fun-ai-talk

A Glimpse Into LLM, RL and ChatGPT

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April 2023

Agenda today

- First Hour
  - Large Language Model (LLM) Foundation
  - Reinforcement Learning (RL) Essentials
  - ChatGPT Unveiled
  - ChatGPT-like AI Frontier Applications
  - Societal Impacts
  - Q&A
- Next Half Hour
  - More discussion

Disclaimer

- This talk is my personal voluntary effort, prepared and conducted during my personal time outside of working hours.

- All content is derived from publicly available sources, and the views expressed herein only represent my personal opinions, and do not reflect the positions of DeepMind®, Google®, or Alphabet®

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April 2023

About me



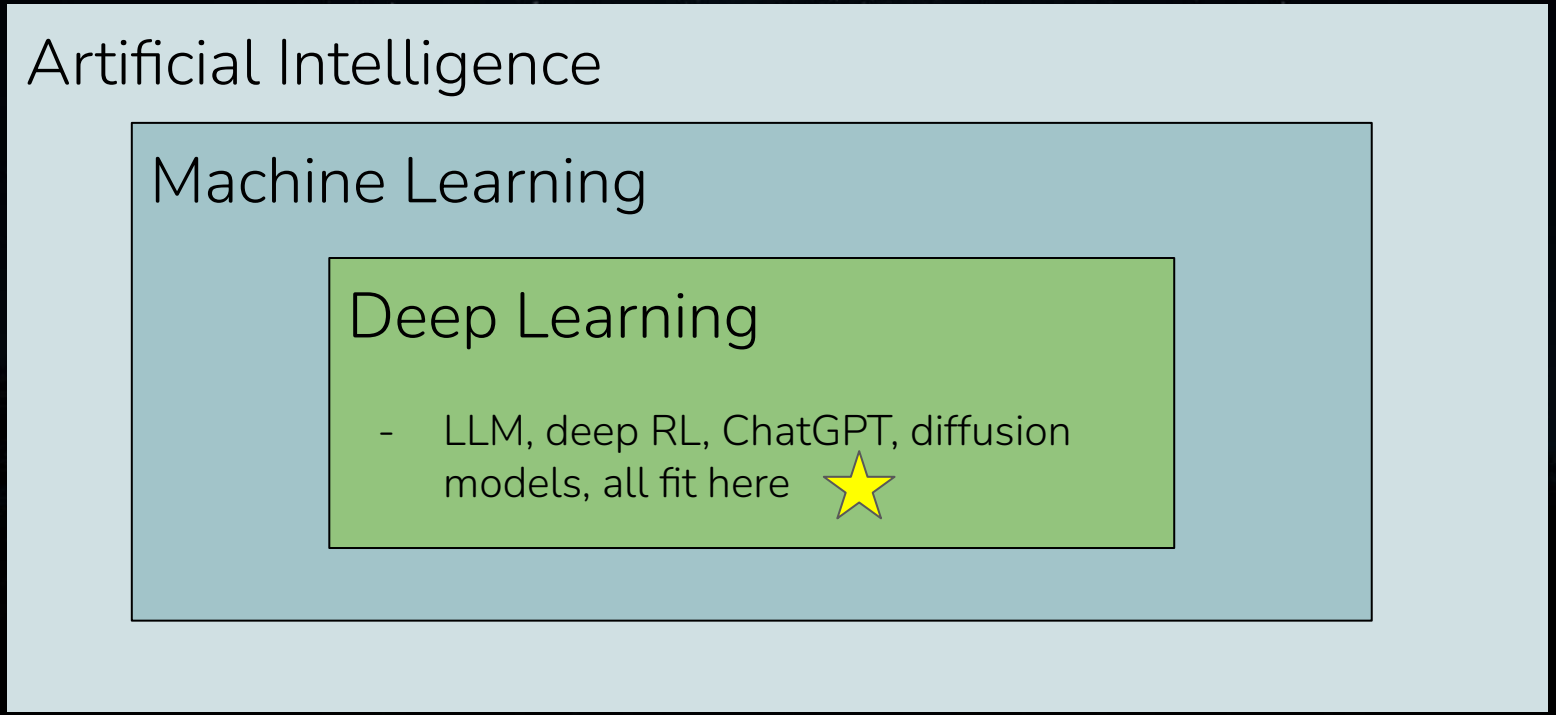



Student | Intern | Software Eng | Research Eng

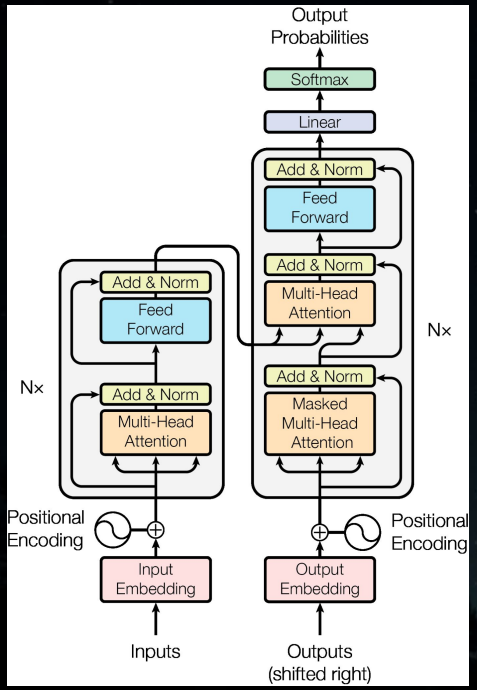
Accessibility | Engineering | Data Science | Deep Learning

LLM Foundation: Deep Learning and Transformer-based LLMs

AI, Machine Learning, and Deep learning



Modern LLM building blocks: Transformer Architecture



Transformer as dominating architecture for NLP since 2018

- Multi-head attention
- Encoder-Decoder
- Embedding layers
- Positional encoding
- Cross-Attention in decoder layers
- Output Softmax

Note: Tokenization (e.g. wordpiece, sentencePiece, BPE) is needed (outside Transformer) to convert text to token ids

Note: Sometimes we call it XFormer since there are many variations to the original Transformer

Attention Is All You Need (Transformer paper) by Google | The Annotated Transformer by Harvard NLP | A Survey of Transformers by Fudan

Language Models (LM) and Large Language Models (LLM)

LM for understanding (*e.g. BERT*)

- Text in
- Embedding (numeric representation of understanding) out
  - The Embedding can be connected to other output heads for tasks like classification or regression

LM for generation (*e.g. GPT or T5* or OpenAI ChatGPT or Google Bard)

- Text in
- Text out

* In most cases, **LLM** refers to **huge** (e.g. >1B params) Deep Learning LM for **generation**

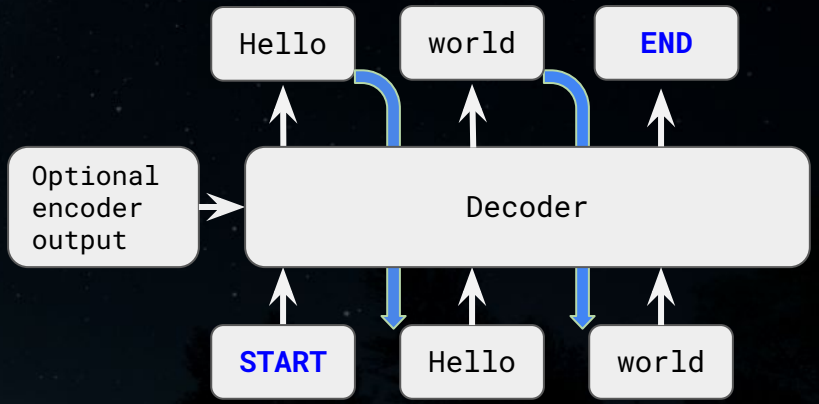
LLM Intro: Training Objectives for LLMs [in pretraining]?

- Fill the blanks (aka masks) for “Masked Language Models” (e.g. BERT)
  - **Ground Truth:** “Paris is a beautiful city”
    - **X:** “Paris is a **[MASK]** city”
    - **Y:** “beautiful”
    - **Model:** “good”
    - **Optimize:** “good”👎 “beautiful”👍
- Predict the next text given prompt, for “Generative Language Models” (e.g. GPT)
  - **Aka Causal LM**
  - **Ground Truth:** “Paris is a **|** beautiful city”
    - **X:** “Paris is a”
    - **Y:** “beautiful”
    - **Model:** “good”
    - **Optimize:** “good”👎 “beautiful”👍
    - **X:** “Paris is a beautiful”
    - **Y:** “city”
    - **Model:** “place”
    - **Optimize:** “place”👎 “city”👍
- The “Self-supervised” Learning Paradigm
  - It is supervised (given x, predict y)
  - It does NOT require expensive human labels (more precisely, this statement is only true for pre-training)

Decoding/Generating Algorithms in Generative LLMs

Decode **token** by **token**, left to right. A new output token is appended as next token's decoder input

- Beam Search
  - Maintain a max size of searching "beams (paths)" to get best overall best beam
- Sampling
  - Sampling based on probabilities
- Greedy
  - Select the argmax(prob) token at every position
- Top-k, Top-p and more



https://huggingface.co/blog/how-to-generate

Quick Walkthrough of Selected LLMs

- Google BERT
- OpenAI GPT 1, 2, & 3
- Google T5
- Google LaMDA
- Google PaLM
- NVidia Megatron LM
- OpenAI WebGPT
- DeepMind Chinchilla
- Tsinghua Univ GLM 130B
- OpenAI InstructGPT (ChatGPT)
- Anthropic RLHF LLM and RLAIF LLM
- Facebook/Meta OPT
- Facebook/Meta LLaMA
- OpenAI GPT4 (eval report, no tech detail)
- BigScience bloom 176B
- Stanford Alpaca
- Baidu Ernie 3.0 Titan
- BloombergGPT 176B

Selected Important LLM concept

- Pretraining, finetuning, prompt engineering, prompt tuning
- Scaling laws
- Emergent Abilities
- Chain of Thoughts
- Hallucination

Check out this deck to include more LLM concepts and examples

Guess what current most powerful LLMs not so good at?

