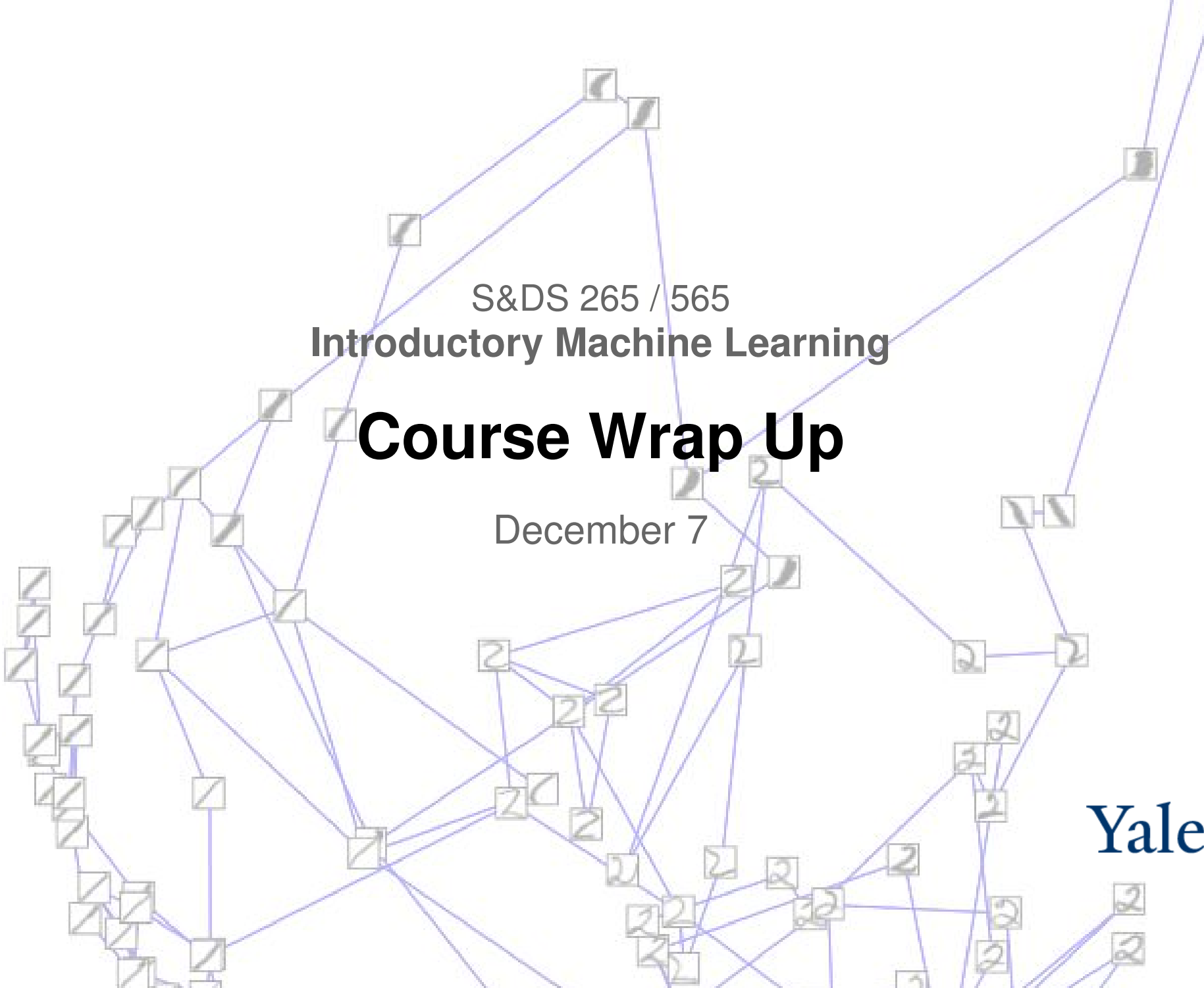


S&DS 265 / 565

Introductory Machine Learning

Course Wrap Up

December 7

Yale

Endgame

- Quiz 6 open today at 1pm; closes Friday at 6pm
- Final exam: Friday, Dec 15 at 2pm in SSS 114
- Practice exams posted
- Review sessions:
  - Regina: Wednesday (Dec 13): 5-7pm Bass L73
  - Kaylee: Thursday: (Dec 14) 5-7pm KT 211
  - Hannah: Thursday: (Dec 14) 7-9pm KT 211

