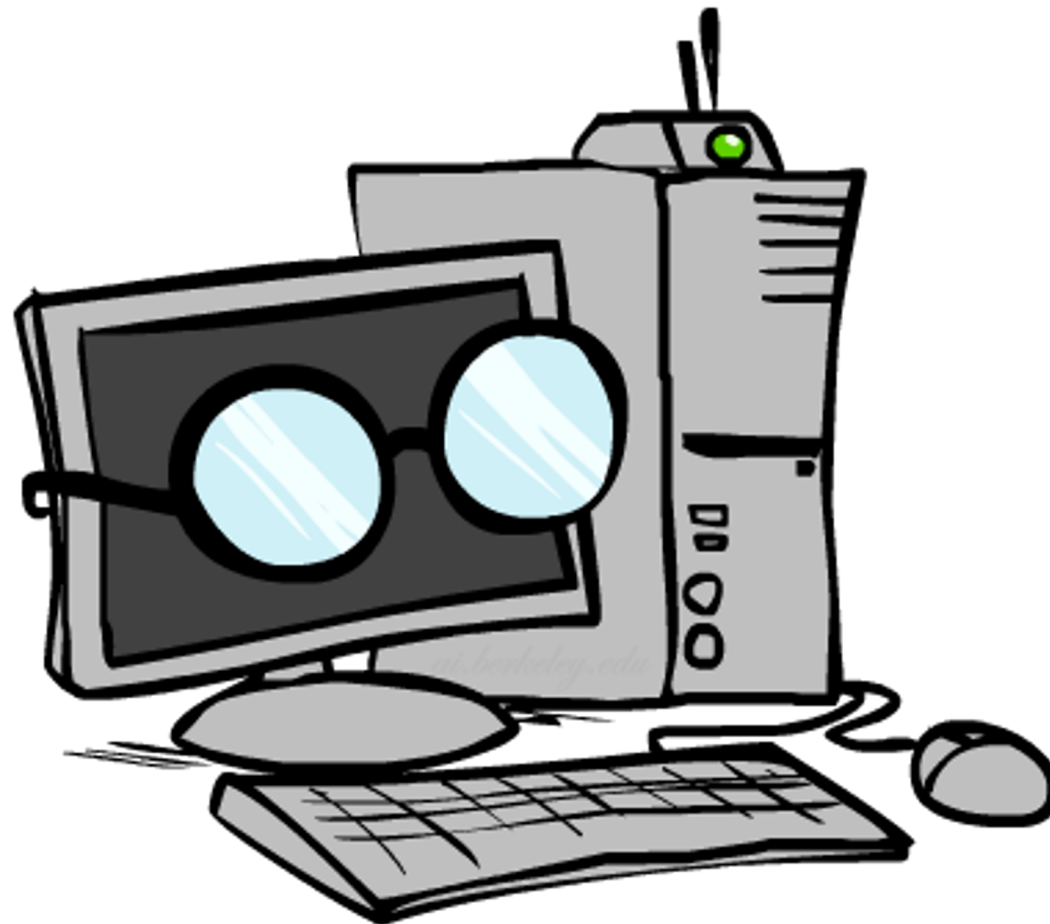
a large enough 2 layer neural network can represent any continuous function with arbitrary accuracy

Today

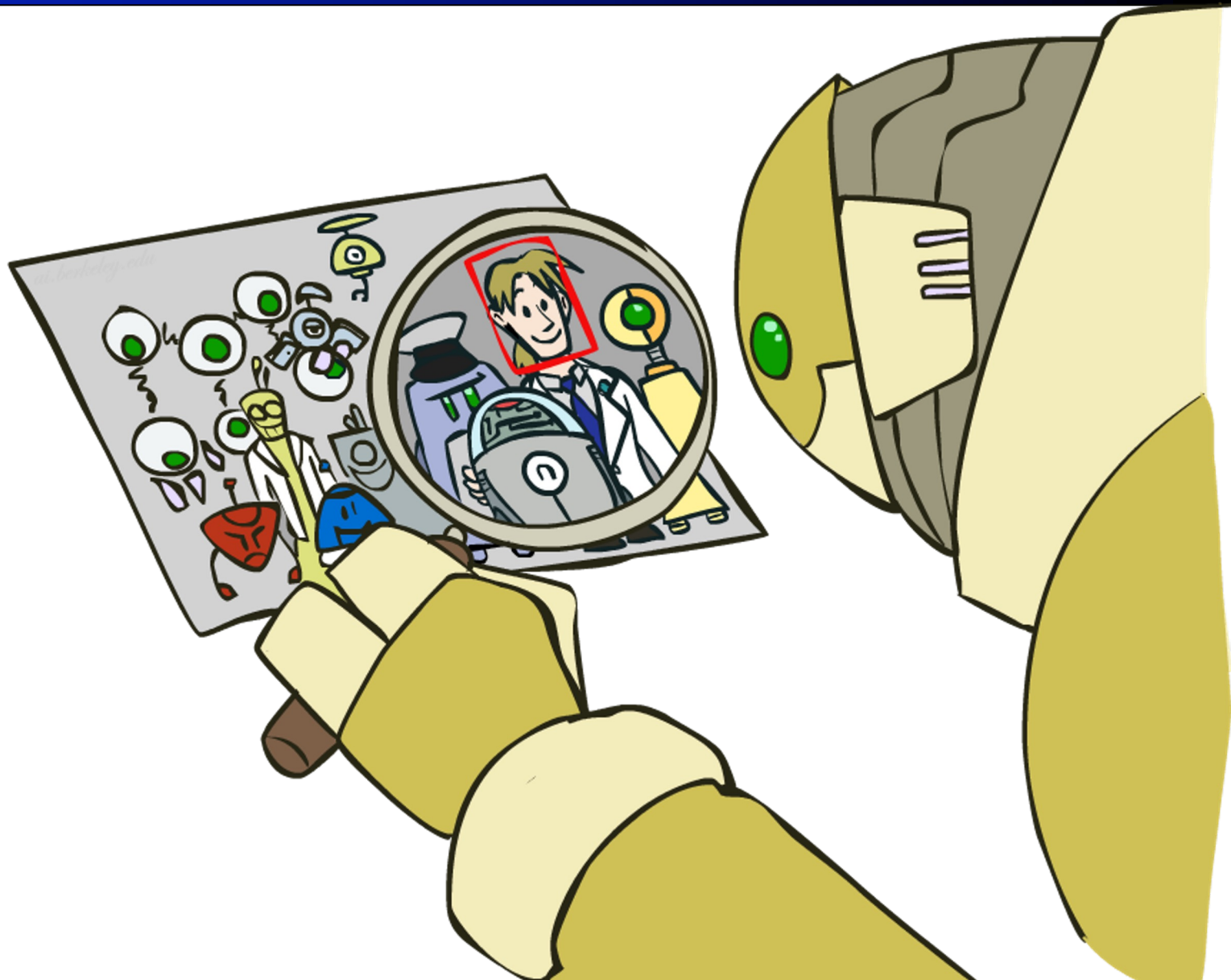
- Applications of supervised deep learning
- Brief overview of unsupervised learning
- Frontier applications of AI
 - Language and text models
 - Image-language models
 - Reinforcement learning (Go and Robotics)
- AI ethics considerations

How well does deep learning work?

Computer Vision



Object Detection and Image Classification

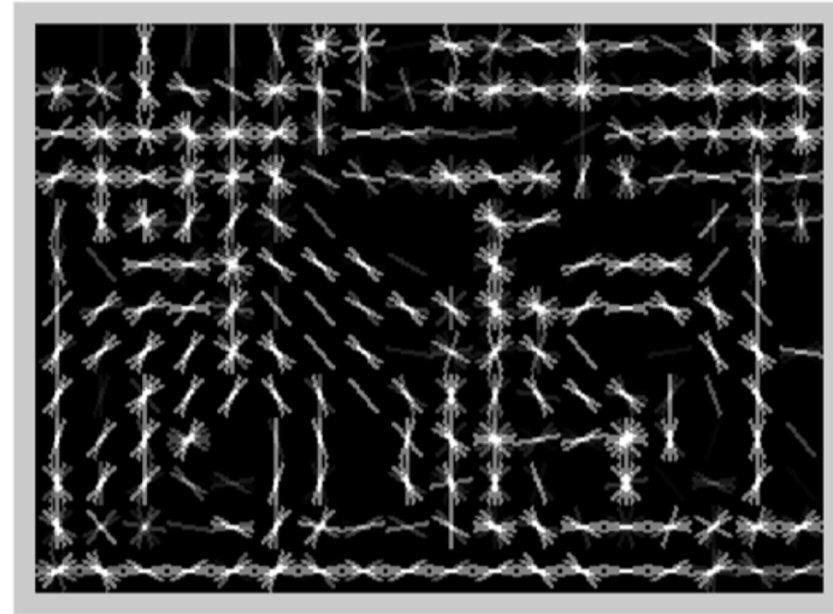


Traditional Computer Vision

- Manual Feature Design



Image



Histogram of Gradients (HoG)