Selected Important LLM concept

- Pretraining, finetuning, prompt engineering, prompt tuning
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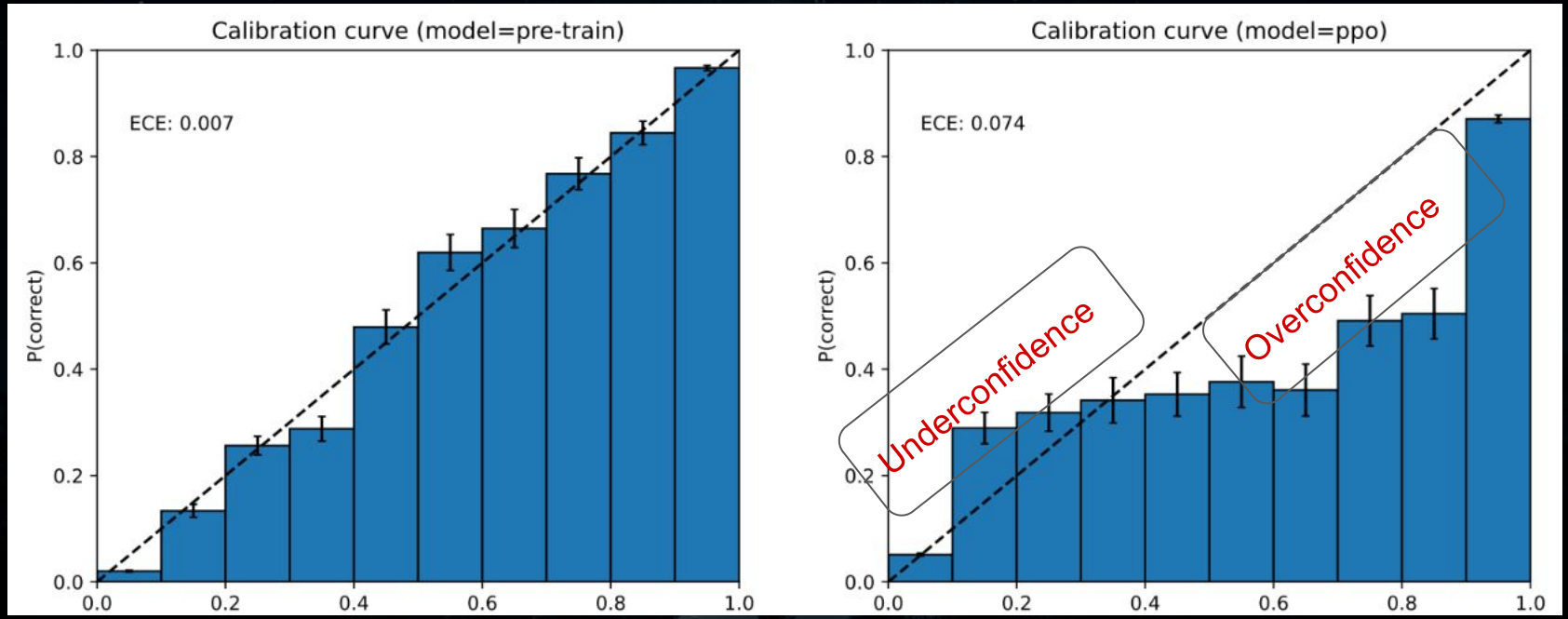
Guess what current most powerful LLMs not so good at?

- My personal take: “LLMs do not know what they do not know”

Re “LLMs do not know what they do not know”

Misaligned Calibration for GPT4 after RLHF (from GPT4 tech report)



Success of modern LLMs comes from

- ***Large Data:*** Common Crawl, webtexts, books, and Wikipedia
- ***Benchmarks:*** GLUE, SuperGLUE, BIG-bench
- ***Improved Infra:*** GPU/TPU, TensorFlow/PyTorch/JAX, Cloud service
- ***Architecture:*** seq2seq, Transformer
- ***Invest:*** Google, OpenAI, now more
- ***EcoSystem:*** HuggingFace, arxiv, github
- ***Leaders:*** Ilya Sutskever, Geoffrey Hinton, Yoshua Bengio, Yann LeCun, Fei-Fei Li, Demis Hassabis, Jeff Dean, and more

Reinforcement Learning Essentials: Foundational Basics and PPO Algorithm

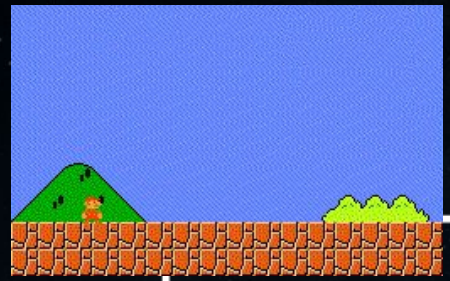
Selected Success Stories of RL

- AlphaGo, AlphaStar, AlphaTensor by DeepMind

Check out this deck for a summary of more Alpha* papers by DeepMind

What is Reinforcement learning?

What is Reinforcement learning? Cont (Mario case)



Environment

action
a_t

Reward
R_t

State
s_t

Points

Agent

- No-op
- Jump
- Right
- Fire
- ...

(1/4) RL optimization algorithm explained

Q-learning:

- Action Value Function Q(s, a)
  - Given state s
  - Which action a shall we take?
    - So that it will lead to optimal expected total (delayed) rewards!

- Often overestimate the expected optimal reward

(2/4) RL optimization algorithm explained

Policy Gradient $\pi(a \mid s)$

- A policy tells which action a to take on state s
  - That implicitly optimized for better [delayed] total rewards
- Uses 1st order derivative for linear search, thus leads to unstable improvements

Jonathan Hui: RL — Trust Region Policy Optimization (TRPO) Explained

(3/4) RL optimization algorithm explained

TRPO Trust Region Policy Optimization

- Trust Region: Region with radius **δ** to avoid bad big moves
- Uses MM (minorize maximization) and Advantage function (expected rewards over average actions)
- Constrain of KL-divergence between old and new parameters
    - Ensures new policy is not drastically different from the current

- Often considered computationally expensive (because of inverse of hessian), and constrained by linear and quadratic approximations following static defined formula (conjugate gradient approximation)