Last unit: Language/Sequence models

- Generative process, any sequence (of words, characters, stock prices, nucleotides...) is assigned a probability

$$p(x_1, \ldots, x_n)$$

which can be factored as

$$p(x_1, \ldots, x_n) = p(x_1)p(x_2 \mid x_1) \ldots p(x_n \mid x_1, \ldots, x_{n-1})$$

Transformers

The current state-of-the-art is based on *transformers*

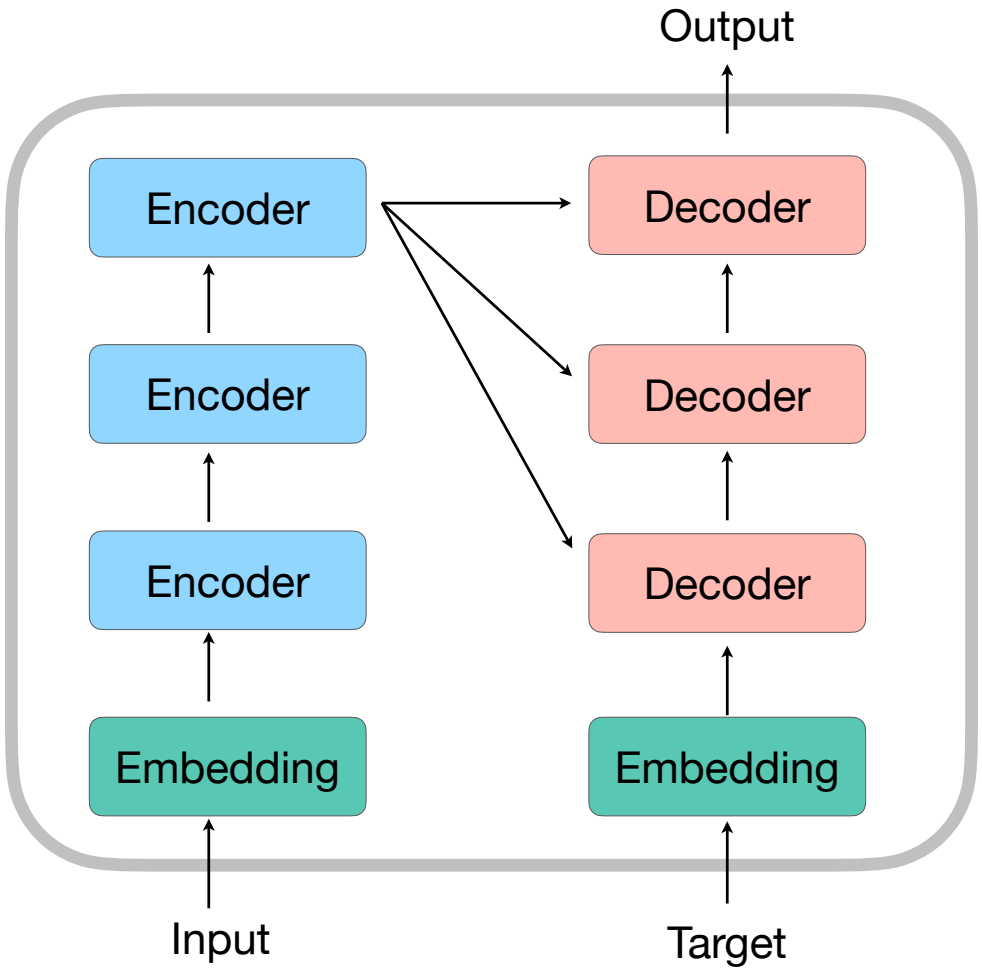
- Attention is the key ingredient
- Rather than processing sequences word-by-word, transformers handle larger chunks of text at once
- Incorporate “interactions” between words and hidden states