Image Classification: Performance

ImageNet Error Rate 2010-2014

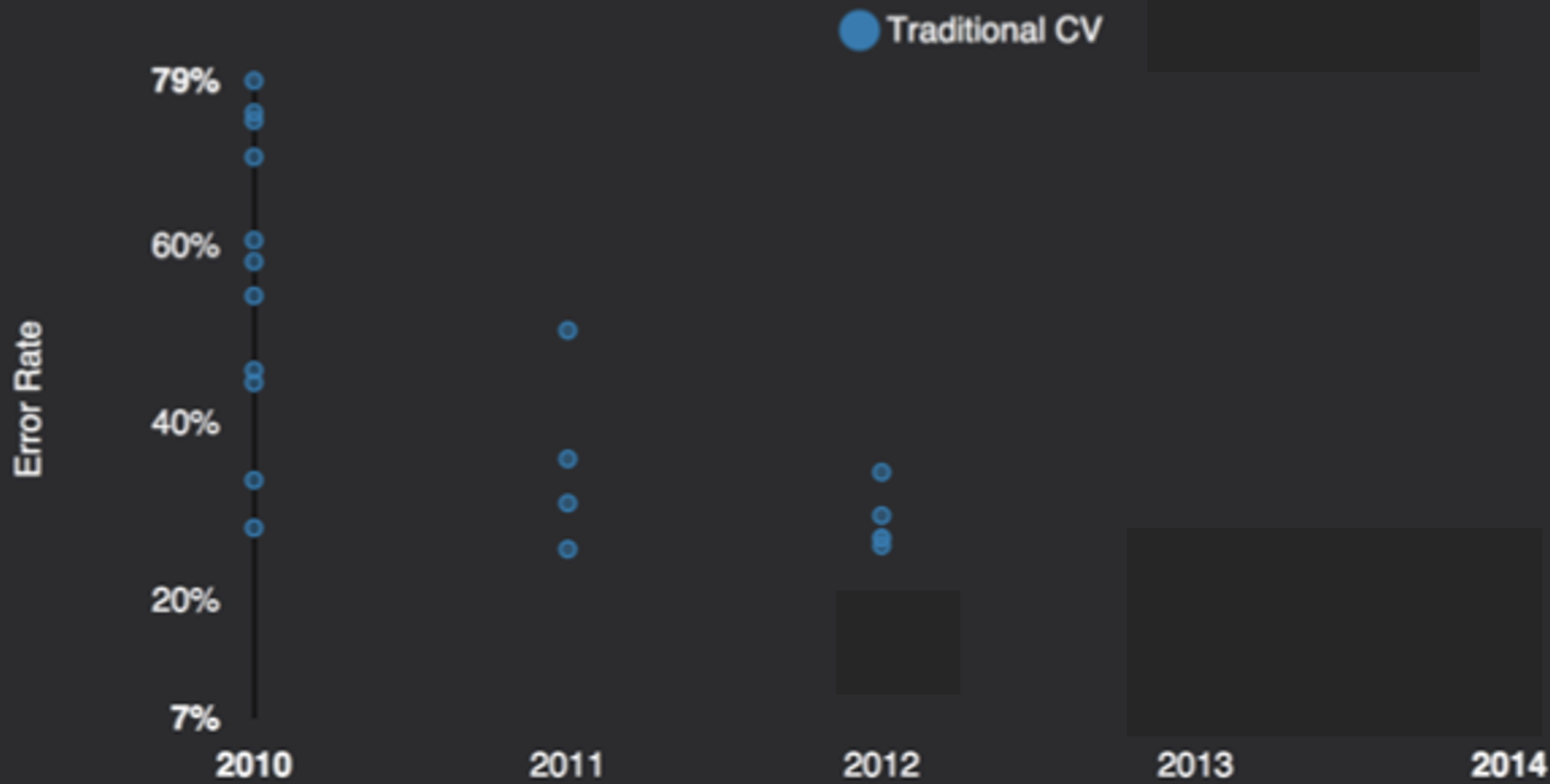


Image Classification: Performance

ImageNet Error Rate 2010-2014

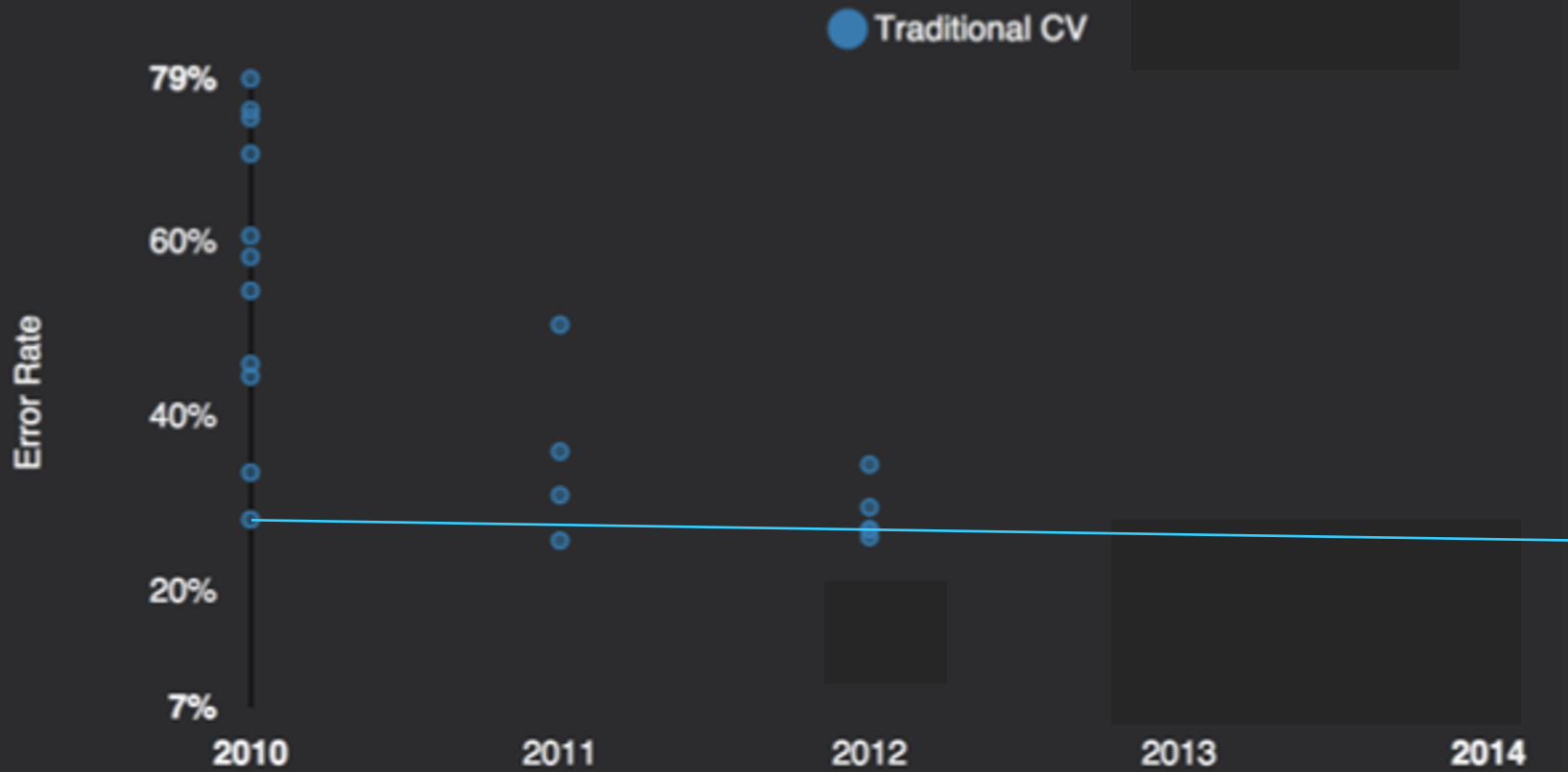


Image Classification: Performance

ImageNet Error Rate 2010-2014

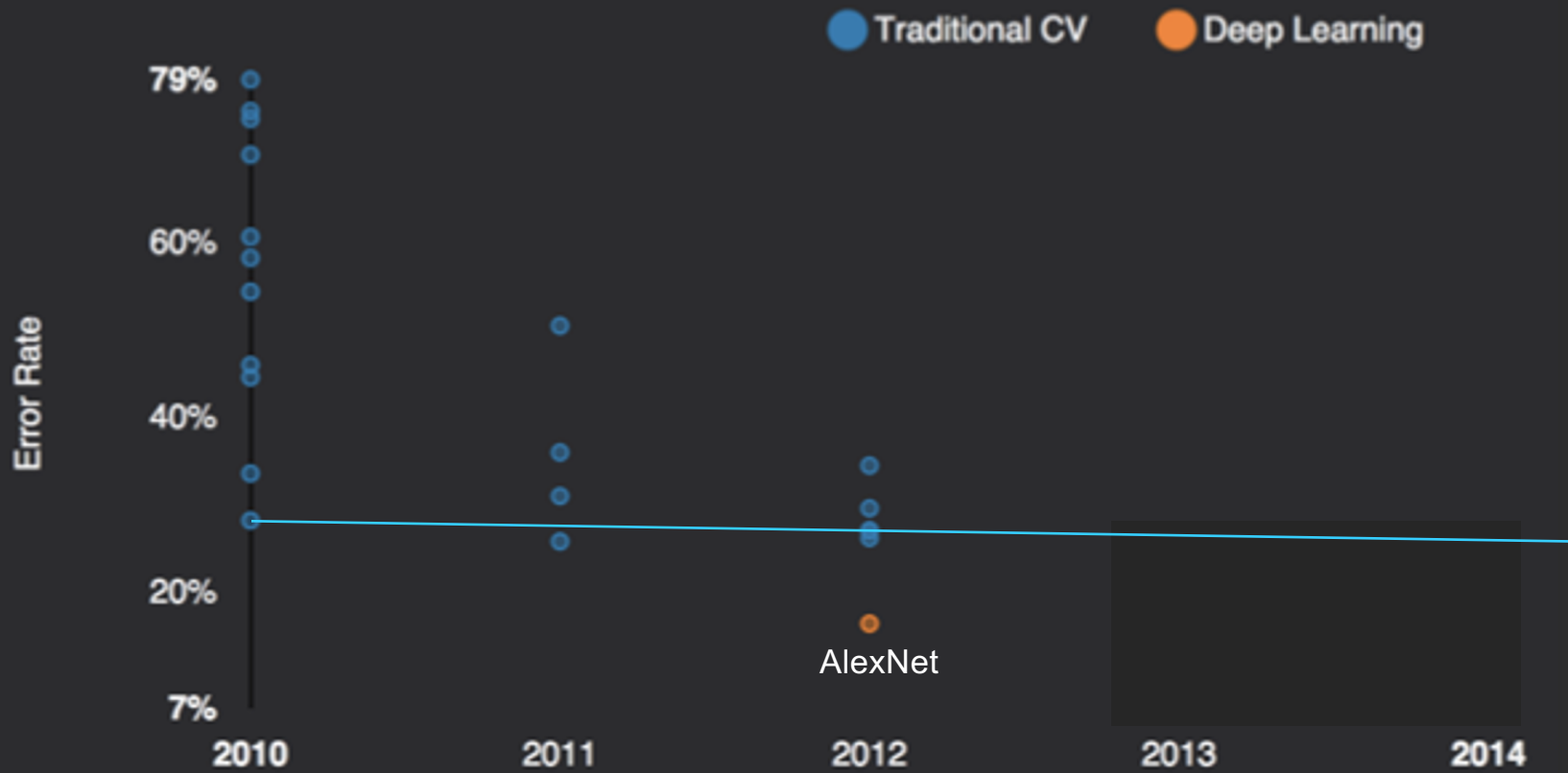


Image Classification: Performance

ImageNet Error Rate 2010-2014

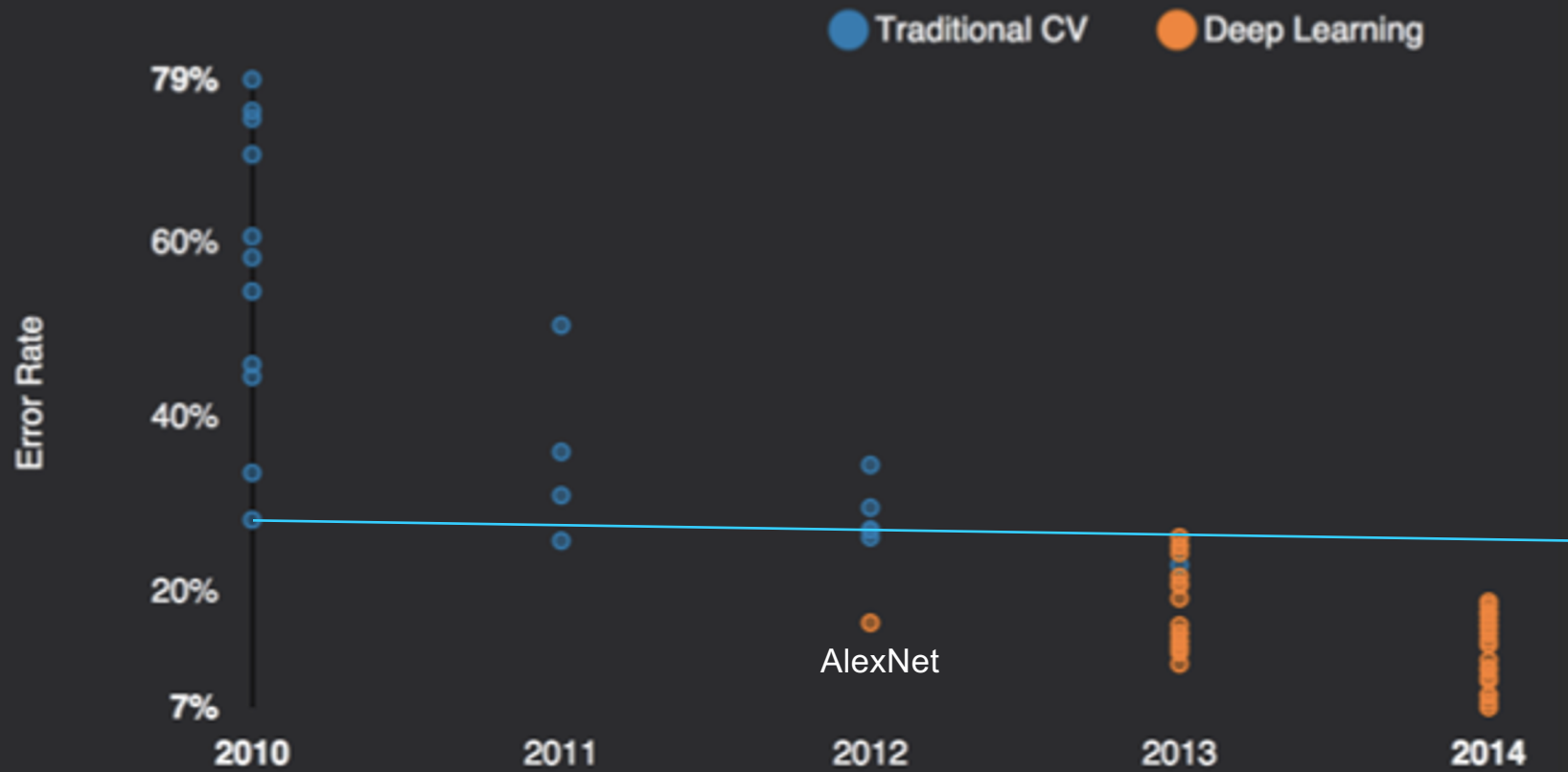


Image Classification: Performance

ImageNet Error Rate 2010-2014

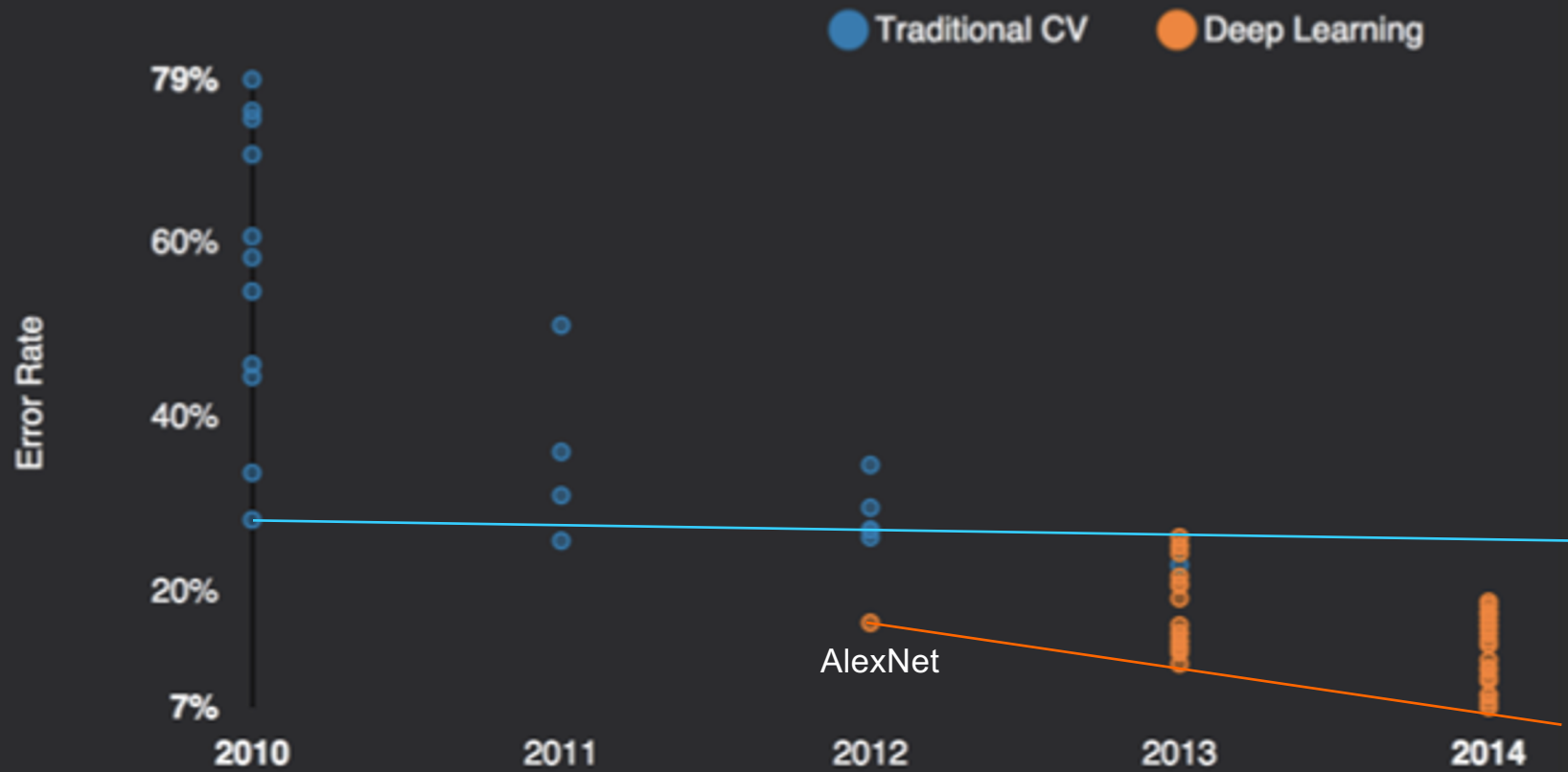


Image Classification: Performance

Leaderboard Dataset

View by for

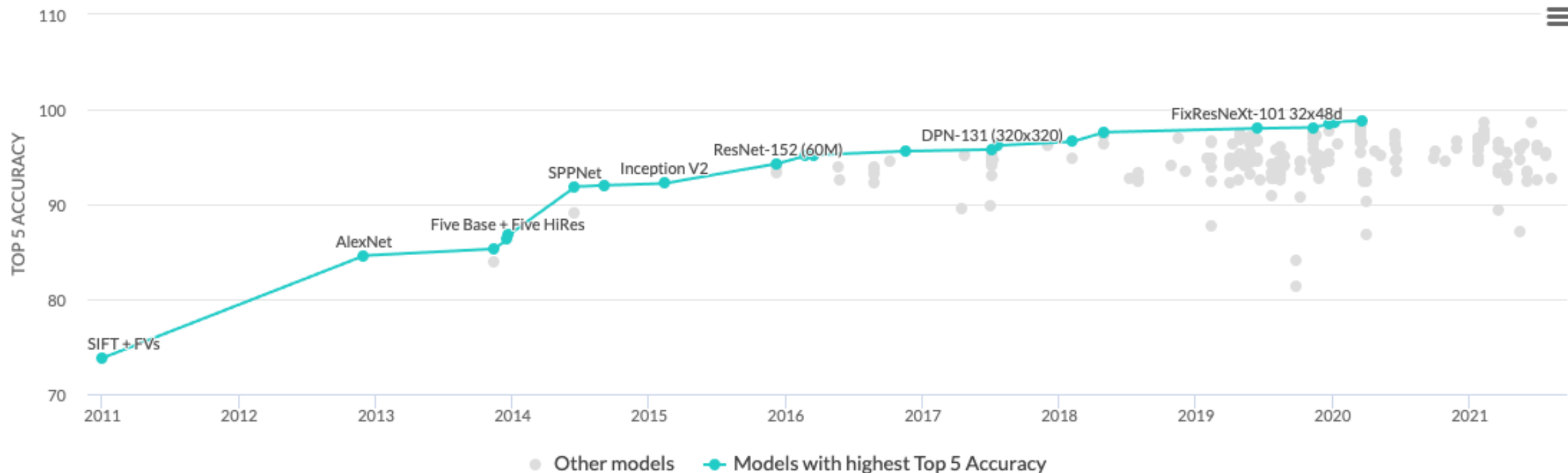
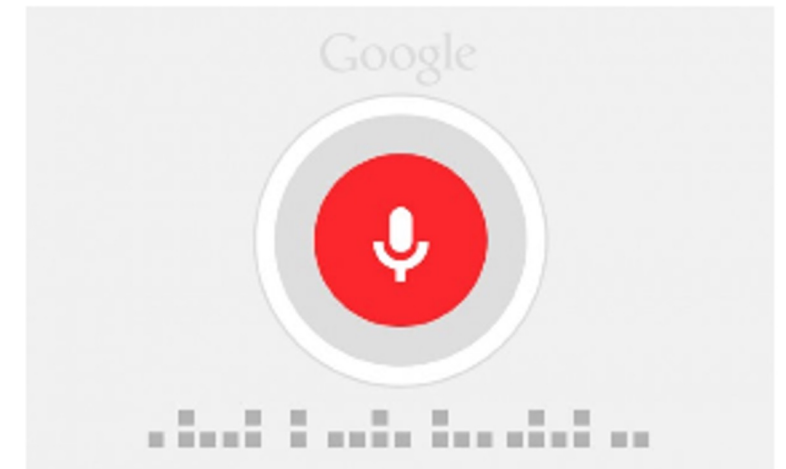
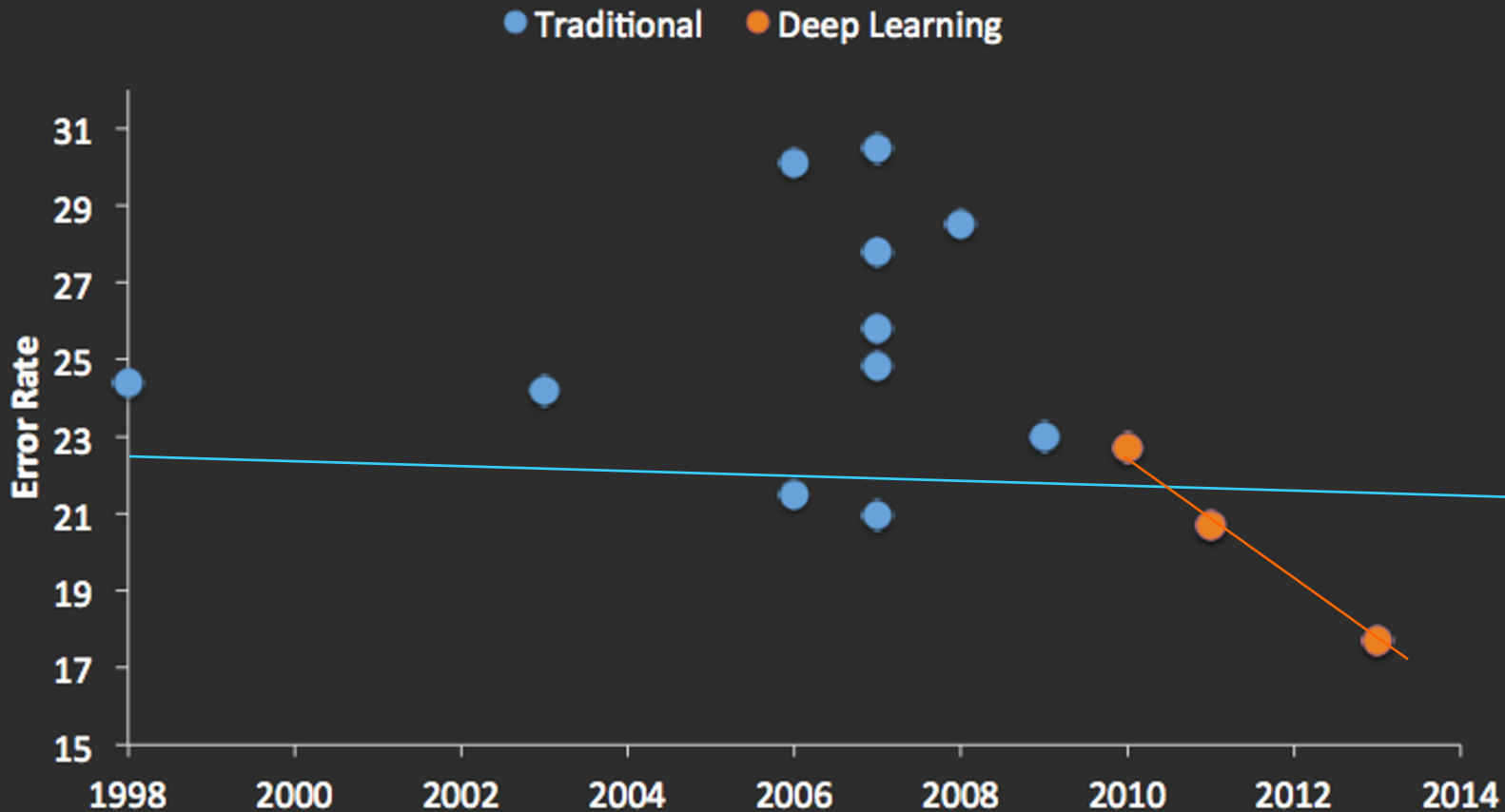


Image Segmentation



Speech Recognition

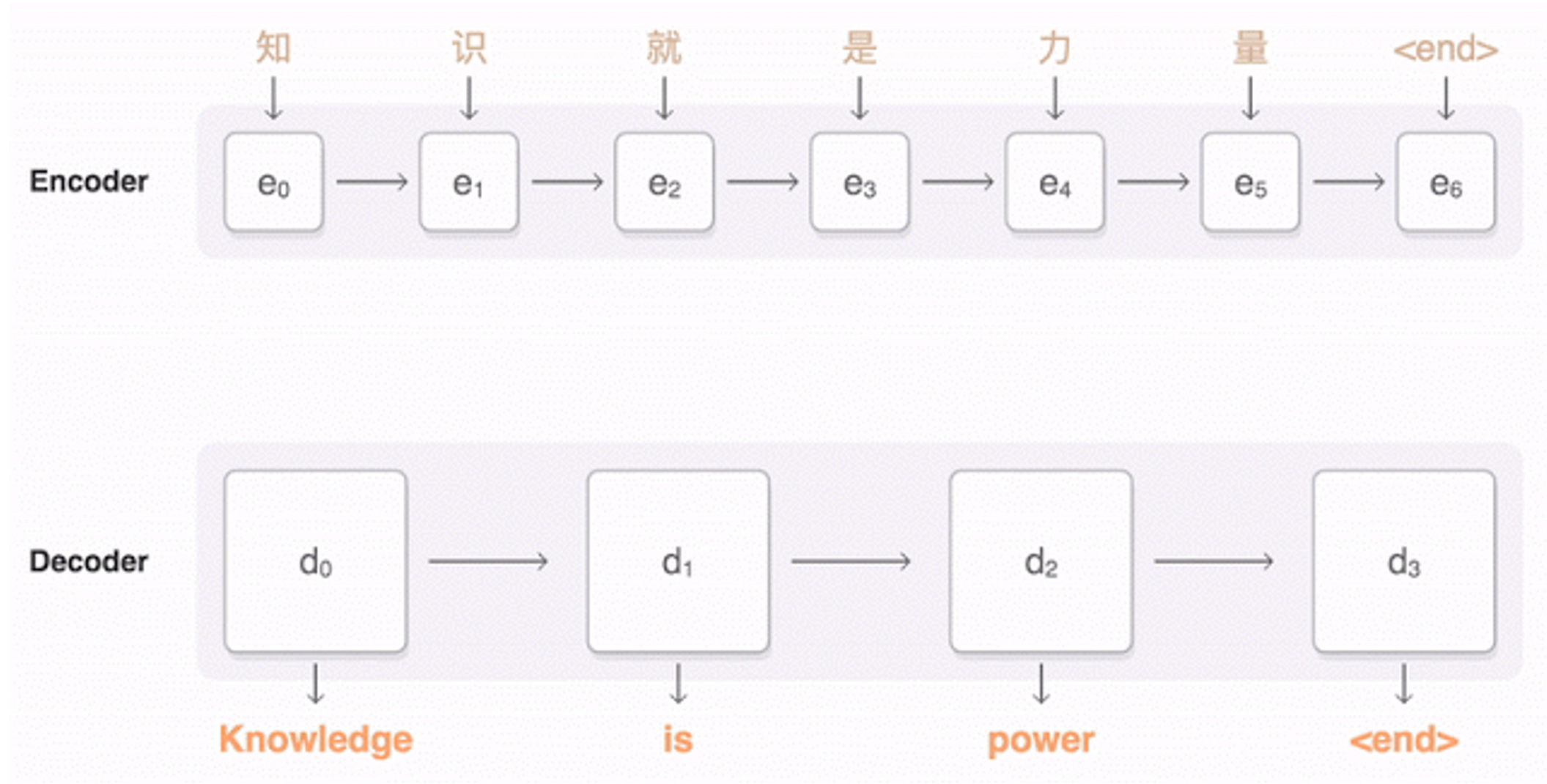
TIMIT Speech Recognition



graph credit Matt Zeiler, Clarifai

Machine Translation

Google Neural Machine Translation



Google and DeepMind are using AI to predict the energy output of wind farms

To help make that energy more valuable to the power grid