(4/4) RL optimization algorithm explained

PPO Proximal Policy Optimization

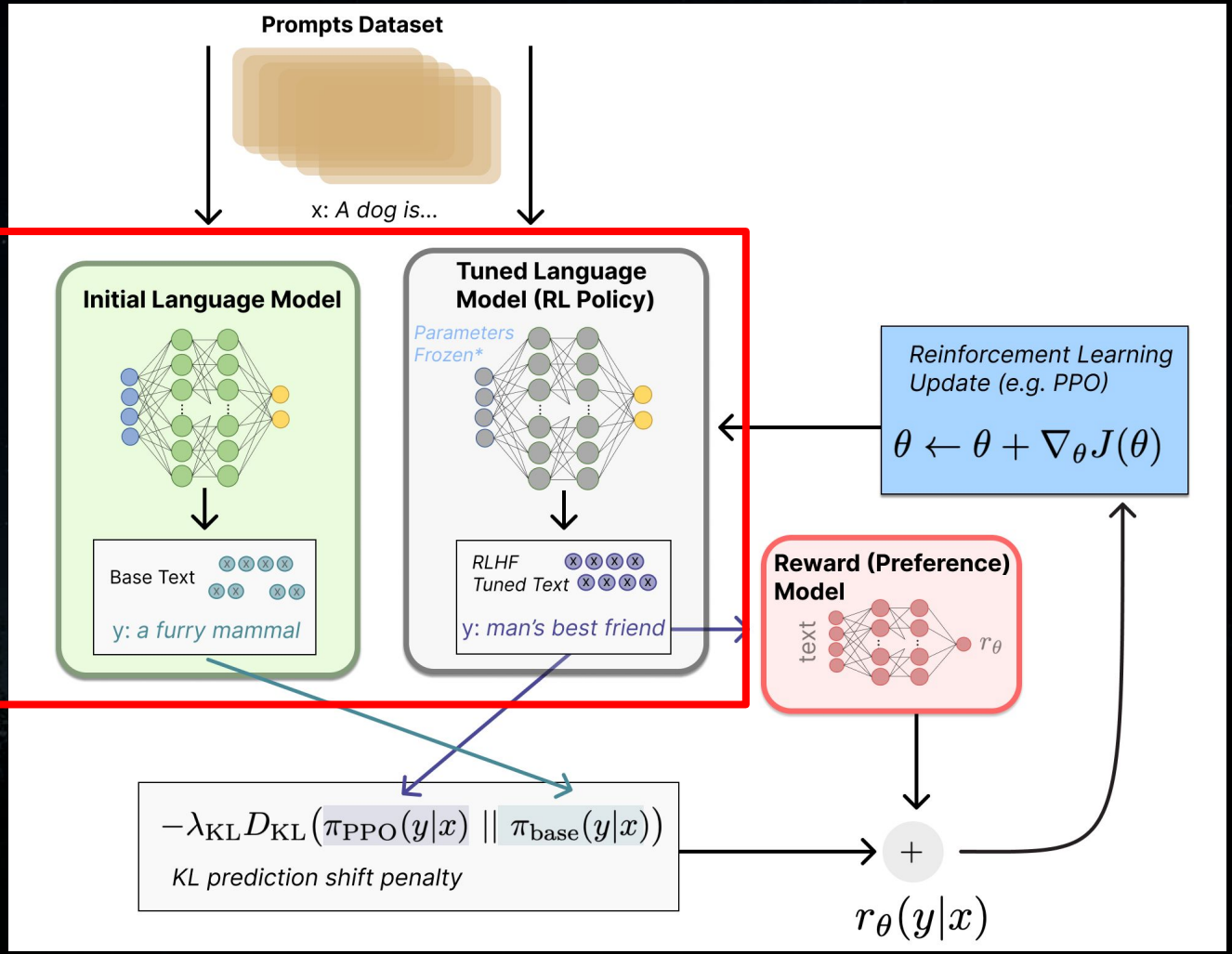
- Similar to TRPO, but add “proximal” constraint directly into model optimization objectives
  - PPO with Clip: removes the KL-divergence, clips the objective function within bounds
  - PPO with Adaptive KL-Penalty: Approximate and penalize KL constraints to speed up the computation and reduce memory need
- Reportedly one of the “best” RL algorithms that is faster and more stable to train as of 04/2022

And *PPO with Clip* is used by OpenAI Five DOTA2 AI and ChatGPT!

ChatGPT Unveiled: LLMs and PPO together to train the powerful ChatGPT

RLHF

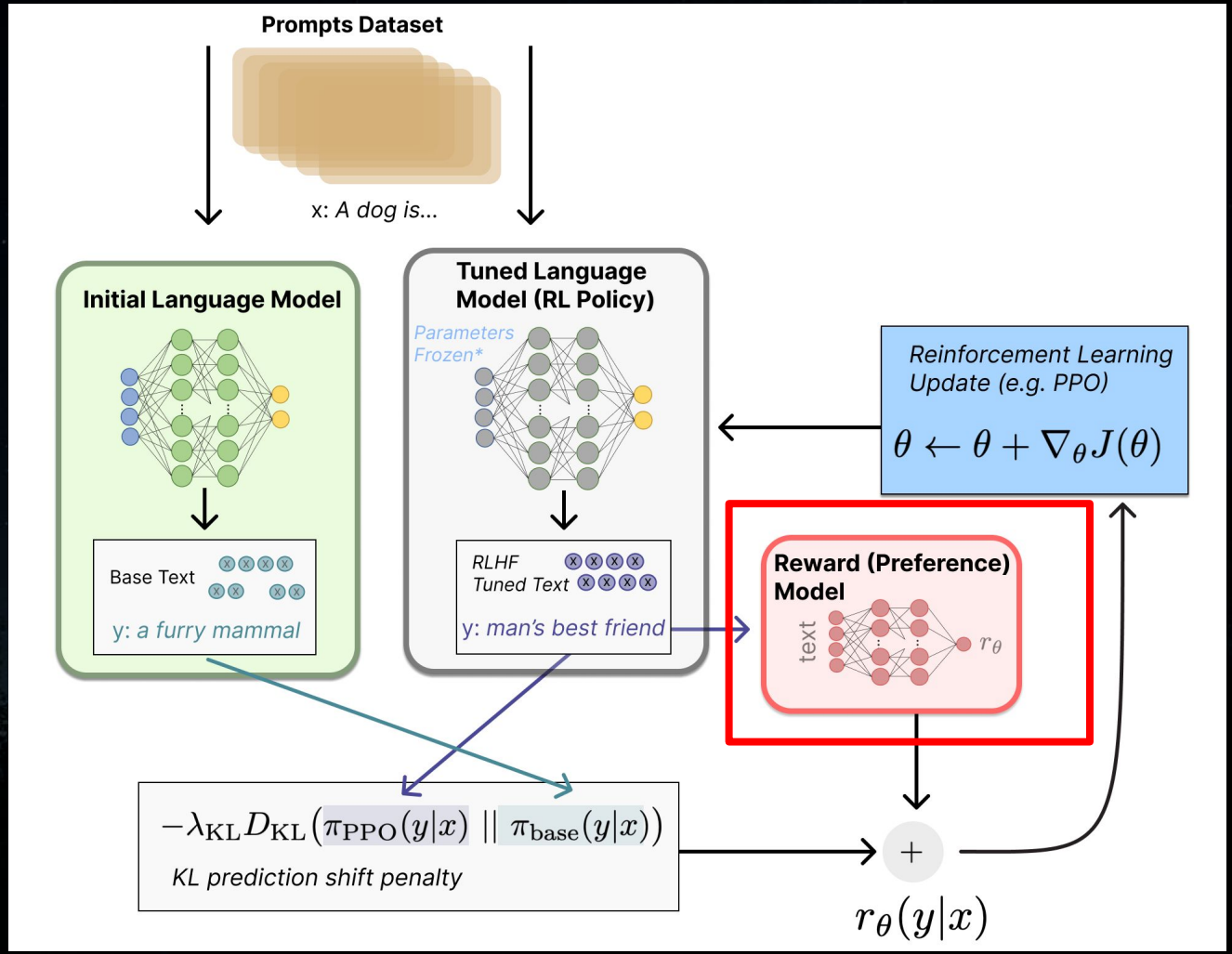
Reinforcement Learning from Human Feedback



https://huggingface.co/blog/rlhf

RLHF

Reinforcement Learning from Human Feedback



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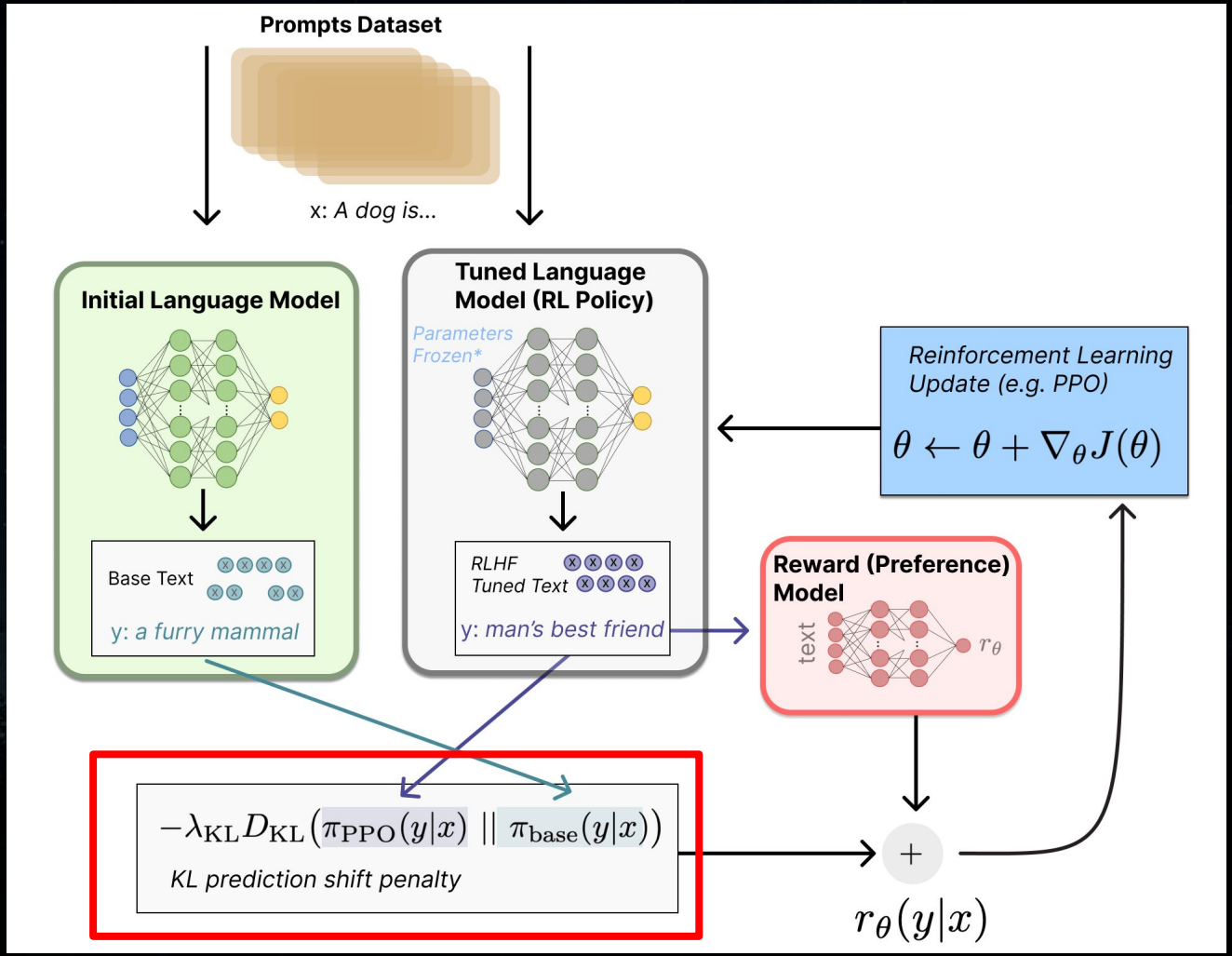