Transformer architecture

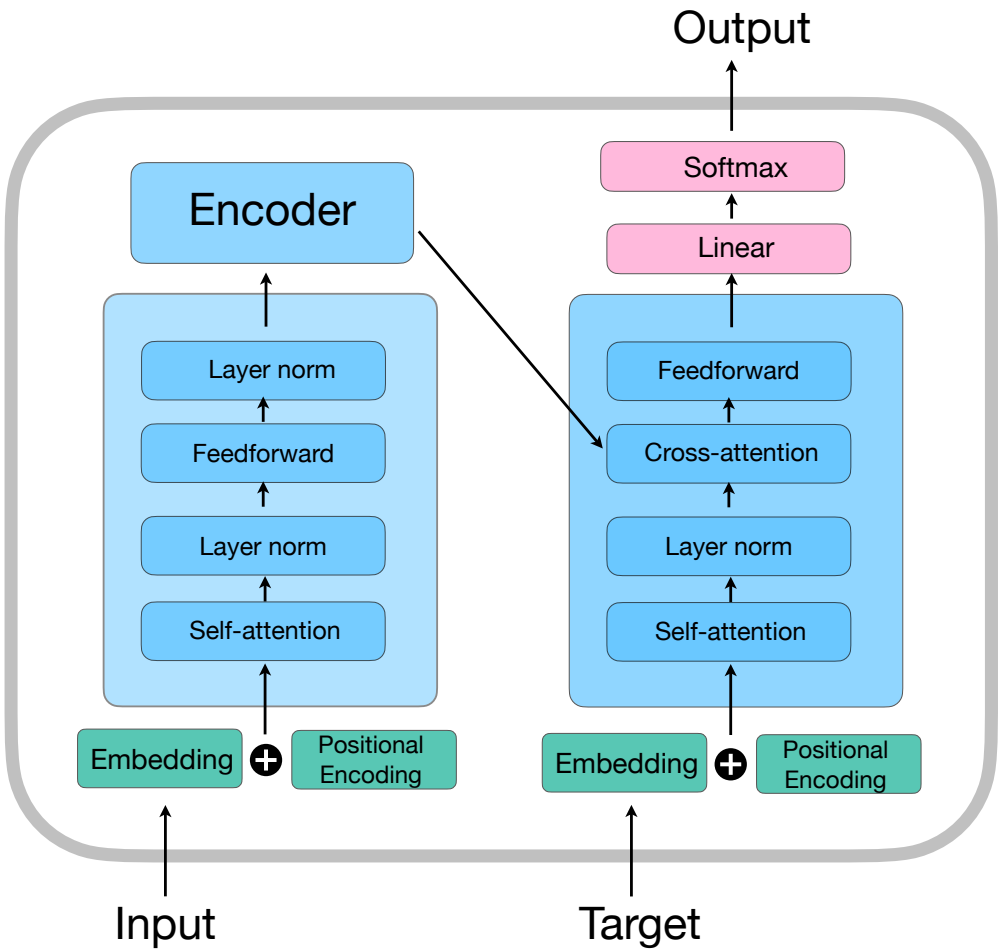
A Transformer is a seq2seq model based on encoder and decoder modules.

Transformers are powerful alternatives to RNNs that transform the encoder/decoder states using (multi-head) attention mechanisms.