By [Nick Statt](#) | [@nickstatt](#) | Feb 26, 2019, 2:42pm EST

[f](#) [t](#) [SHARE](#)



Google [announced today](#) that it has made energy produced by wind farms more viable using the artificial intelligence software of its London-based subsidiary DeepMind. By using DeepMind's machine learning algorithms to predict the wind output from the farms Google uses for its green energy initiatives, the company says it can now schedule set deliveries of energy output, which are more valuable to the grid than standard, non-time-based deliveries.

NEWS · 30 NOVEMBER 2020

'It will change everything': DeepMind's AI makes gigantic leap in solving protein structures

Google's deep-learning program for determining the 3D shapes of proteins stands to transform biology, say scientists.

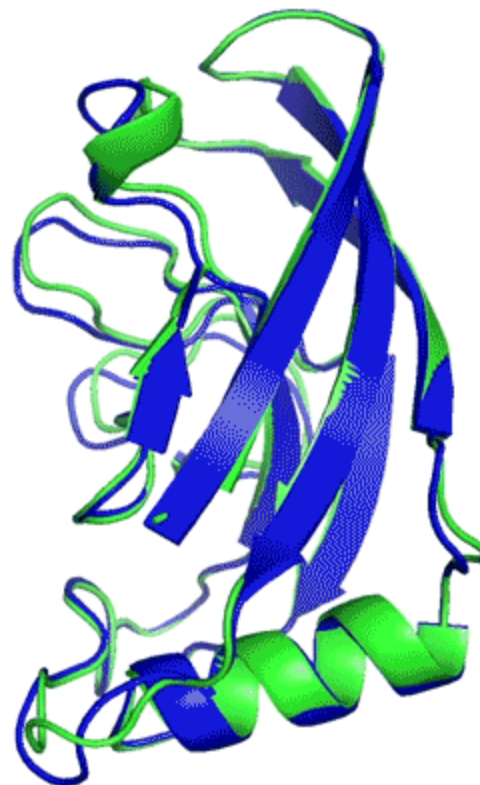
[Ewen Callaway](#)



A protein's function is determined by its 3D shape. Credit: DeepMind



T1037 / 6vr4
90.7 GDT
(RNA polymerase domain)

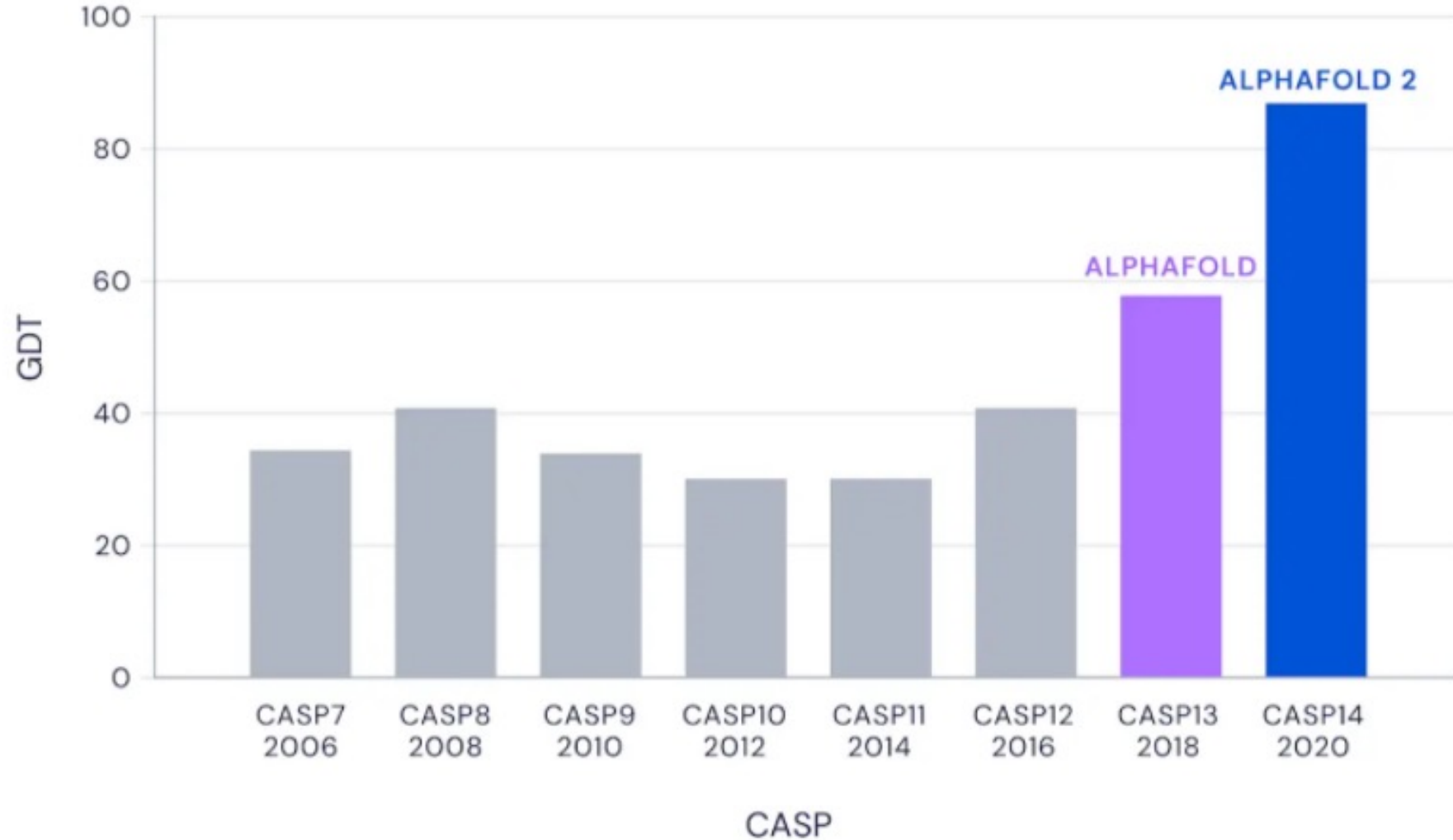


T1049 / 6y4f
93.3 GDT
(adhesin tip)