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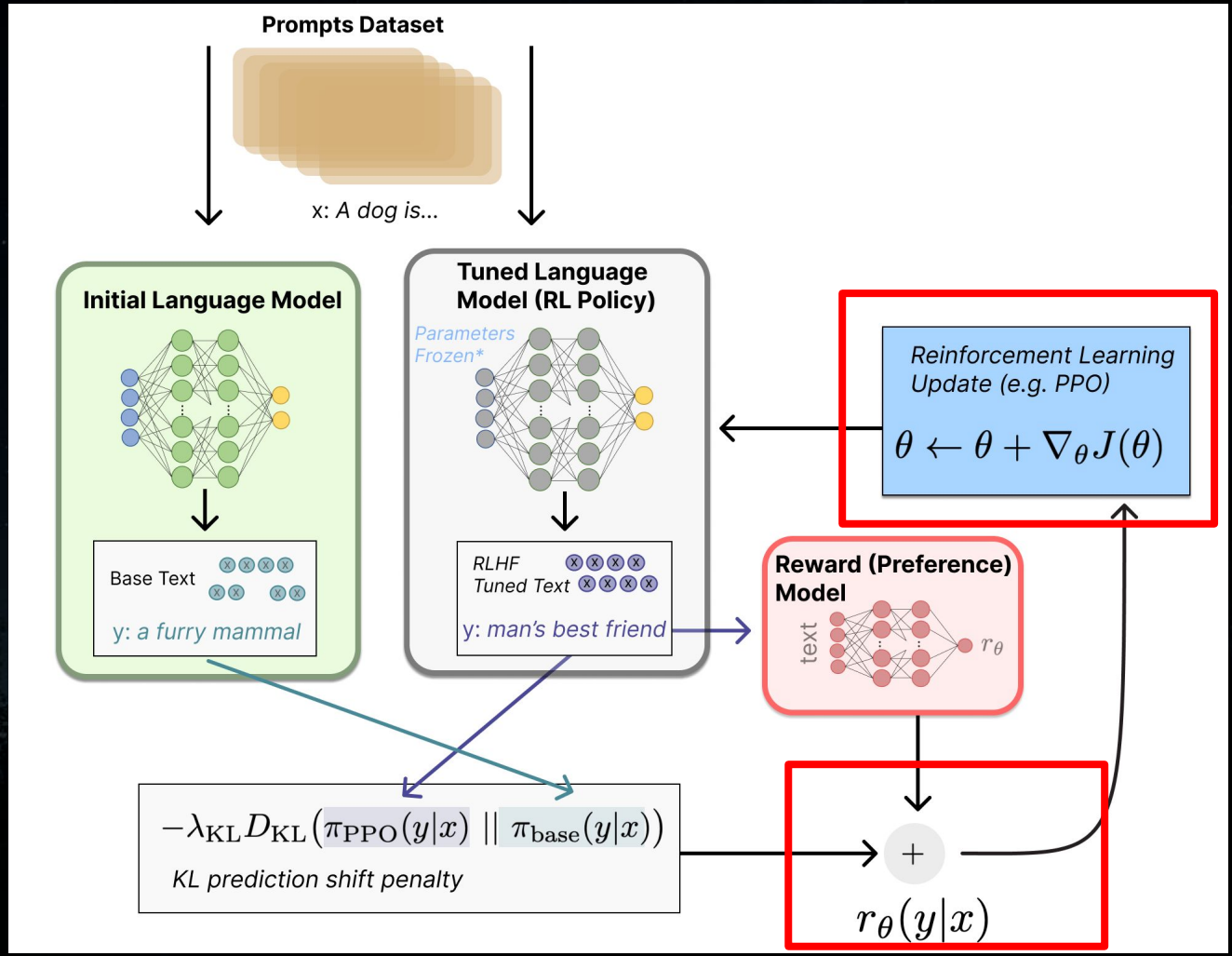
RLHF

Reinforcement Learning from Human Feedback



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Steps to train ChatGPT (instructGPT paper)

Pretrain	SFT	RM (Reward Model)	RLHF

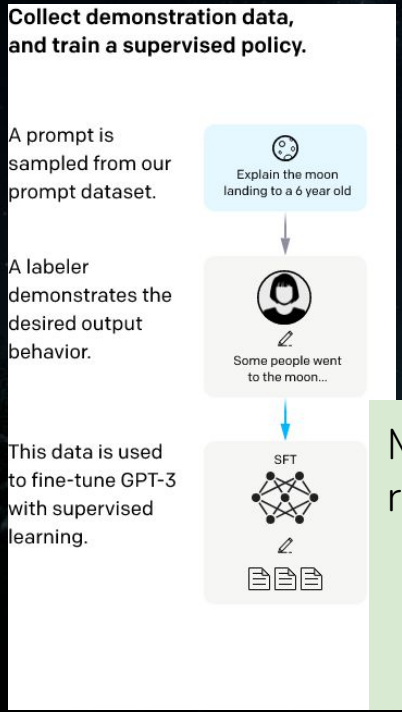
GPT3

Model gains
“**knowledge**”

Steps to train ChatGPT (instructGPT paper)

Pretrain	SFT	RM (Reward Model)	RLHF

GPT3

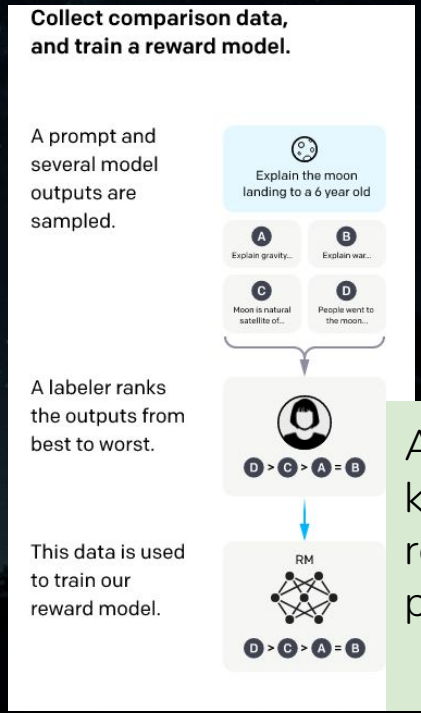


Model aligns its response “**style**”

- Overfit intentionally!

Steps to train ChatGPT (instructGPT paper)

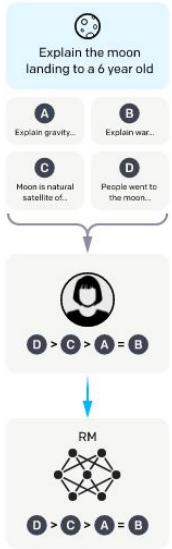
Pretrain	SFT	RM (Reward Model)	RLHF
GPT3			

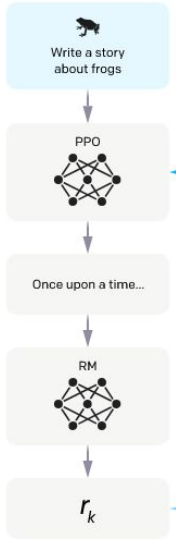


A reward model know how to "**rate**" response based on prompt input

Steps to train ChatGPT (instructGPT paper)

Pretrain	SFT	RM (Reward Model)	RLHF
GPT3	**Collect demonstration data, and train a supervised policy.** A prompt is sampled from our prompt dataset. A labeler demonstrates the desired output behavior. …is data is used fine-tune GPT-3 …th supervised …arning.	**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.	**Optimize a policy against the reward model using reinforcement learning.** A new prompt is sampled from the dataset. The policy generates an output. The reward model calculates a reward for the output. The reward is used to update the policy using PPO.