Transformer architecture

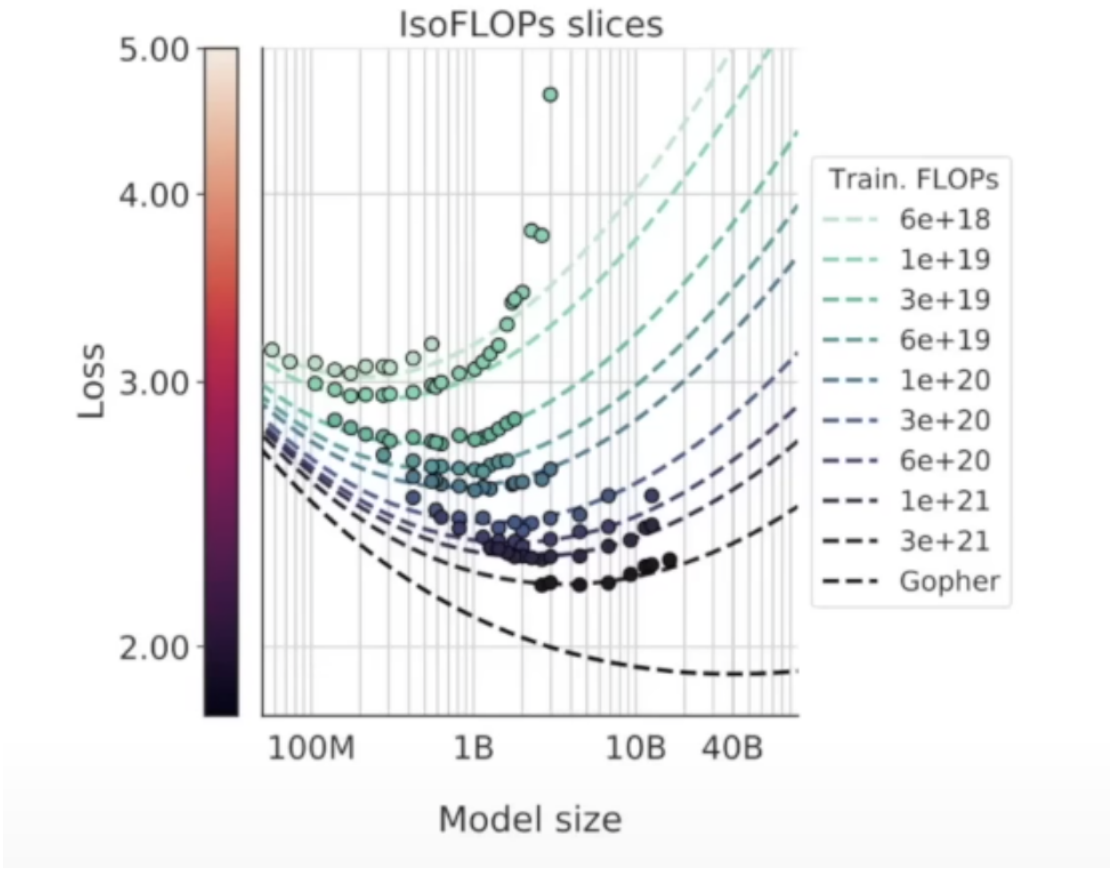


Transformer architecture



Two encoder layers and one decoder layer

LLM scaling laws: Bigger is better

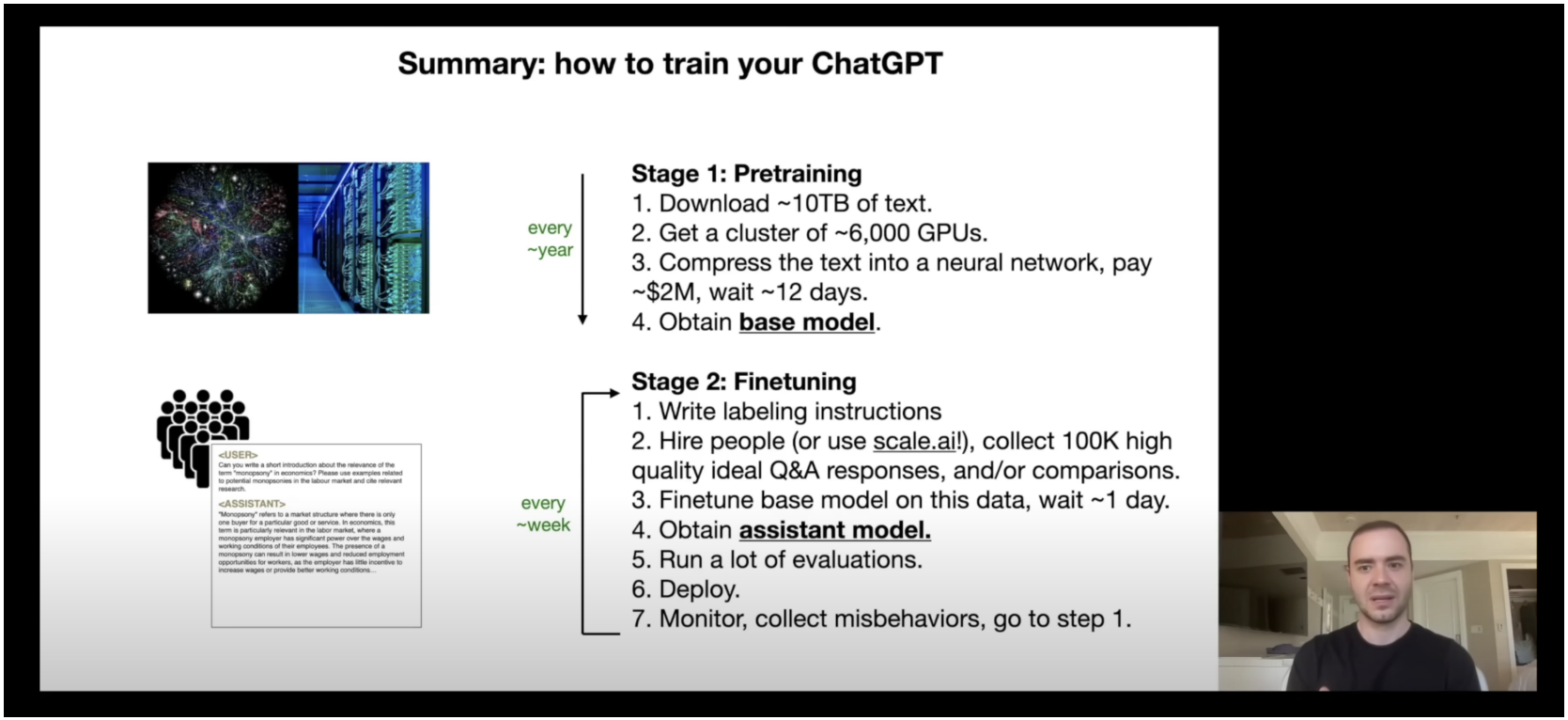


https://www.youtube.com/watch?v=zjkBMFhNj_g&t=25m40s

Finetuning (Training an LLM Decoder)