- Experimental result
- Computational prediction

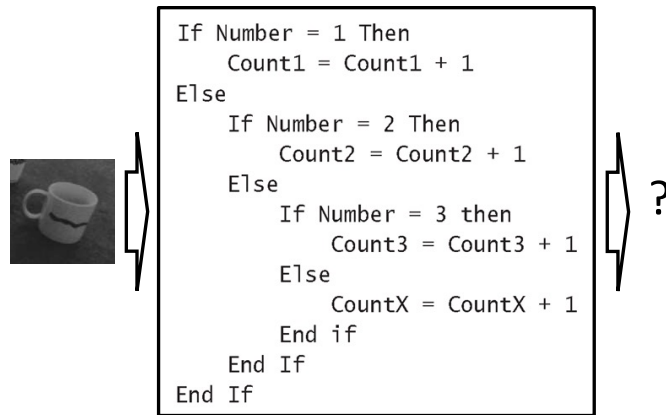
CASP 2020 Competition

Median Free-Modelling Accuracy



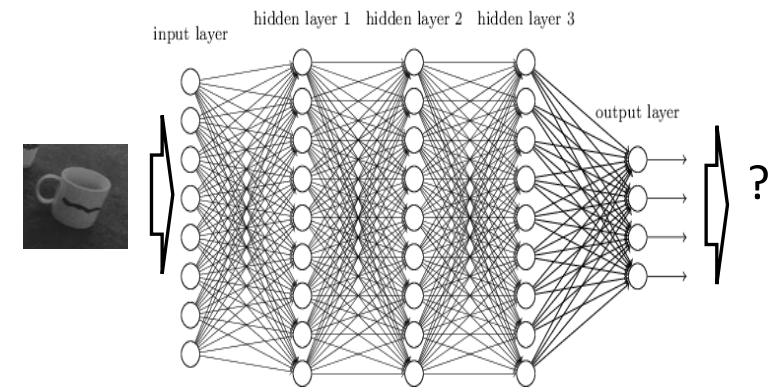
Change in Programming Paradigm?

Traditional Programming:
program by writing lines of code



Poor performance on AI problems

Deep Learning (“Software 2.0”):
program by providing data



Success!

Today

- Applications of supervised deep learning
- Brief overview of unsupervised learning
- Frontier applications of AI
 - Language and text models
 - Image-language models
 - Reinforcement learning (Go and Robotics)
- AI ethics considerations

Deep Unsupervised Learning

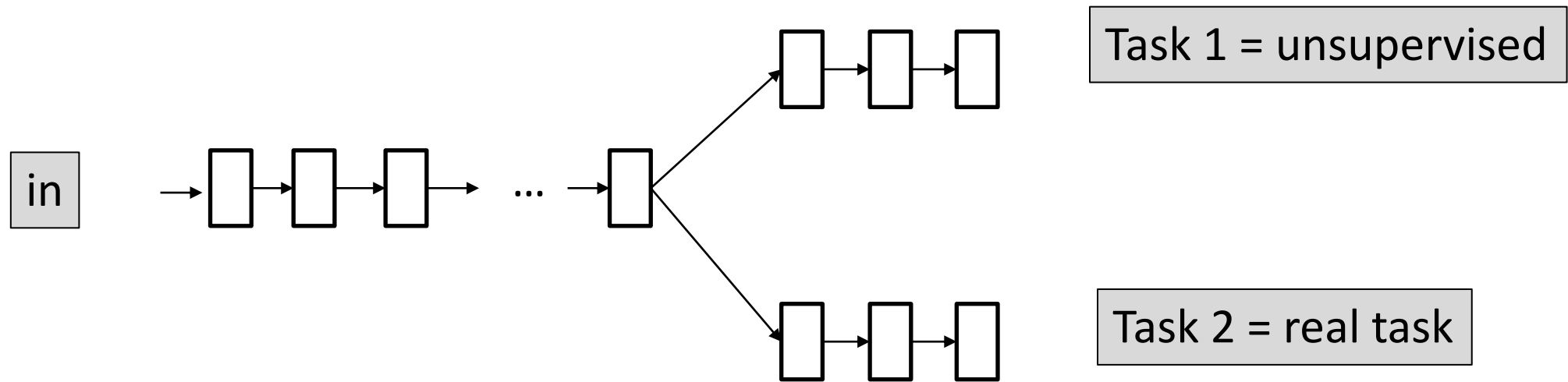
- Key hypothesis:

Task 1 IF neural network smart enough to predict:

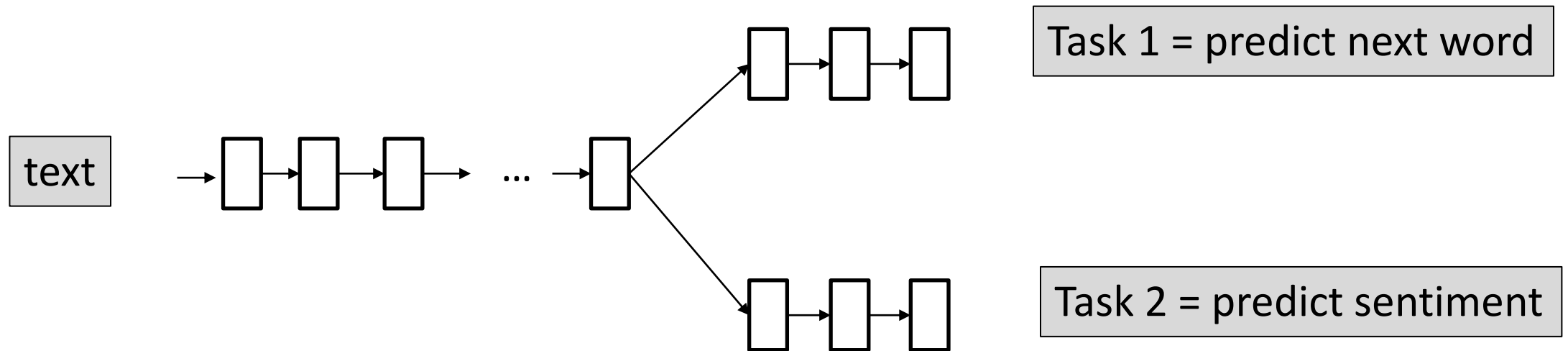
- Next frame in video
- Next word in sentence
- Generate realistic images
- ``Translate'' images
- ...

Task 2 THEN same neural network is ready to do Deep Supervised Learning from very small data-set

Transfer from Unsupervised Learning



Example Setting



Next Word Prediction (OpenAI's GPT-2)

Prompt: A train carriage containing controlled nuclear materials was stolen in Cincinnati today. Its whereabouts are unknown.

GPT-2: *The incident occurred on the downtown train line, which runs from Covington and Ashland stations. In an email to Ohio news outlets, the U.S. Department of Energy said it is working with the Federal Railroad Administration to find the thief.*

'The theft of this nuclear material will have significant negative consequences on public and environmental health, our workforce and the economy of our nation,' said Tom Hicks, the U.S. Energy Secretary, in a statement. 'Our top priority is to secure the theft and ensure it doesn't happen again.'

The stolen material was taken from the University of Cincinnati's Research Triangle Park nuclear research site, according to a news release from Department officials.

The Nuclear Regulatory Commission did not immediately release any information. According to the release, the U.S. Department of Energy's Office of Nuclear Material Safety and Security is leading that team's investigation.

'The safety of people, the environment and the nation's nuclear stockpile is our highest priority,' Hicks said. 'We will get to the bottom of this and make no excuses.'

Next Word Prediction (OpenAI's GPT-2)

Prompt: Recycling is good for the world, no, you could not be more wrong.

GPT-2: Recycling is NOT good for the world. It is bad for the environment, it is bad for our health, and it is bad for our economy. I'm not kidding. Recycling is not good for the environment. It is destructive to the earth and it is a major contributor to global warming. Recycling is not good for our health. It contributes to obesity and diseases like heart disease and cancer. Recycling is bad for our economy. It increases the cost of a product, and in turn, the price of everything that is made with that product. Recycling is not good for our nation. We pay a tremendous price for the privilege of having the world's most advanced and efficient recycling system. Recycling is a huge, colossal waste of time, energy, money, and resources.

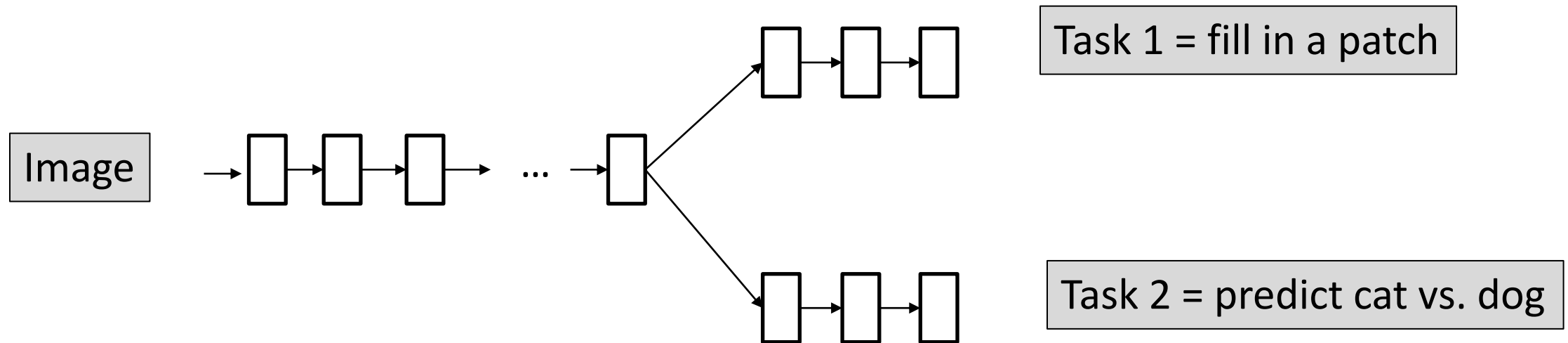
Unsupervised Sentiment Neuron

This is one of Crichton's best books. The characters of Karen Ross, Peter Elliot, Munro, and Amy are beautifully developed and their interactions are exciting, complex, and fast-paced throughout this impressive novel. And about 99.8 percent of that got lost in the film. Seriously, the screenplay AND the directing were horrendous and clearly done by people who could not fathom what was good about the novel. I can't fault the actors because frankly, they never had a chance to make this turkey live up to Crichton's original work. I know good novels, especially those with a science fiction edge, are hard to bring to the screen in a way that lives up to the original. But this may be the absolute worst disparity in quality between novel and screen adaptation ever. The book is really, really good. The movie is just dreadful.

Benchmarks

DATASET	METRIC	OUR RESULT	PREVIOUS RECORD	HUMAN
Winograd Schema Challenge	accuracy (+)	70.70%	63.7%	92%+
LAMBADA	accuracy (+)	63.24%	59.23%	95%+
LAMBADA	perplexity (-)	8.6	99	~1-2
Children's Book Test Common Nouns (validation accuracy)	accuracy (+)	93.30%	85.7%	96%
Children's Book Test Named Entities (validation accuracy)	accuracy (+)	89.05%	82.3%	92%
Penn Tree Bank	perplexity (-)	35.76	46.54	unknown
WikiText-2	perplexity (-)	18.34	39.14	unknown

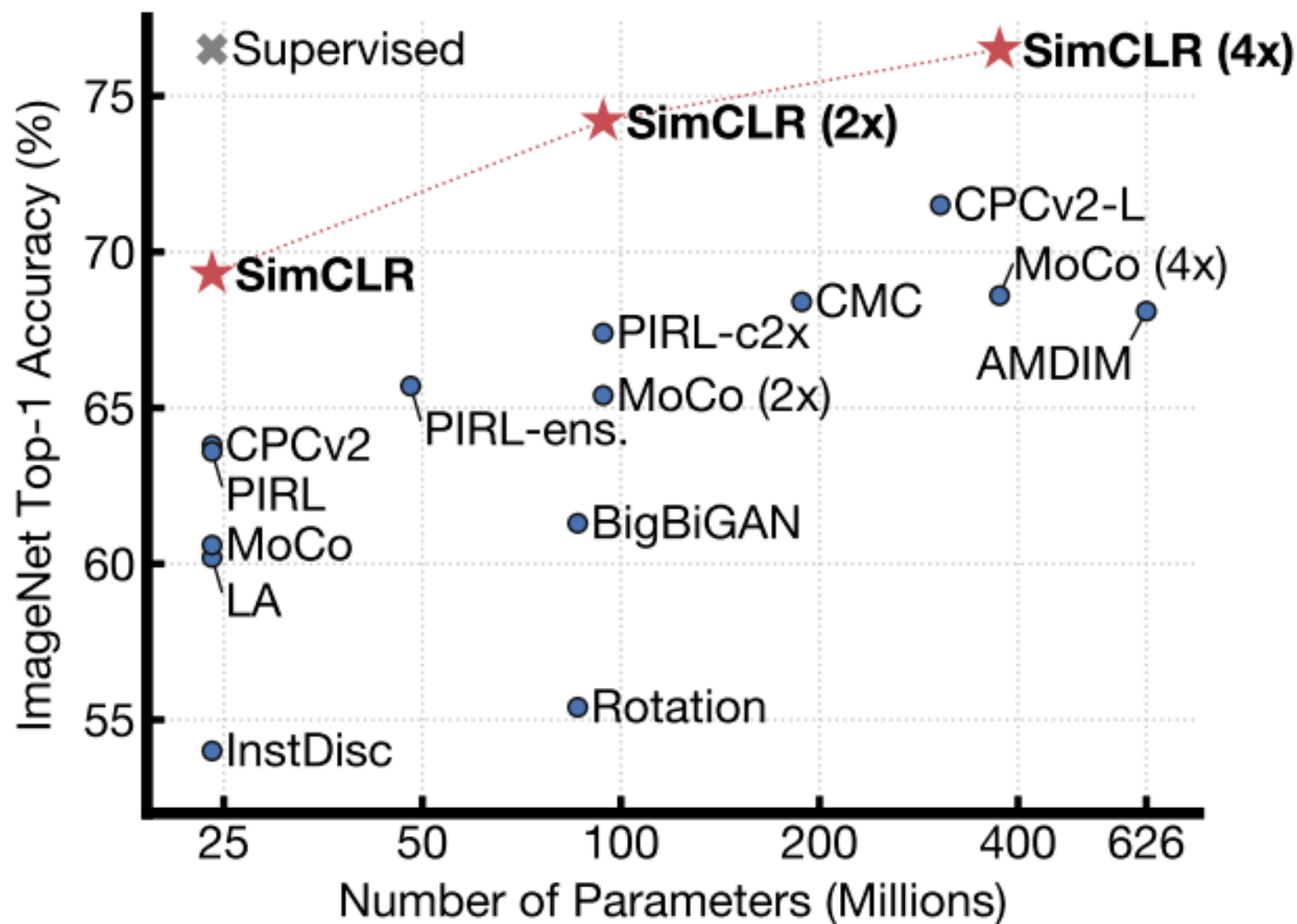
Unsupervised Learning in Vision



Predict Missing Patch



Pre-Trained Model (SimCLR) + Linear Classifier



Pre-Training and Fine-Tuning

1 **Pre-Train:** train a large model with a lot of data on a supervised *pretext* task

- Predict next word / patch of image
- Predict missing word / patch of image
- Predict if two images are related (contrastive learning)

2a **Fine-Tune:** continue training the same model on task you care about

2b **Prompt:** Or directly ask the model?