With SFT+RM+RLHF, the model "**self-play**" to improve itself (***toward higher rewards***)

My personal guess about GPT4 (tech report no tech details)

- Similar scale (0.3-3x size of GPT3) because of computing budget and serving cost
- May apply DeepMind Chinchilla scaling law to balance text data/model size
- Vision encoding fusing to LLM may be similar to DeepMind Flamingo
- May apply some Transformer optimizations
  - E.g. multi-query attention, flash attention, rotary position embedding
- Special "System message" steerability (Role in API) in training (*probably as some strong prior*) to fight against jailbreak
- Enhanced reasoning capabilities may come borrow ideas from OpenAI codex Google Minerva
- ChatGPT Plugin version is probably trained (or finetuned from GPT4) similarly to Facebook ToolFormer

Frontier Applications:
Most Advanced LLM Capabilities

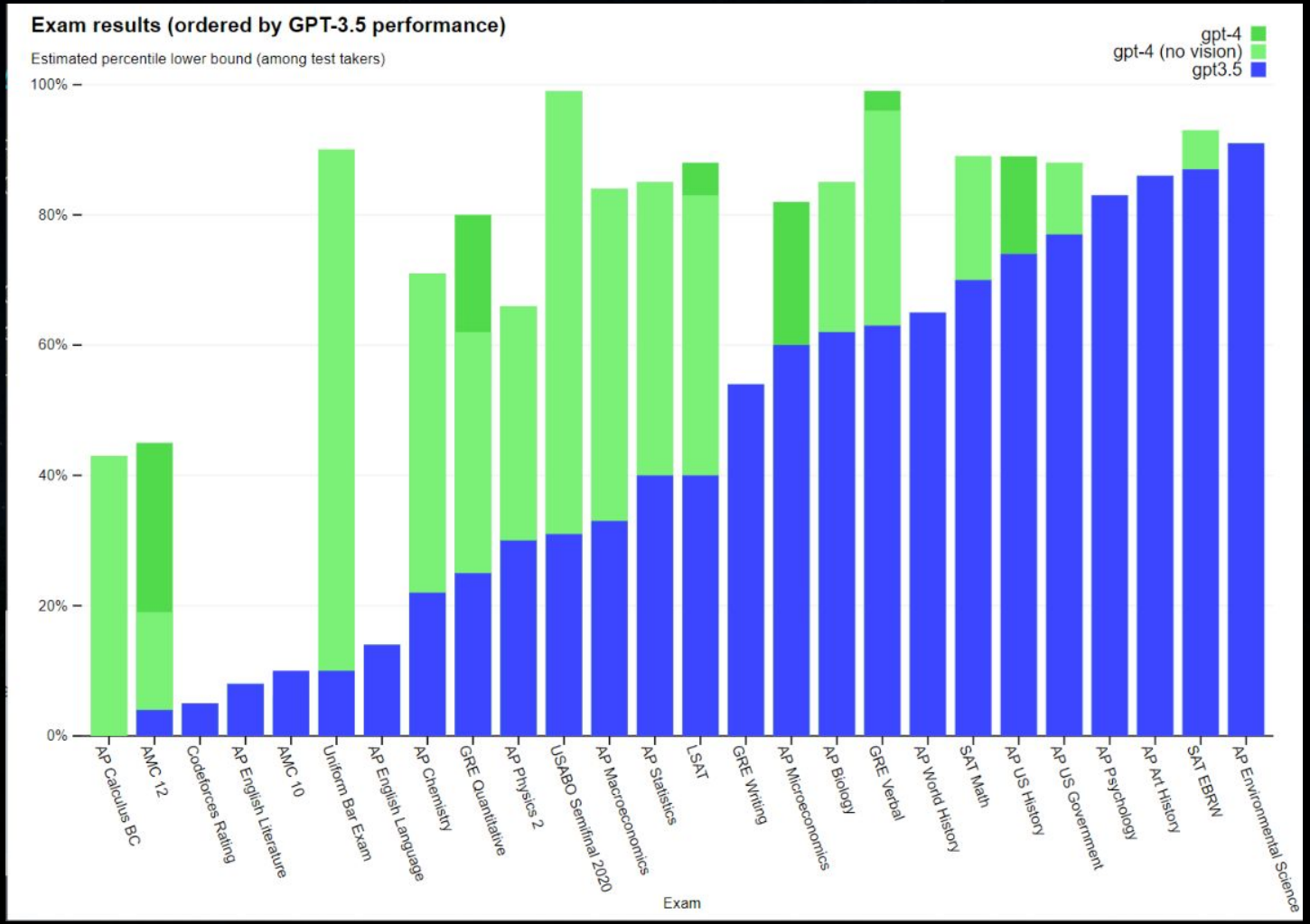
Pre-ChatGPT/GPT4 Advanced LLM capabilities

- Write competitive code, DeepMind's AlphaCode AI writes code at a competitive level | TechCrunch
- Write better code with reinforcement learning, Salesforce's CodeRL Achieves SOTA Code Generation Results With Strong Zero-Shot Transfer Capabilities | Synced
- Solve college level Math/Physics/Chemistry/Economics problems, see Google AI Introduces Minerva: A Natural Language Processing (NLP) Model That Solves Mathematical Questions
- Solve Math Olympiad Problems, OpenAI: Solving (Some) Formal Math Olympiad Problems
- Math theorem proving, OpenAI: Solving (Some) Formal Math Olympiad Problems

The disruptive GPT4

Good at so many standard tests!, but not so in

- AP English
- AMC
- CodeForces



GTP4 = Sparks of AGI selected highlights

- The awesome “Text in, text out”
  - Write poem and haiku
  - Mimic style/role (e.g. Shakespeare, or “be polite” to , or “be socratic”)
  - Math proving
  - Passing LeetCode
  - Write and Debug code
  - Debating
  - “Execute” the code
  - Explainability
- “Text in, text out” is more than text-only scenarios!
  - Ascii or LaTeX output to draw pictures
  - Python code to draw a chart
  - AppScript to build slides
- Can be combined with other models with more modalities!
  - Generate image or music with text out and diffusion models
  - Other tools (e.g. calculator, web search and more)

Other GPT4 use cases

Some Highlights

- Tutoring: e.g. Khanmigo powered by GPT4
- Vision Text question: bemyeyes
- Study: ChatPDF, chatYoutube

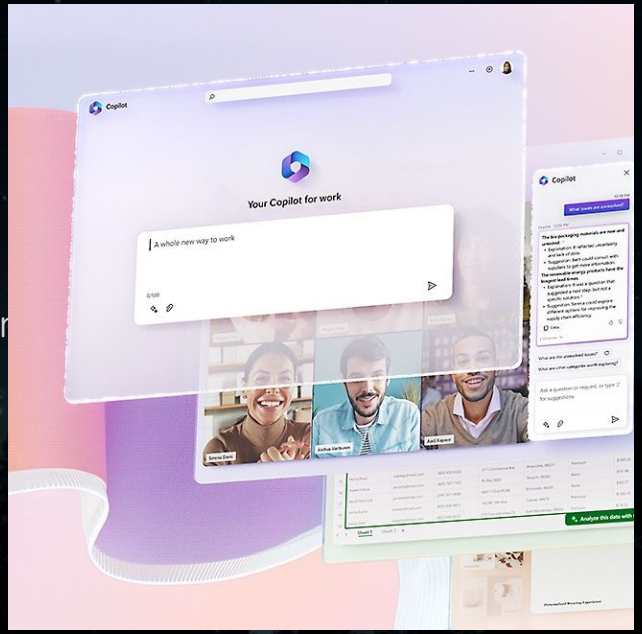
Some lowlights

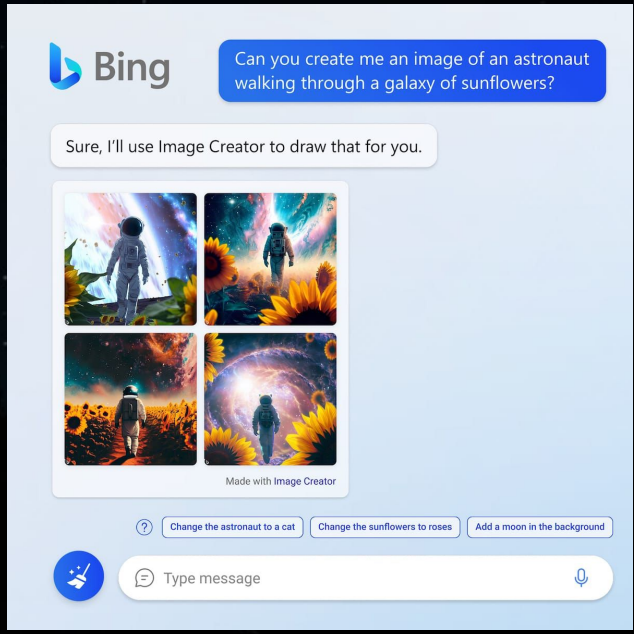
- How to detect ChatGPT plagiarism — and why it's becoming so difficult
- GPT-4 Was Able To Hire and Deceive A Human Worker Into Completing a Task | PCMag