- An incredible amount of knowledge is stored implicitly in the weights of the transformer
- To be made useful, supervised learning and reinforcement learning are used to teach the model how to respond

Finetuning



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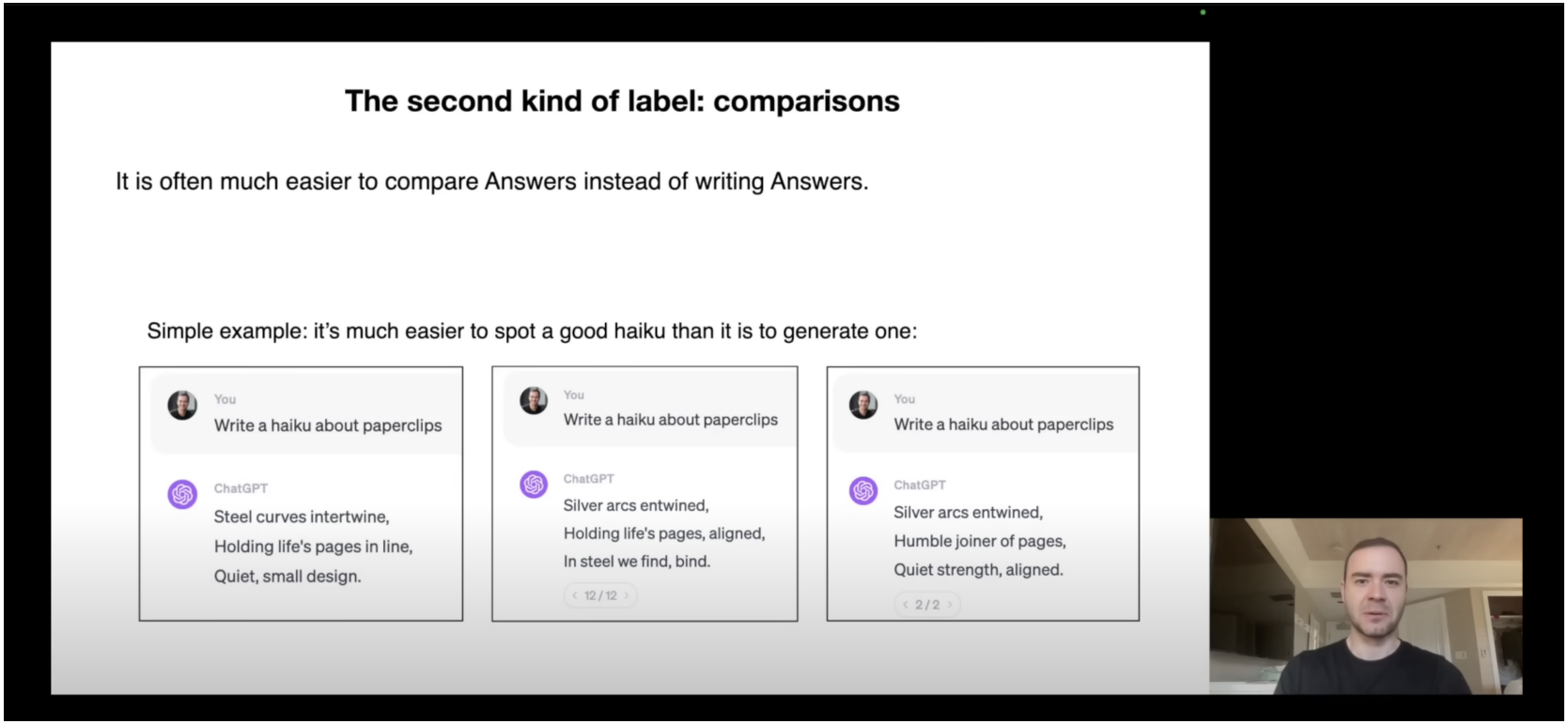
Finetuning