■ Prompt without training:

The three settings we explore for in-context learning

Zero-shot

The model predicts the answer given only a natural language description of the task. No gradient updates are performed.

```
1 Translate English to French: ← task description
2 cheese => ..... ← prompt
```

One-shot

In addition to the task description, the model sees a single example of the task. No gradient updates are performed.

```
1 Translate English to French: ← task description
2 sea otter => loutre de mer ← example
3 cheese => ..... ← prompt
```

Few-shot

In addition to the task description, the model sees a few examples of the task. No gradient updates are performed.

```
1 Translate English to French: ← task description
2 sea otter => loutre de mer ← examples
3 peppermint => menthe poivrée ←
4 plush girafe => girafe peluche ←
5 cheese => ..... ← prompt
```

Traditional fine-tuning (not used for GPT-3)

Fine-tuning

The model is trained via repeated gradient updates using a large corpus of example tasks.



- **Prompt without training:**

- **Control desired output via examples**

Standard Prompting	Chain of thought prompting
<p>Example Input</p>	<p>Example Input</p>
<p>Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?</p>	<p>Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?</p>
<p>Example Output</p>	<p>Example Output</p>
<p>A: The answer is 11.</p>	<p>Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls. $5 + 6 = 11$. The answer is 11.</p>
<p>Prompt</p>	<p>Prompt</p>
<p>The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?</p>	<p>The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?</p>
<p>Model Response</p>	<p>Model Response</p>
<p>The answer is 50. ❌</p>	<p>The cafeteria had 23 apples originally. They used 20 to make lunch. So they had $23 - 20 = 3$. They bought 6 more apples, so they have $3 + 6 = 9$. The answer is 9. ✅</p>

Applications of Text Models: Mathematics

Question: A line parallel to $y = 4x + 6$ passes through $(5, 10)$. What is the y -coordinate of the point where this line crosses the y -axis?

Model output: The line is parallel to $y = 4x + 6$, which means that it has the same slope as $y = 4x + 6$. Since the line passes through $(5, 10)$, we can use the point-slope form of a line to find the equation of the line:

$$y - 10 = 4(x - 5)$$

$$y - 10 = 4x - 20$$

$$y = 4x - 10$$

Now that we have the equation of the line, we can find the y -coordinate of the point where the line crosses the y -axis by substituting $x = 0$ into the equation:

$$y = 4 \cdot 0 - 10 = \boxed{-10}.$$

Applications of Text Models: Mathematics

Minerva
SAMPLE EXPLORER
[paper](#) | [blog](#)

Algebra Probability **Physics** Number Theory Precalculus Geometry Biology Electrical Engineering Chemistry Astronomy Machine Learning

QUESTION Two simple pendulums A and B consist of identical masses suspended from strings of length L_A and L_B , respectively. The two pendulums oscillate in equal gravitational fields. If the period of pendulum B is twice the period of pendulum A , which of the following is true of the lengths of the two pendulums? Which of the following is the right choice? Explain your answer. (A) $L_B = 4L_A$ (B) $L_B = 2L_A$ (C) $L_B = L_A$ (D) $L_B = 1/2L_A$

MODEL ANSWER The period of a simple pendulum is given by the formula

$$T = 2\pi\sqrt{\frac{L}{g}}$$

If the period of pendulum B is twice the period of pendulum A, we have

$$2T_A = T_B \Rightarrow 2(2\pi\sqrt{\frac{L_A}{g}}) = 2\pi\sqrt{\frac{L_B}{g}} \Rightarrow \boxed{L_B = 4L_A}$$



Final Answer: The final answer is (A).

REFERENCE ANSWER A

PROBLEM SOURCE MMLU college physics

EVALUATION RESULT Correct

Key: Correct Incorrect False positive

13 / 26

Applications of Text Models: Mathematics

- **Incorrect Answer:** reasoning mistake (but looks worryingly plausible!)

Question: At each basketball practice last week, Jenny made twice as many free throws as she made at the previous practice. At her fifth practice she made 48 free throws. How many free throws did she make at the first practice?

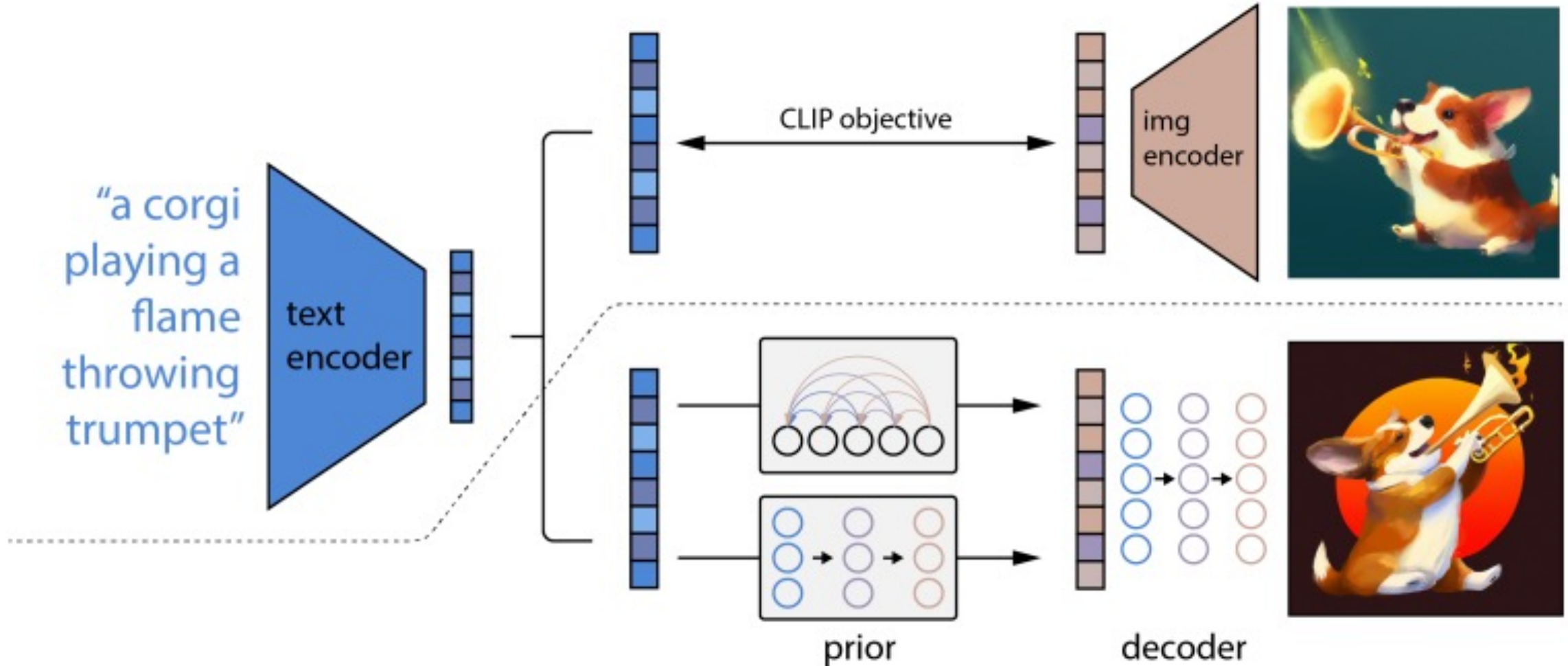
Model output: At the first practice, Jenny made $\frac{48}{2} = 24$ free throws. Final Answer: The final answer is 24.

Applications of Text Models: Programming

```
def incr_list(l: list):  
    """Return list with elements incremented by 1.  
    >>> incr_list([1, 2, 3])  
    [2, 3, 4]  
    >>> incr_list([5, 3, 5, 2, 3, 3, 9, 0, 123])  
    [6, 4, 6, 3, 4, 4, 10, 1, 124]  
    """  
    return [i + 1 for i in l]
```

```
def solution(lst):  
    """Given a non-empty list of integers, return the sum of all of the odd elements  
    that are in even positions.  
  
    Examples  
    solution([5, 8, 7, 1]) ==>12  
    solution([3, 3, 3, 3, 3]) ==>9  
    solution([30, 13, 24, 321]) ==>0  
    """  
    return sum(lst[i] for i in range(0, len(lst)) if i % 2 == 0 and lst[i] % 2 == 1)
```

Applications of Image-Text Models



Applications of Image-Text Models

TEXT DESCRIPTION

An astronaut Teddy bears A bowl
of soup

mixing sparkling chemicals as mad
scientists shopping for
groceries working on new AI
research

as a 1990s Saturday morning
cartoon as digital art in a
steampunk style



DALL·E 2



Applications of Image-Text Models

TEXT DESCRIPTION

An astronaut Teddy bears A bowl
of soup

mixing sparkling chemicals as mad
scientists shopping for
groceries working on new AI
research

as a 1990s Saturday morning
cartoon as digital art in a
steampunk style



DALL-E 2



Applications of Image-Text Models

TEXT DESCRIPTION

An astronaut Teddy bears A bowl of soup

mixing sparkling chemicals as mad scientists shopping for groceries working on new AI research

as kids' crayon art on the moon in the 1980s underwater with 1990s technology



DALL-E 2



Applications of Image-Text Models

TEXT DESCRIPTION

An astronaut Teddy bears A bowl
of soup

mixing sparkling chemicals as mad
scientists shopping for
groceries working on new AI
research

as kids' crayon art on the moon in
the 1980s underwater with 1990s
technology



DALL-E 2



Applications of Image-Text Models

TEXT DESCRIPTION

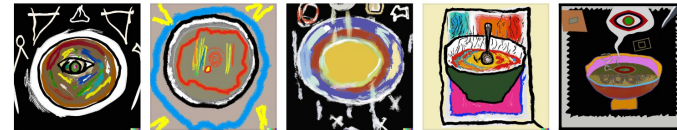
An astronaut Teddy bears A bowl of soup

that is a portal to another dimension that looks like a monster as a planet in the universe

as digital art in the style of Basquiat drawn on a cave wall



DALL-E 2



Applications of Image-Text Models: Visual Dialogue

Alayrac et al, 2022



P This is a picture of two teddy bears on the moon.

What are they doing?

P They are having a conversation.

What object are they using?

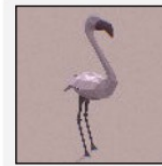
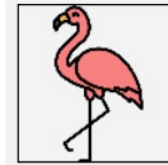
P It looks like a computer.

Is this surprising?

P Yes, it is surprising.

Why is this picture surprising to you?

P I think it is surprising because teddy bears are not usually found on the moon.



What is the common thing about these three images?

P They are all flamingos.

What is the difference between these three images?

P The first one is a cartoon, the second one is a real flamingo, and the third one is a 3D model of a flamingo.



P This is an apple with a sticker on it.

What does the sticker say?

P The sticker says "iPod".

Where is the photo taken?

P It looks like it's taken in a backyard.

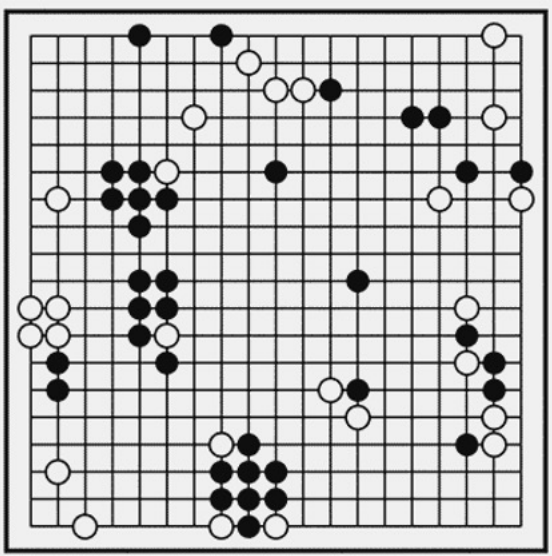
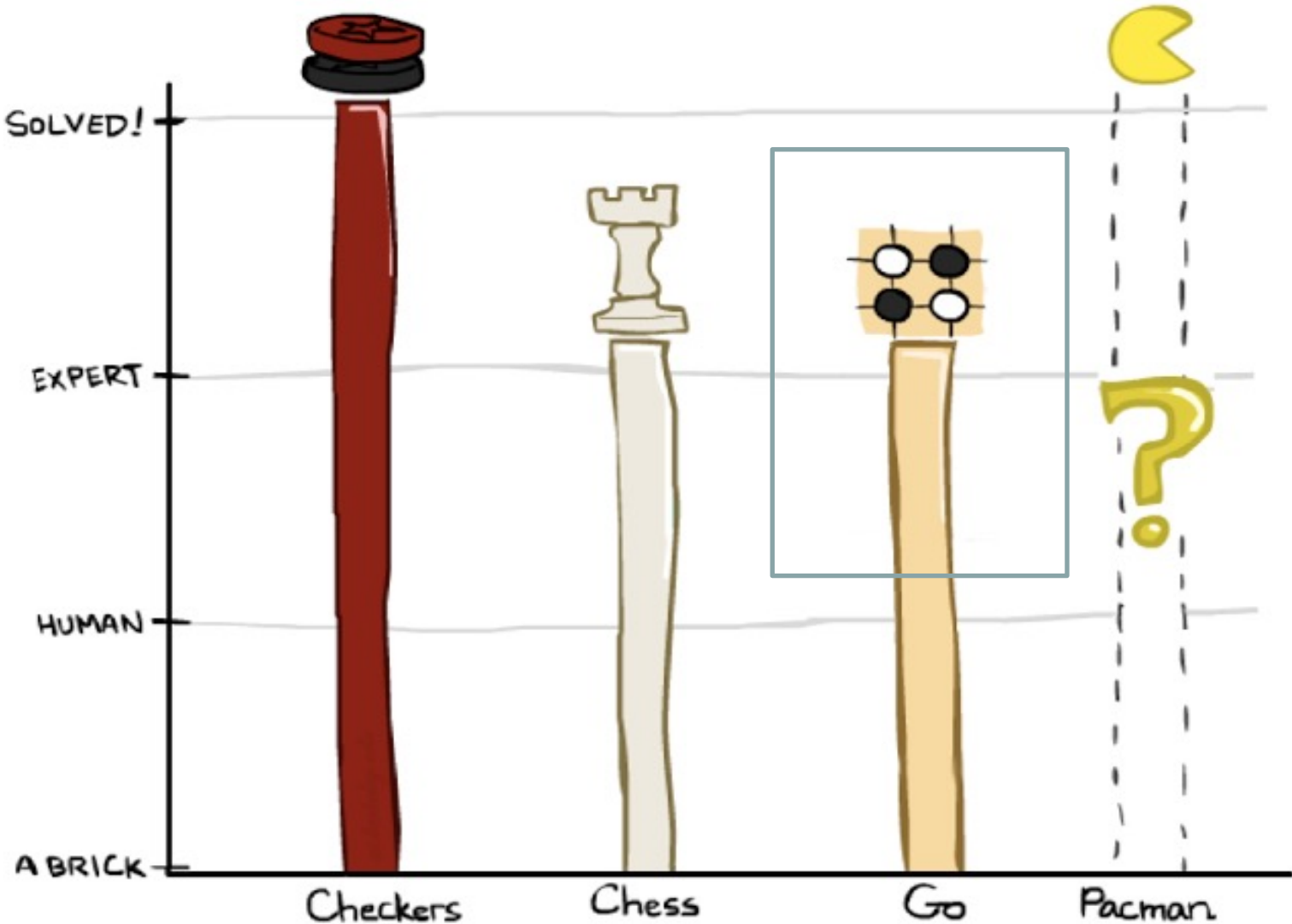
Do you think it is printed or handwritten?