Microsoft Office 365 Copilot and new Bing Chat

GPT4 powers intelligent interactions

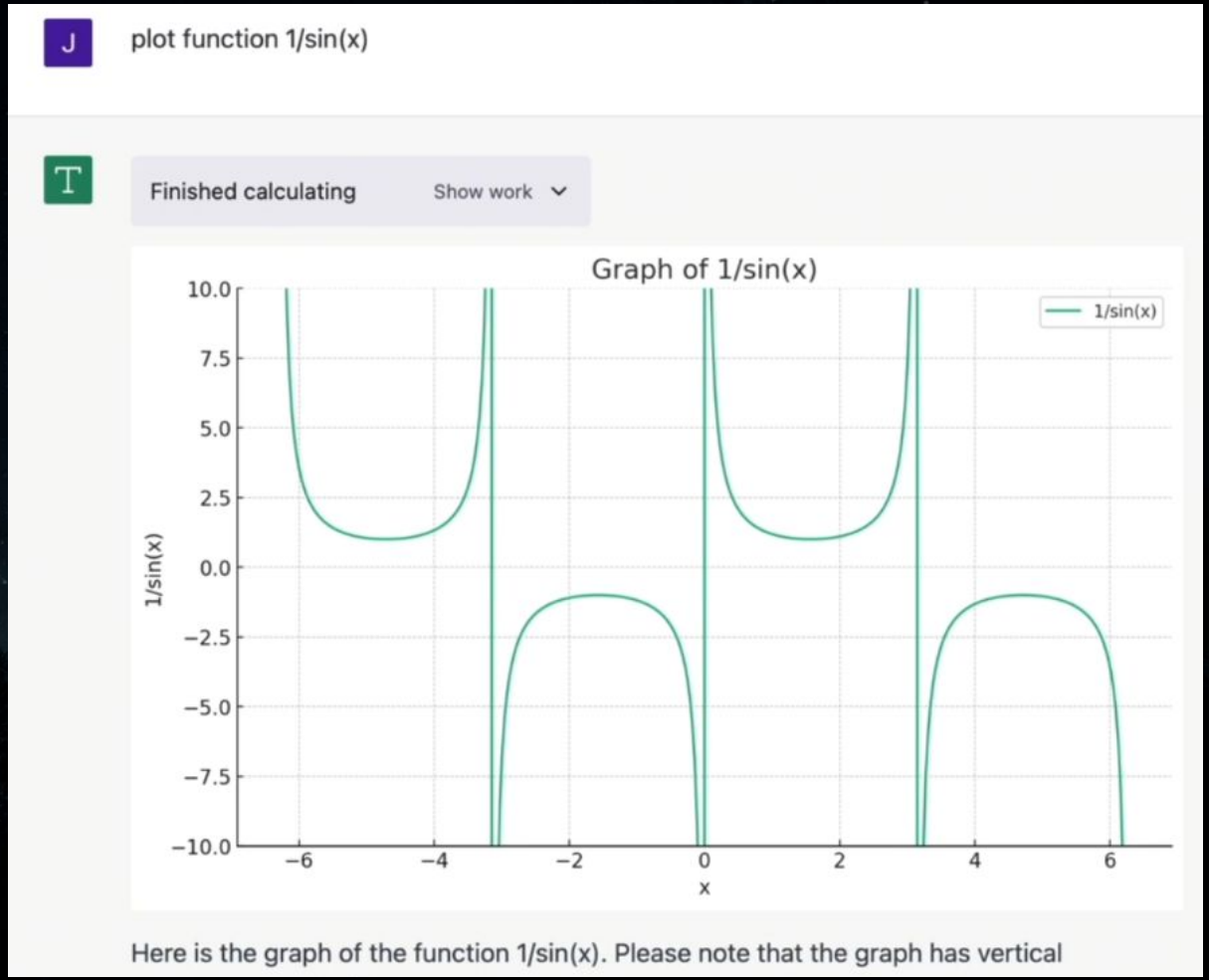
- Text intent in, slide/chart/report/action out in office
- Text in, query summary or pic out





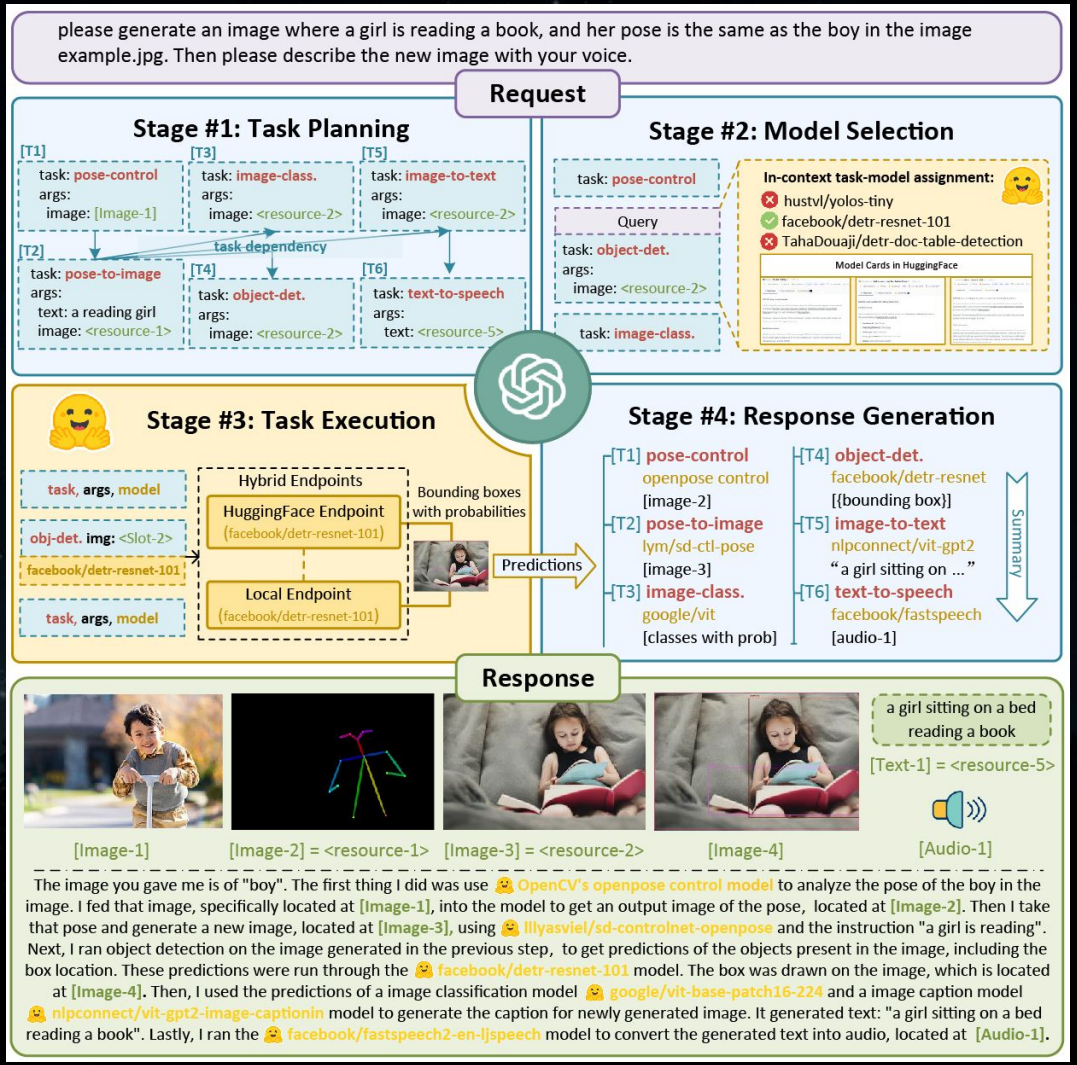
ChatGPT Plugins

Web browsing, code interpreter, Expedia, FiscalNote, Instacart, KAYAK, Klarna, Milo, OpenTable, Shopify, Slack, Speak, Wolfram, and Zapier.