RLHF



https://www.youtube.com/embed/zjkBMFhNj_g?start=1277&end=1340

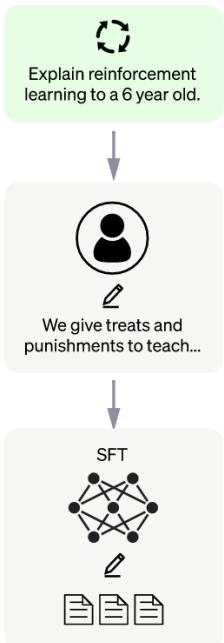
Step 1

Collect demonstration data and train a supervised policy.

A prompt is sampled from our prompt dataset.

A labeler demonstrates the desired output behavior.

This data is used to fine-tune GPT-3.5 with supervised learning.



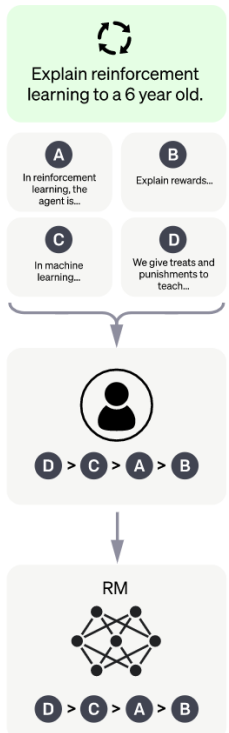
Step 2

Collect comparison data and train a reward model.

A prompt and several model outputs are sampled.

A labeler ranks the outputs from best to worst.

This data is used to train our reward model.



Step 3

Optimize a policy against the reward model using the PPO reinforcement learning algorithm.

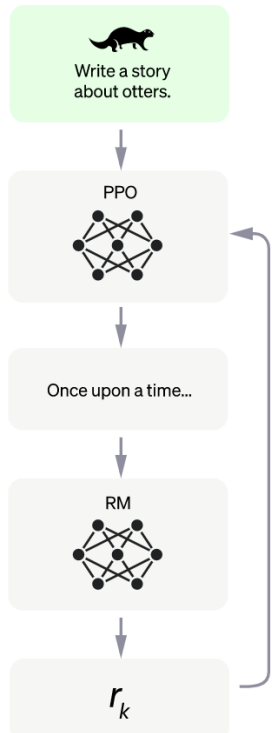
A new prompt is sampled from the dataset.

The PPO model is initialized from the supervised policy.