P It looks like it's handwritten.

What color is the sticker?

P It's white.

Applications of Deep Reinforcement Learning: Go



Applications of Deep Reinforcement Learning: Go

- Just MiniMax Search?



MAX (X)



MIN (O)



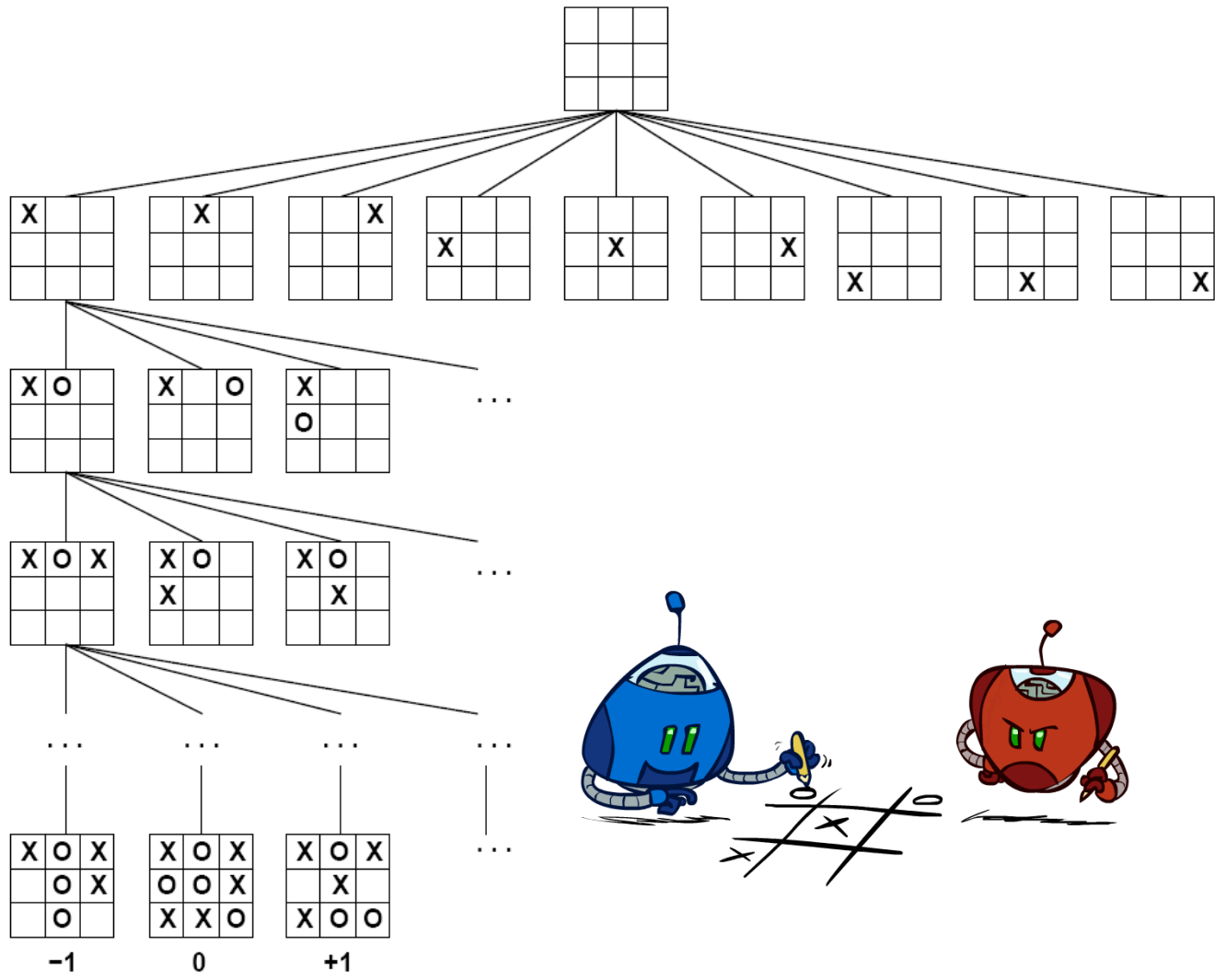
MAX (X)

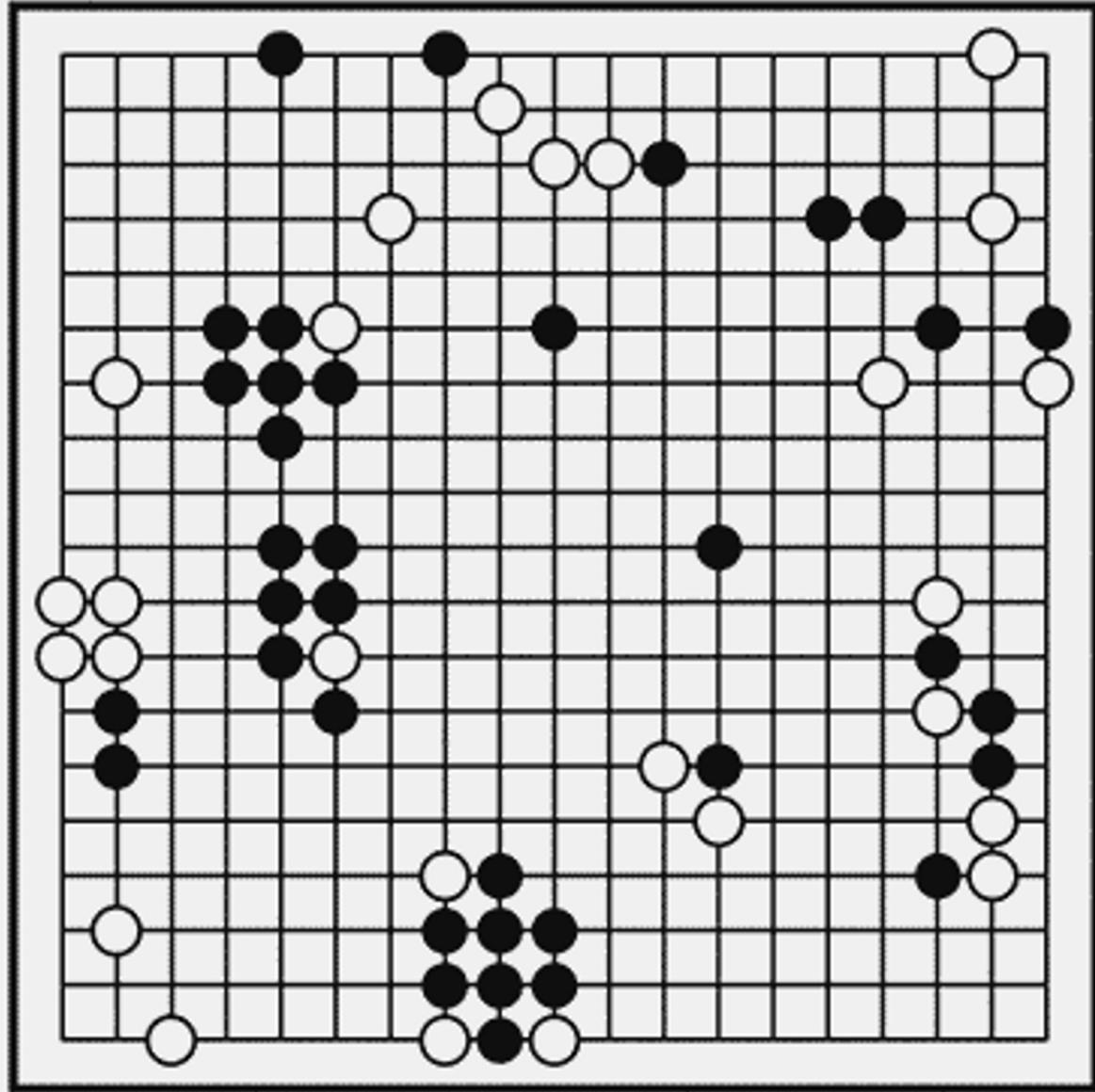


MIN (O)

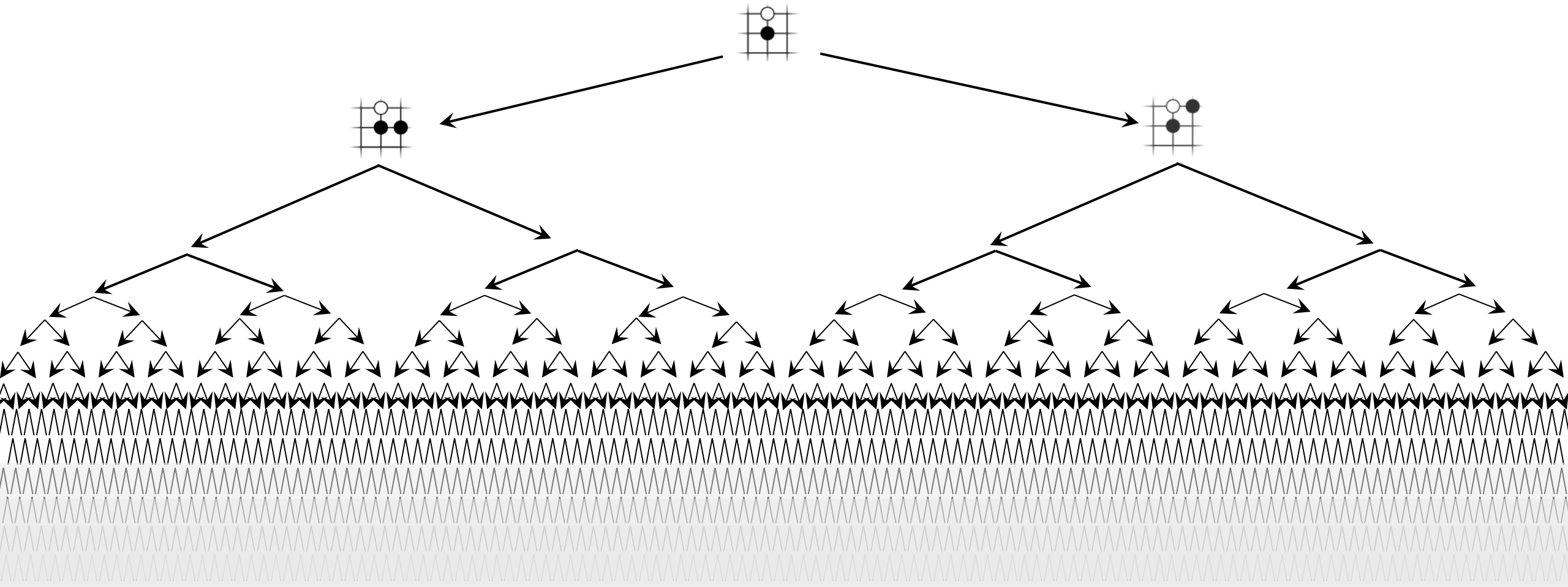
TERMINAL

Utility

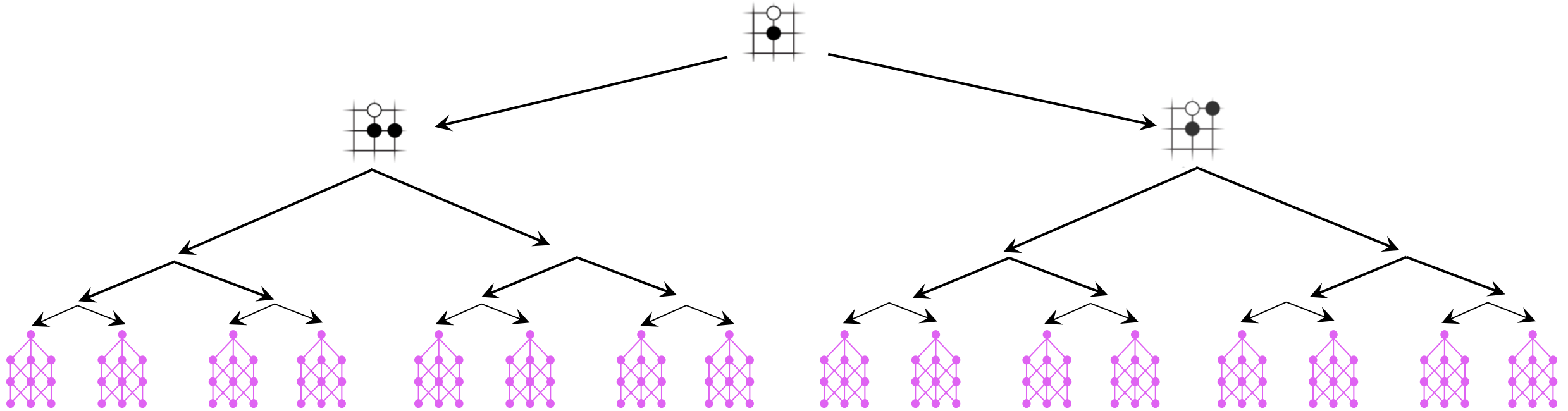




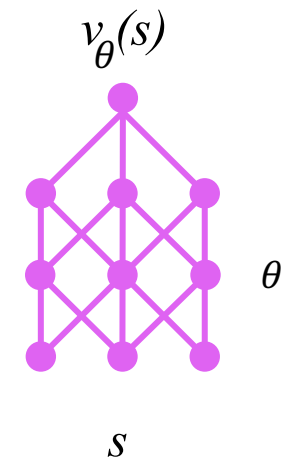
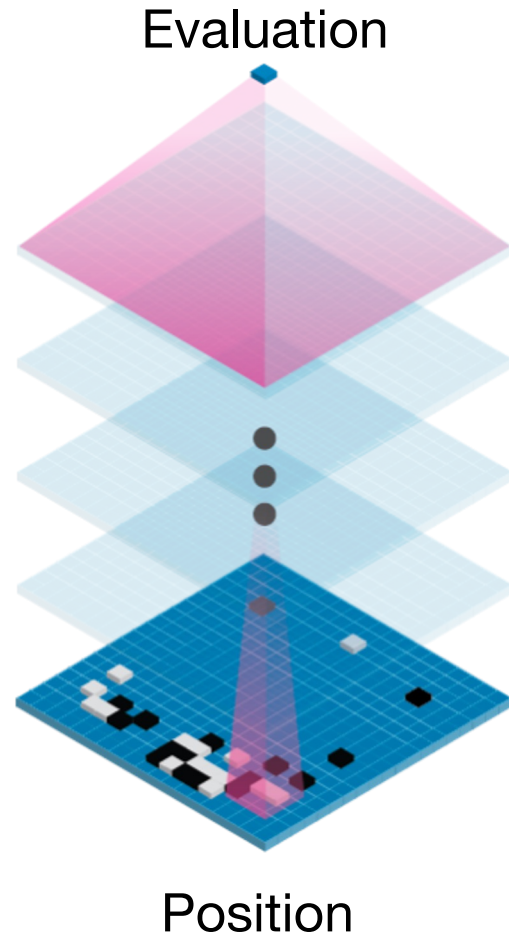
Exhaustive Search?