HuggingGPT

(more powerful "plugin"), aka Microsoft Jarvis at Github



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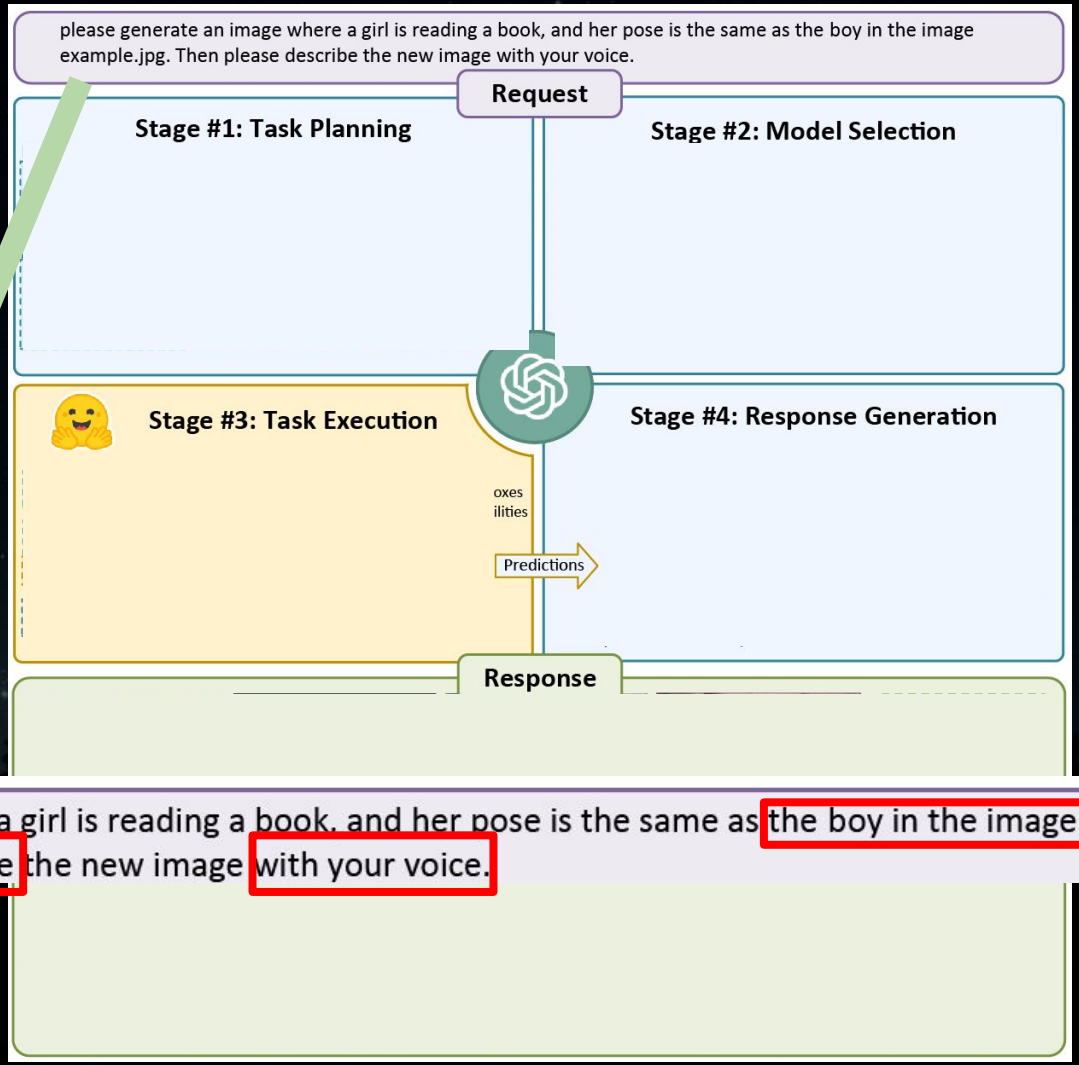
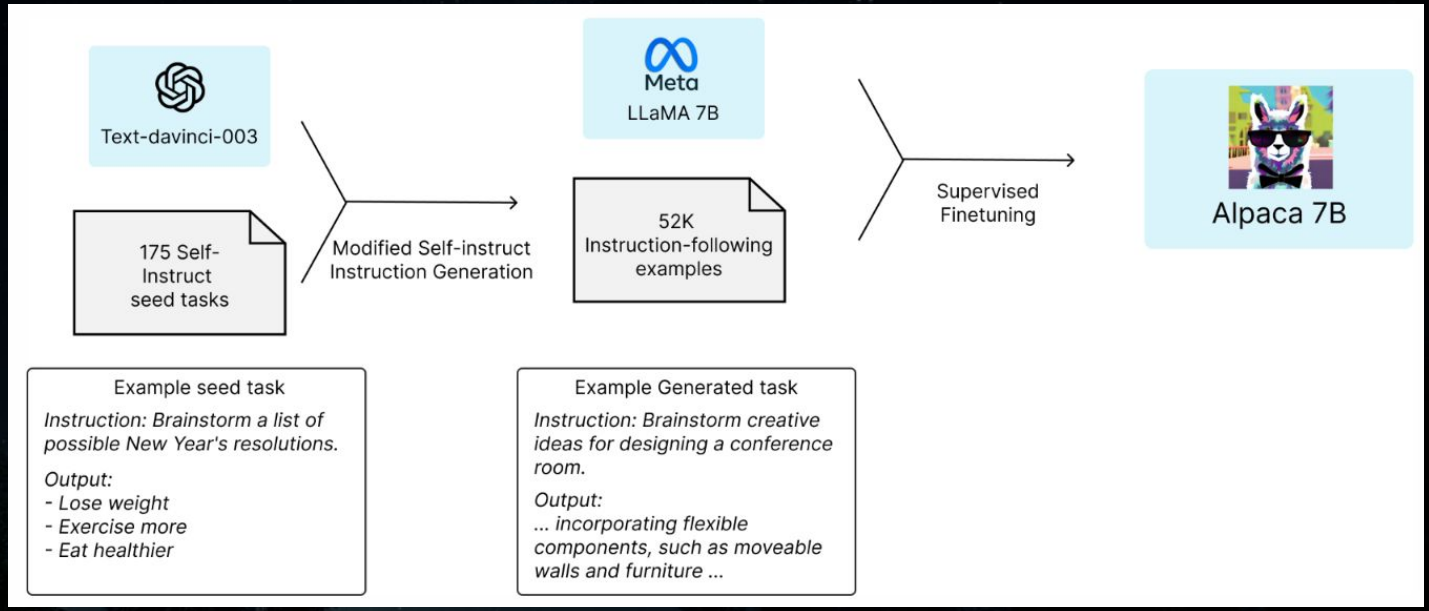


please generate an image where a girl is reading a book, and her pose is the same as the boy in the image example.jpg. Then please describe the new image with your voice.

Alpaca

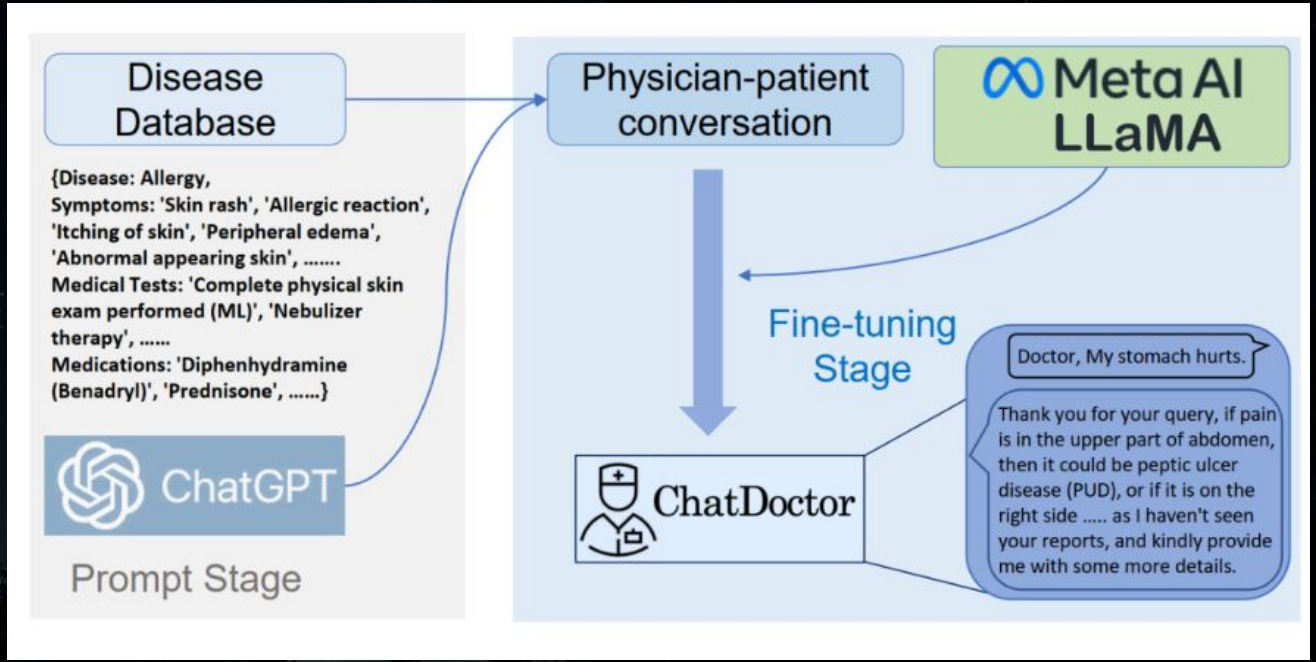
Finetune your ChatGPT with <$600

Opens a door for cheap academic LLM research



ChatDoctor, similar to Alpaca

ChatGPT indirectly powered LLM



AI as a Service

- OpenAI API
- Google PaLM API
- Claude API
- HuggingFace
- And more

Societal Impacts: Imminent Effects of ChatGPT-like AI

Impact Assess to US Job Market (OpenAI report)