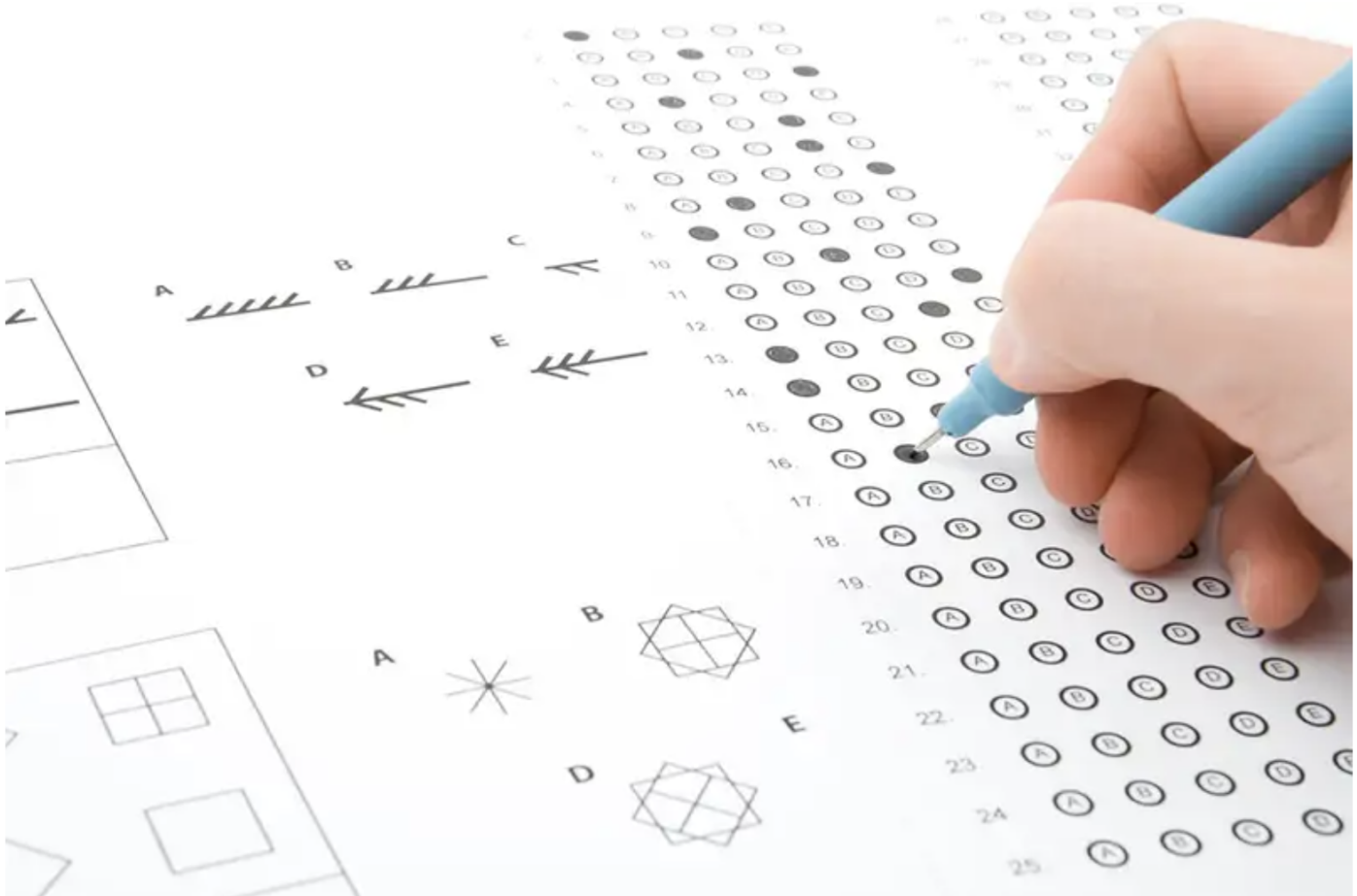
The policy generates an output.

The reward model calculates a reward for the output.

The reward is used to update the policy using PPO.



What’s next?: Fast learning, slow thinking



AI struggles with IQ tests
Panther Media GmbH / Alamy Stock Photo

Always news—on both sides

The Economist

Menu | Weekly edition | The world in brief | Search

Science and technology | Crystal balls

A Google AI has discovered 2.2m materials unknown to science

Zillions of possible crystals exist. AI can help catalogue them

Just one of trillions IMAGE: SCIENCE PHOTO LIBRARY

Nov 29th 2023

Save | Share | Give

Always news—on both sides

The Economist

Menu | Weekly edition | The world in brief | Search

Business | Of evils and evals

The world wants to regulate AI, but does not quite know how

There is disagreement over what is to be policed, how and by whom

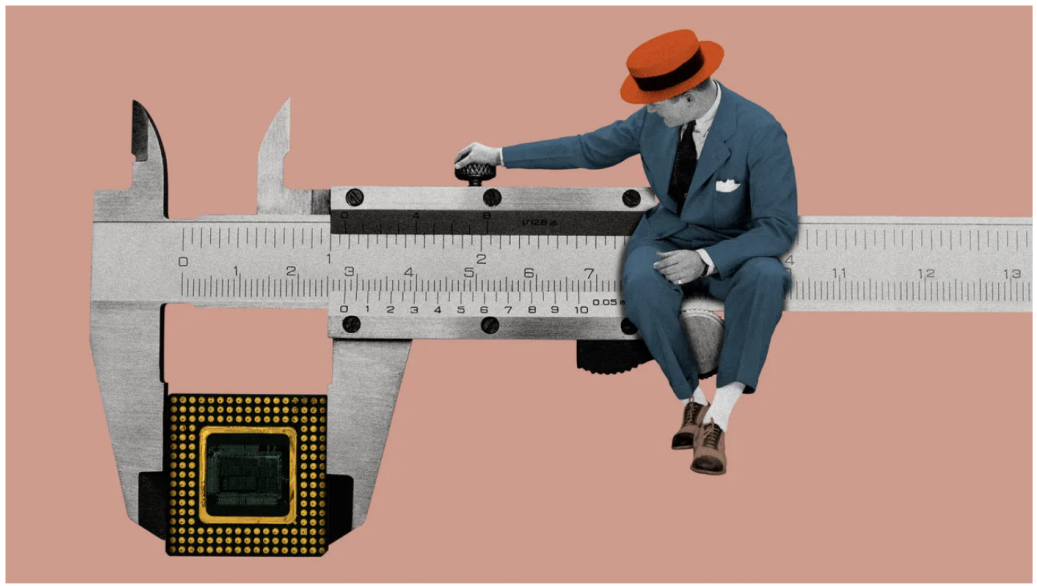


IMAGE: MARI FOUZ

Oct 24th 2023 | BLETCHLEY PARK

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Advancing ML: Something for everyone