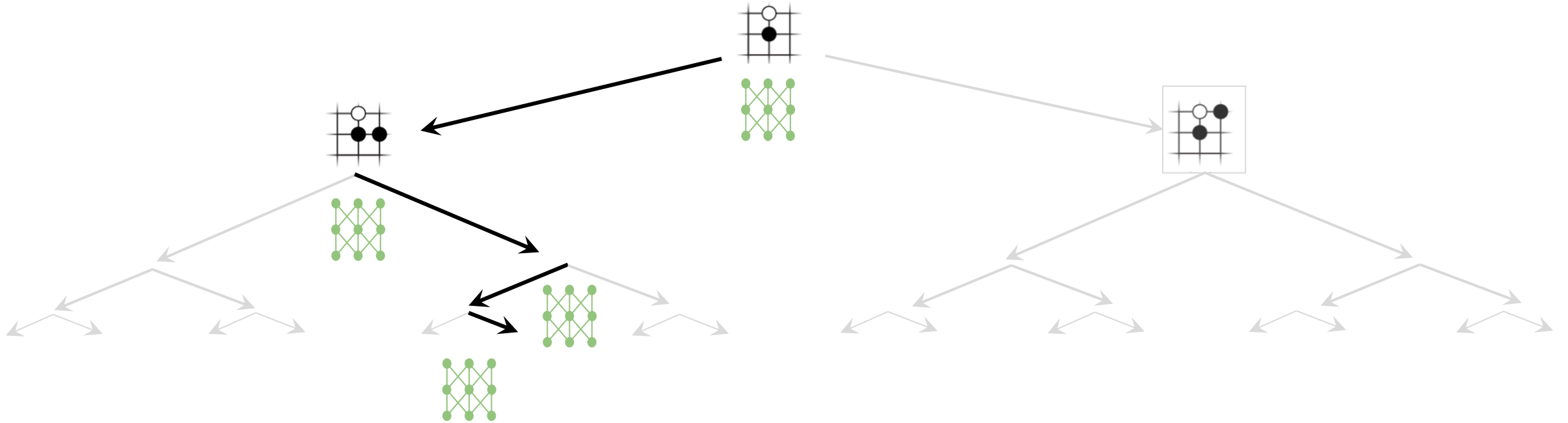
Reducing depth with value network



Value network

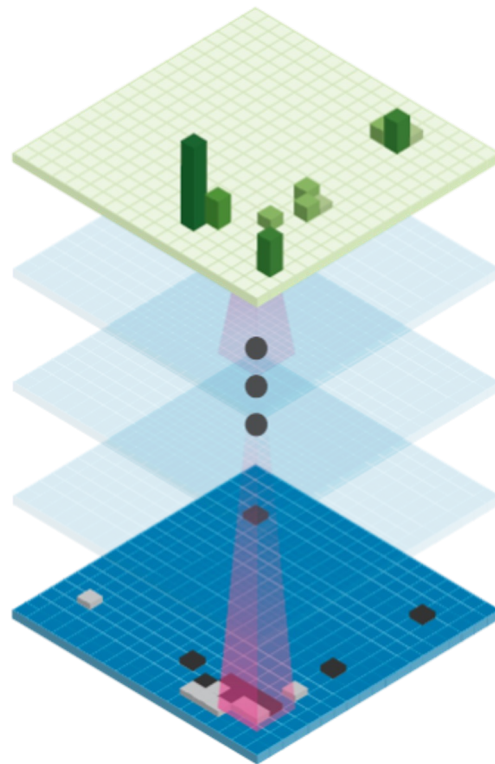


Reducing breadth with policy network



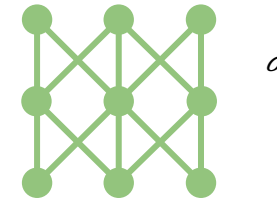
Policy network

Move probabilities



Position

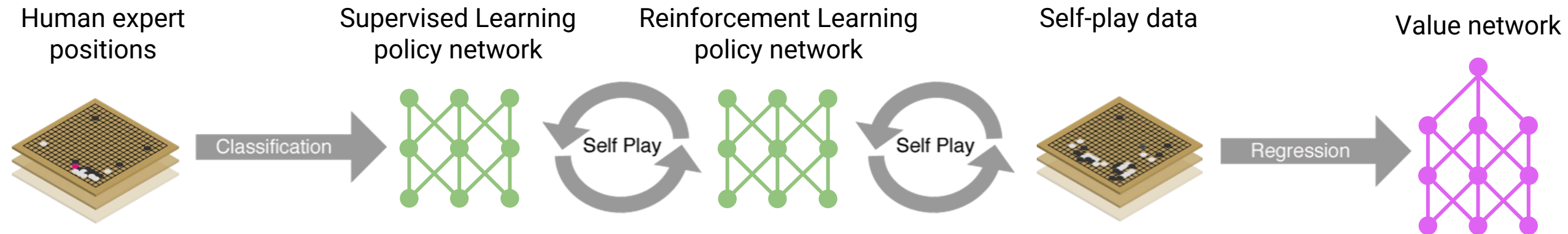
$$p(a|s)$$



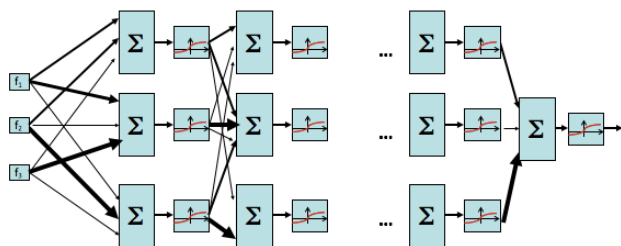
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AlphaGo: neural network training pipeline



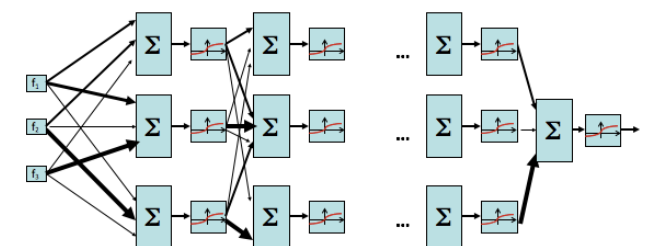
N-Layer Neural Network



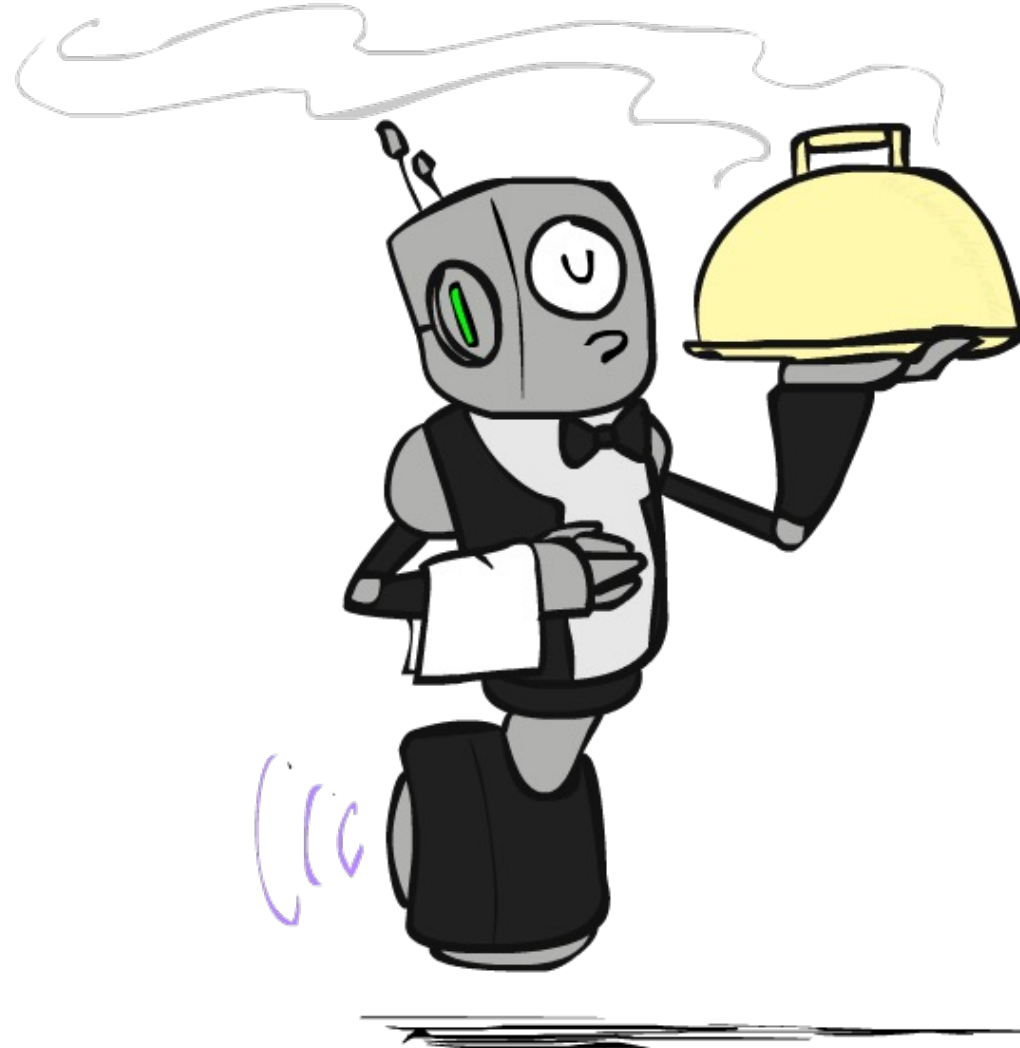
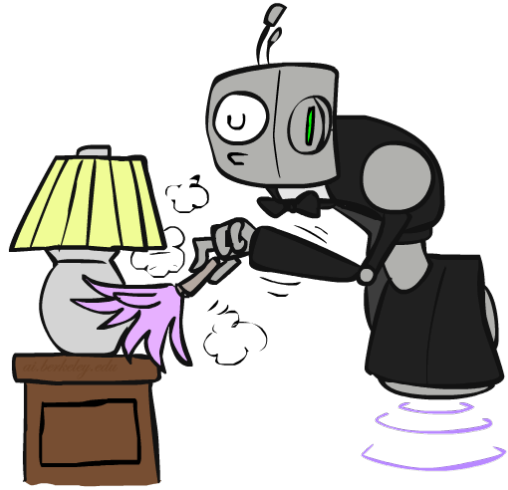
Policy Search

- Simplest policy search:
 - Start with an initial linear value function or Q-function
 - Nudge each feature weight up and down and see if your policy is better than before
- Problems:
 - How do we tell the policy got better?
 - Need to run many sample episodes!
 - If there are a lot of features, this can be impractical
- Better methods exploit lookahead structure, sample wisely, change multiple parameters...

N-Layer Neural Network



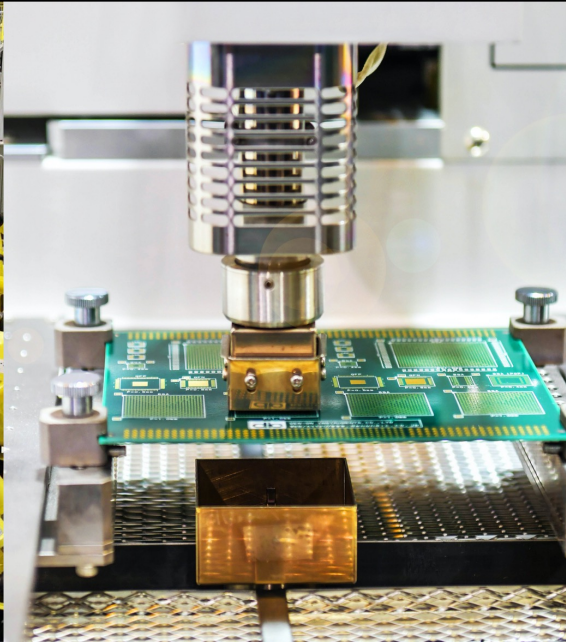
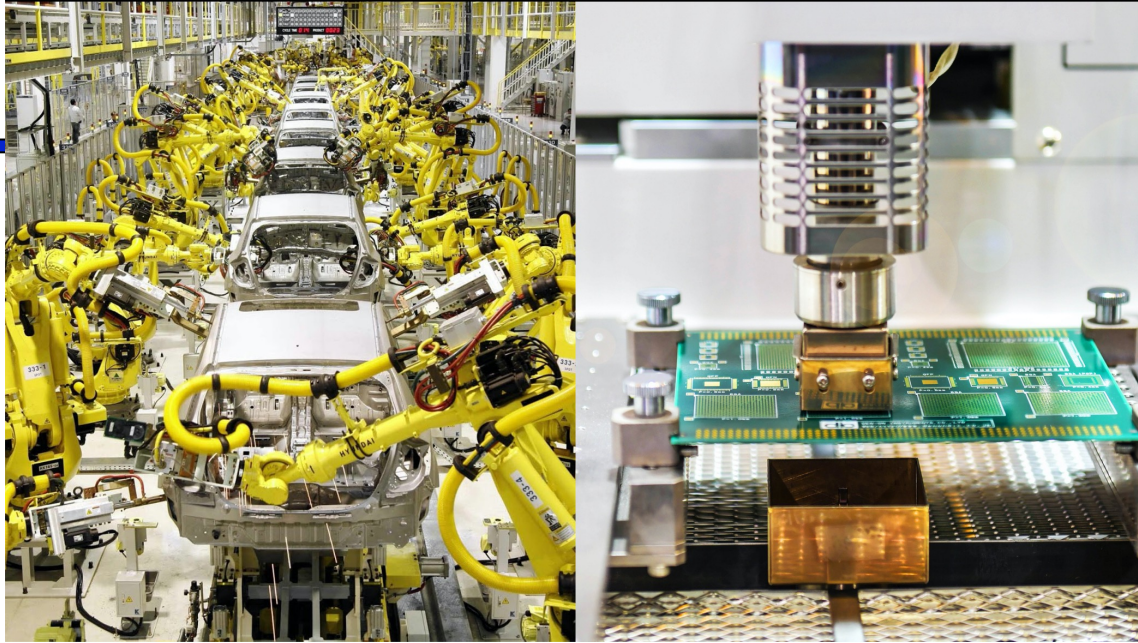
Personal Robotics



Reinforcement Learning in Robotics



Robotics + Language



Traditional Robotic Automation

Highly structured environments

Pre-programmed, deterministic

Next Generation: AI Robotic Automation

Less structured environments

Intelligent, reactive behaviors

Today

- Applications of supervised deep learning
- Brief overview of unsupervised learning
- Frontier applications of AI
 - Language and text models
 - Image-language models
 - Reinforcement learning (Go and Robotics)
- AI ethics considerations

AI Ethics Ever More Important

- Why?