"The projected [LLM] effects span all wage levels, with **higher-income jobs potentially facing greater exposure** to LLM capabilities and LLM-powered software…"

"…with access to an LLM, about 15% of all worker tasks in the US could be completed significantly faster at the same level of quality. When incorporating software and tooling built on top of LLMs, this share increases to between 47 and 56% of all tasks"

- *My person take: The higher your income is, **statistically** more impacted by LLM*
- *My person take: Positive:"assistive AI to help humans", Negative: "automation AI to replace humans"*

Impact Assess to US Job Market (OpenAI report) cont

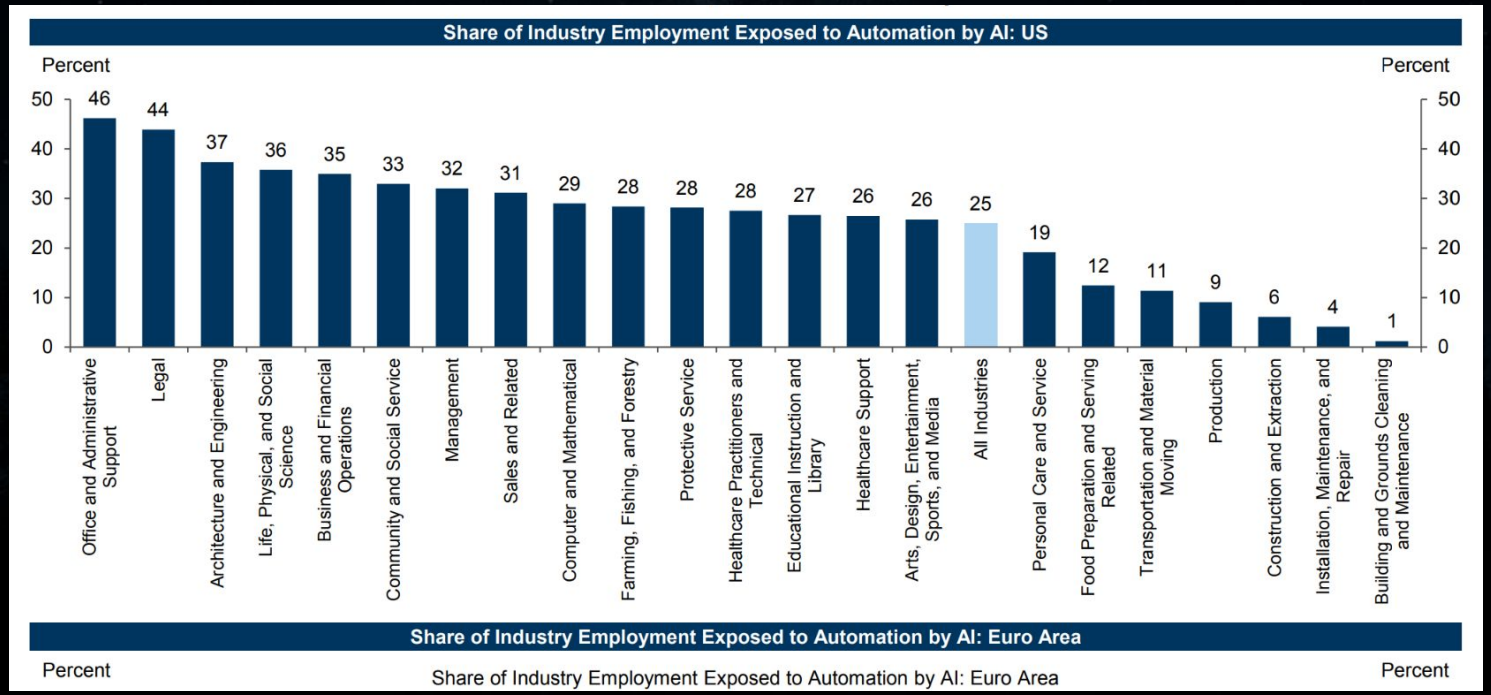
"Our findings reveal that around 80% of the U.S. workforce could have at least 10% of their work tasks **affected** by the introduction of LLMs, while approximately 19% of workers may see at least 50% of their tasks **impacted**."

- *My personal take: Most of the white-collar jobs are in the 19% bucket*
- *My personal take: most of the blue-collar jobs are in the 80% bucket, but eventually the advanced robotics (maybe powered by LLM like GPT4) will gradually affect more over time*

Impact to Job Market (Goldman Sachs report)

"**One-Fourth** of Current Work Tasks **Could Be Automated** by AI in the US and Europe"

- *My person take: I believe wall street better than OpenAI here, because OpenAI has conflict of interest to report similar result, so OpenAI has good reasons to use more careful wording intentionally*

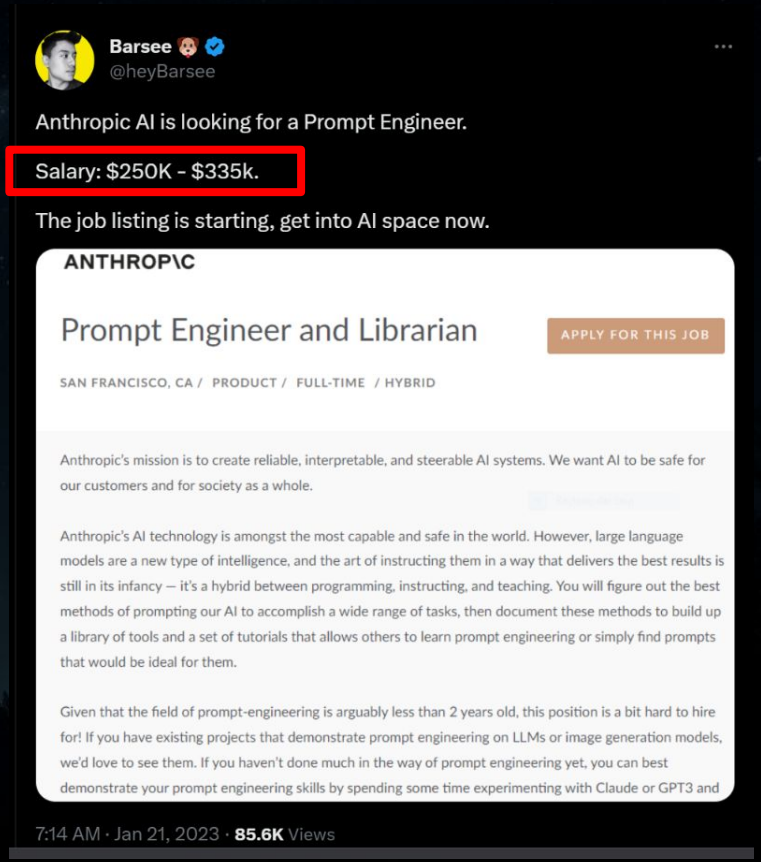


How to prepare for an AI world?

My personal [very dry] thoughts

- Work with AI now, to know its capabilities and limits
- Be experts in your domain
  - Leverage AI to boost your performance
- Push AI infra boundary
  - AI researcher and engineers
  - Foundational theory like Math/Physics to improve infra/algorithm and more
  - Neural science or more to apply what learn from human brain to AI
- AI as a service, to solve real world problems
  - Inter-discipline research
  - Business landing using AI API
  - Embodied AI to have smart robots
- Be bold to solve the most difficult problems for the humanity

Maybe switch jobs to the hottest “Prompt Engineer”?



Selected Highlights from Popular Articles

- Stephen Wolfram: Will AIs Take All Our Jobs and End Human History—or Not?
  - "highest leverage will come from figuring out **new possibilities** [...] as a result of **new capabilities**"
  - "let us concentrate on setting the "**strategy**" [...]—delegating the details [to AI]"

- Bill Gates: The Age of AI has begun
  - "**balance fears** about the **downsides of AI** [... and AI's] **ability to improve people's lives**"
  - "we will need to focus the world's **best AIs on its biggest problems**."
    - My take: Assume we may want to focus on AI application on weather/health/energy?
  - "the world needs to establish the rules of the road so that **any downsides of [AI] are far outweighed by its benefits**"

- Sam Altman: Moore's Law for Everything
  - "Imagine a world where, for decades, everything–housing, education, food, clothing, etc.–became half as expensive every two years. [...] **We will discover new jobs** [...], we will have incredible freedom to be creative about what they are."
    - My take: really?
  - "As long as the country keeps doing better, every citizen would get more money from the Fund every year [...]. Every citizen would therefore increasingly partake of the freedoms, powers, autonomies, and opportunities [...]"
    - My take: seriously?

fun-ai-talk @ UNIVERSITY OF NORTH CAROLINA CHARLOTTE

Thank you! Questions?

A Glimpse Into LLM, RL and ChatGPT

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April 2023

fun-ai-talk @ UNIVERSITY OF NORTH CAROLINA CHARLOTTE

Time for more discussion!

LLM, RL, ChatGPT, and more?

hululu.zhu@gmail.com

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