- Designing new methods
- Applying to new domains
- Solving deep mathematical puzzles
- Tackling unique engineering challenges
- Designing interfaces
- Collecting data
- Equitable use through policy and law
- Outreach and communication to broad communities

We've covered a lot of ground!

Calendar Fall 2023

Lectures: Tuesday/Thursday 11:35-12:50pm
Davies Auditorium

Complementary readings marked ISL refer to sections in the book An Introduction to Statistical Learning (Python version, July 2023). Assignments and quizzes are posted and due on Thursday in a given week.

Week	Dates	Topics	Demos & Tutorials	Lecture Slides	Readings and Notes	Assignments & Exams
1	Aug 31	Course overview		Thu: Course overview		
2	Sept 5, 7	Python and background concepts	Python elements Covid trends	Tue: Python elements Thu: Pandas and linear regression	Data8 Chapters 3, 4, 5	Quiz 1 Assn 1 out
3	Sept 12, 14	Linear regression and classification	Covid trends (revisited) Classification examples	Tue: Regression concepts Thu: Classification	ISL Sections 3.1, 3.2, 3.5 Notes on regression ISL Sections 4.3, 4.4 Notes on classification	
4	Sept 19, 21	Stochastic gradient descent	SGD examples	Tue: Classification (continued) Thu: Stochastic gradient descent	ISL Section 6.2.2 ISL Section 10.7.2	Assn 1 in Assn 2 out

We've covered a lot of ground!

5	Sept 26, 28	Bias and variance, cross-validation	Bias-variance tradeoff Covid trends (revisited) California housing	Tue: Bias and variance Thu: Cross-validation	ISL Section 2.2 ISL Section 5.1	Quiz 2
6	Oct 3, 5	Tree-based methods and principal components	Trees and forests Visualizing trees PCA examples	Tue: Trees and Forests Thu: PCA	ISL Sections 8.1, 8.2 ISL Section 12.2	Assn 2 in Assn 3 out
7	Oct 10, 12	PCA and dimension reduction	PCA revisited Used for dimension reduction Word embeddings	Tue: PCA and word embeddings Thu: Embeddings and review	ISL Section 12.2	Quiz 3
8	Oct 17	Midterm exam (in class)			On Canvas: Practice midterms / Sample solns Midterm / Sample soln	

We've covered a lot of ground!

10	Oct 31, Nov 2	Topic models, introduction to neural networks	Sanity check Minimal neural network Regression examples	Tue: Topic models Thu: Neural networks	ISL Sections 10.1, 10.2	Quiz 4
11	Nov 7, 9	Neural networks, reinforcement learning	Q-learning	Tue: Neural networks Thu: Reinforcement learning	Notes on backpropagation	Assn 4 in Assn 5 out
12	Nov 14, 16	Deep neural networks	Tensorflow playground Autoencoder examples	Tue: Deep reinforcement learning Thu: Deep networks and autoencoders	ISL Section 10.7	Quiz 5
13	Nov 21, 23	No class, Thanksgiving break				

We’ve covered a lot of ground!

14	Nov 28, 30	Transformers and ChatGPT	GPT-4 Python API	Tue: Autoencoders and transformers Thu: Transformers (continued)		
15	Dec 5, 7	Societal issues for machine learning		Tue: Panel discussion Thu: Course wrap up		Assn 5 in Quiz 6
16	Fri, Dec 15, 2pm, SSS 114	Final exam			Registrar: Final exam schedule Practice finals	

Final exam

- Final exam Friday, Dec 15, 2023 at 2pm in SSS 114
- `https://registrar.yale.edu/general-information/final-exams`
- Review sessions (see times/dates above)
- Length: About 1.5X Midterm
- Emphasis on material after midterm
- Cumulative, closed book, cheat-sheet

Your input

- Please complete a course review!
- I greatly value your comments and feedback
- Feel free to send me comments privately
- Let me know how you use and continue to learn ML!

Thank you!