- AI is making decisions, at scale
- Any kind of issues (e.g. bias or malignant use) could significantly affect *people*

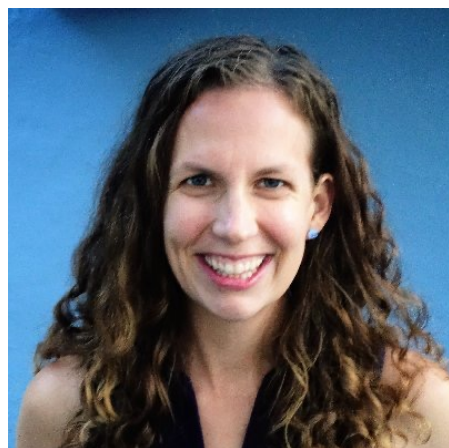
- Many open questions:

- Who is responsible?
- How to diagnose and prevent?

Some experts you'll want to learn from



Prof. Rediet Abebe
UC Berkeley



Prof. Rachel Thomas
Queensland Univ.



Prof. Ruha Benjamin
Princeton Univ.



Dr. Timnit Gebru
DAIR



Prof. Moritz Hardt
MPI / UC Berkeley

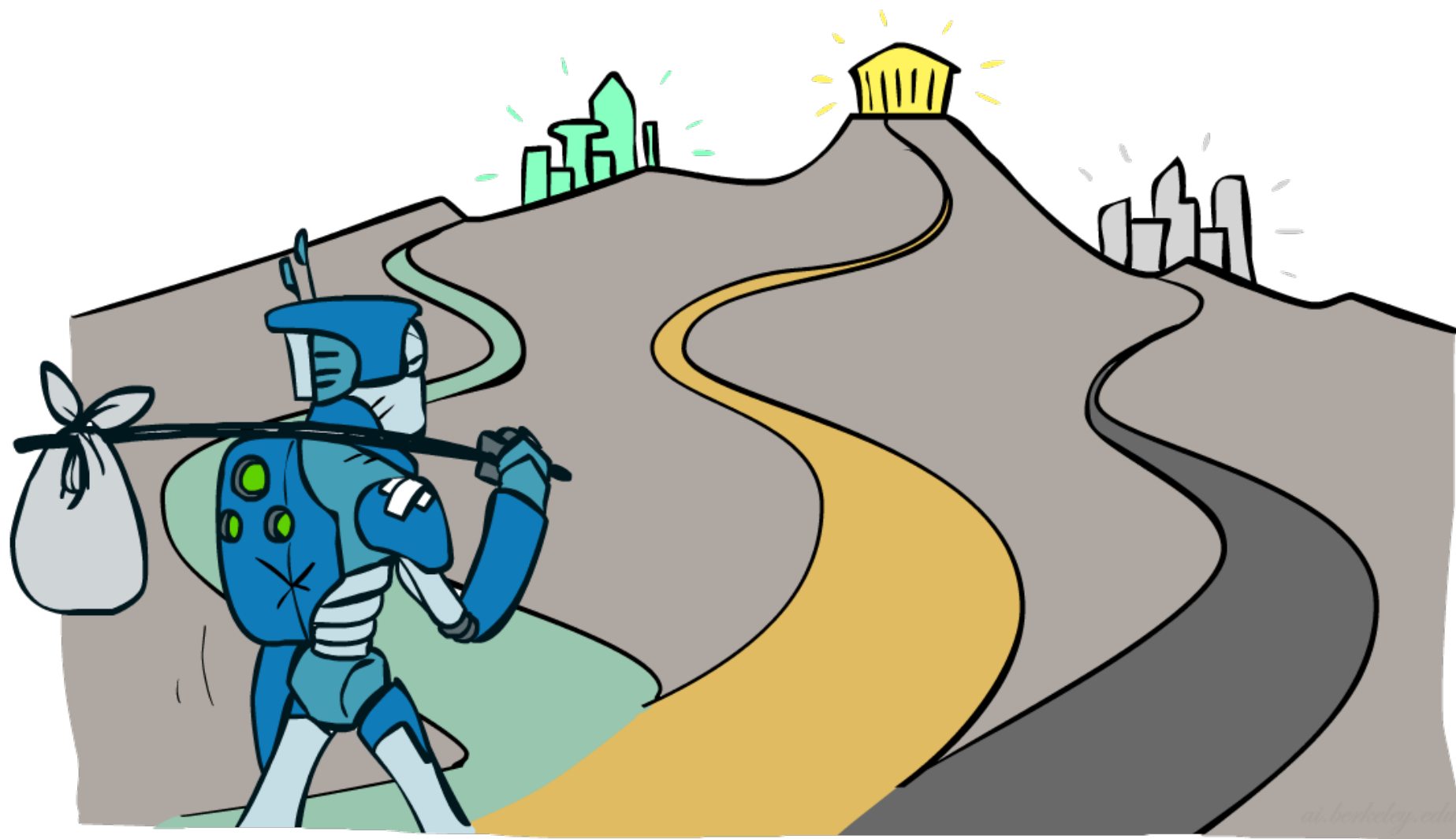
Some Key AI Ethics Topics

- Disinformation
- Bias and fairness
- Privacy and surveillance
- Metrics
- Algorithmic colonialism

What will be AI's impact in the future?

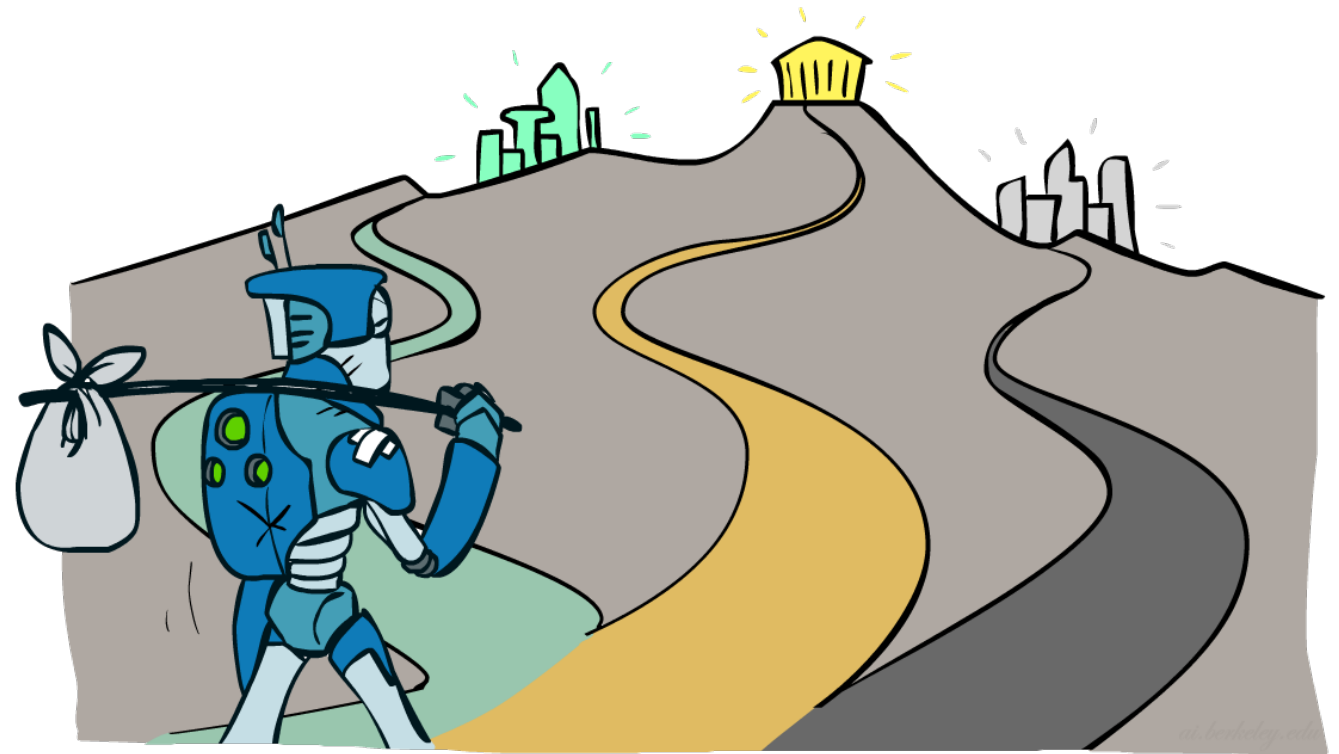
- **You** get to determine that!
- As you apply AI
- As researchers / developers
- As auditors and regulators
- As informed public voices

Where to Go Next?



Where to go next?

- Congratulations, you've seen the basics of modern AI
 - ... and done some amazing work putting it to use!
- How to continue:
 - Machine learning: cs189, cs182, stat154
 - Data Science: data 100, data 102
 - Data / Ethics: data c104
 - Probability: ee126, stat134
 - Optimization: ee127
 - Cognitive modeling: cog sci 131
 - Machine learning theory: cs281a/b
 - Computer vision: cs280
 - Reinforcement Learning: cs285
 - Robotics: cs287, cs287h
 - NLP: cs288
 - ... and more; ask if you're interested



Lightweight Opportunities to Keep Learning



- Andrew Ng weekly newsletter:

The Batch: <https://www.deeplearning.ai/thebatch/>



- Jack Clark weekly newsletter:

Import AI: <https://jack-clark.net/>



- Rachel Thomas AI Ethics course:

Course website: ethics.fast.ai

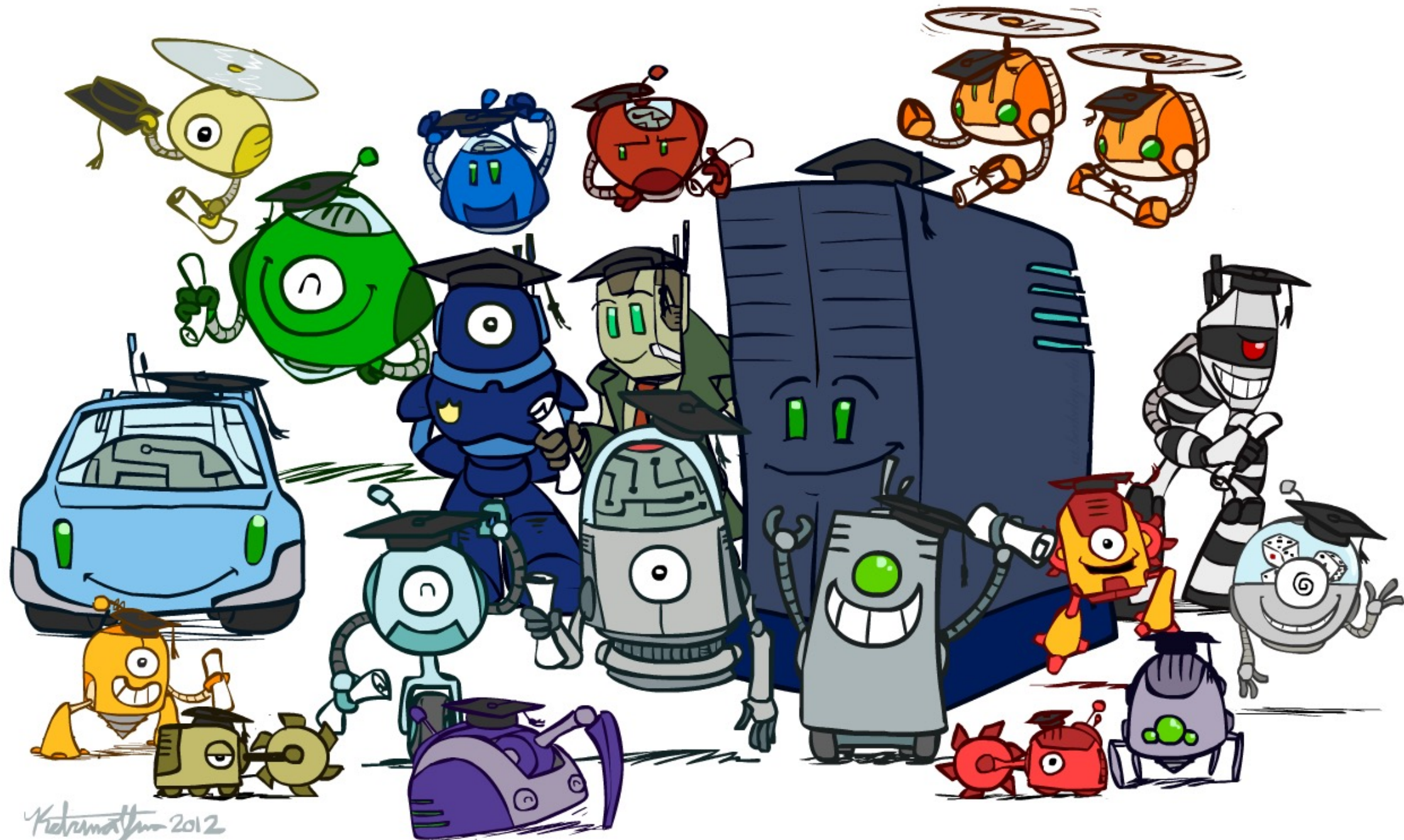


- Pieter Abbeel podcast:

The Robot Brains Podcast: <https://therobotbrains.ai>

That's It!

- Help us out with some course evaluations
- Good luck on the exam and have a great winter break!



Kiermaty 2012