

Can we try to learn more about models like ChatGPT by training our own (smaller) models?

ChatGPT has created a buzz and even led to vigorous arguments amongst very famous researchers about the capabilities and potential dangers of current AI technology.

Can students understand more about such models without million dollar funding? Can they engage in informed discussions about one of the most discussed technology topic of our times?

It is not clear (at least to some people) whether keeping knowledge locked within some companies will prevent misuse over long term. So let us try to understand at least the basics of this technology with the help of open source models and datasets and use it for some good purpose if we can.

Topic: Instruction tuned language models

You are an intelligent assistant for answering questions related to courses and programs at the university. Answer the questions from prospective students.

Question: Do I have to know programming to apply for the business information systems course?

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An old wish

Using dialog to make a computer program perform certain tasks has been a long standing AI goal.

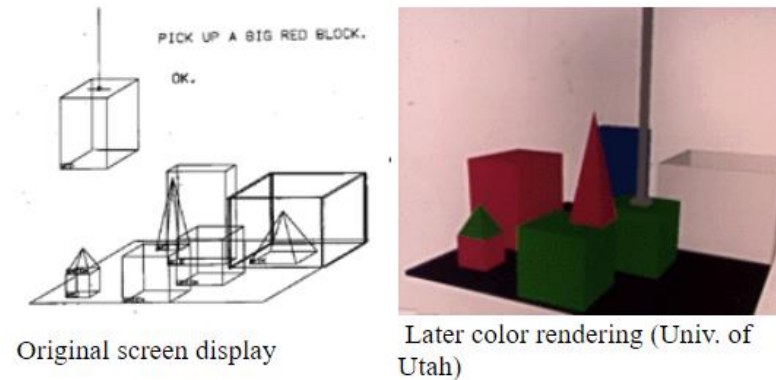
SHRDLU was developed by Terry Winograd at M.I.T. Artificial Intelligence Laboratory in 1968-1970 (snapshot image of a demo on the right)

<https://hci.stanford.edu/~winograd/shrdlu/>

Just for fun (and because what we cover in this session will not be part of the exam)

If you believe that Language Models will take over the world and kill us all, and want to prevent that, read the last part of the story about how SHRDLU got its name

<https://hci.stanford.edu/~winograd/shrdlu/name.html>



The dialog that was used as a SHRDLU demo:

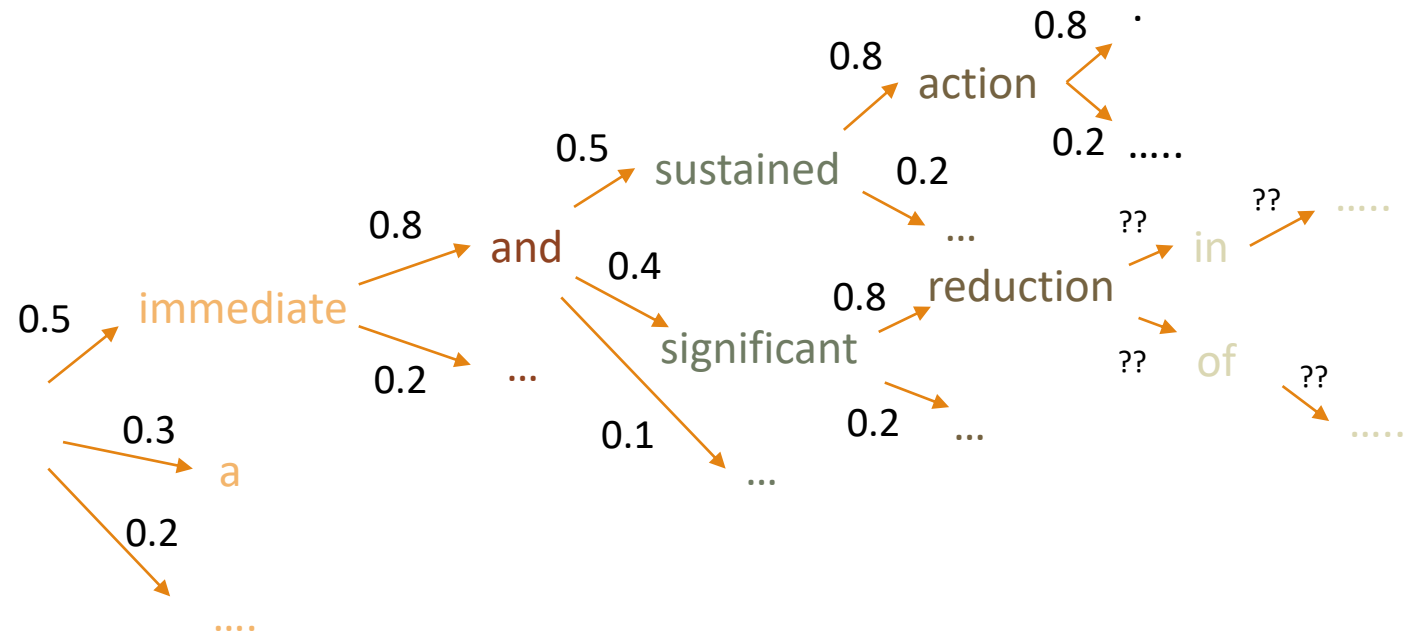
```
Person: PICK UP A BIG RED BLOCK.
Computer: OK. (does it)
Person: GRASP THE PYRAMID.
Computer: I DON'T UNDERSTAND WHICH PYRAMID YOU MEAN.
Person: FIND A BLOCK WHICH IS TALLER THAN THE ONE YOU ARE HOLDING AND PUT IT INTO THE BOX.
Computer: BY "IT", I ASSUME YOU MEAN THE BLOCK WHICH IS TALLER THAN THE ONE I AM HOLDING.
Computer: OK. (does it)
Person: WHAT DOES THE BOX CONTAIN?
Computer: THE BLUE PYRAMID AND THE BLUE BLOCK.
Person: WHAT IS THE PYRAMID SUPPORTED BY?
Computer: THE BOX.
Person: HOW MANY BLOCKS ARE NOT IN THE BOX?
Computer: FOUR OF THEM.
Person: IS AT LEAST ONE OF THEM NARROWER THAN THE ONE WHICH I TOLD YOU TO PICK UP?
Computer: YES, THE RED CUBE.
```

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Language Models – generating the next token

A trivialised example

Addressing climate change requires



For details and an accurate description of how this is done, refer Chapter 10 - Transformers and Pretrained Language Models in the course book Speech and Language Processing (3rd ed. draft), Dan Jurafsky and James H. Martin
<https://web.stanford.edu/~jurafsky/slp3/10.pdf>

Topic: Instruction tuned language models

Aligning human and model objectives

From

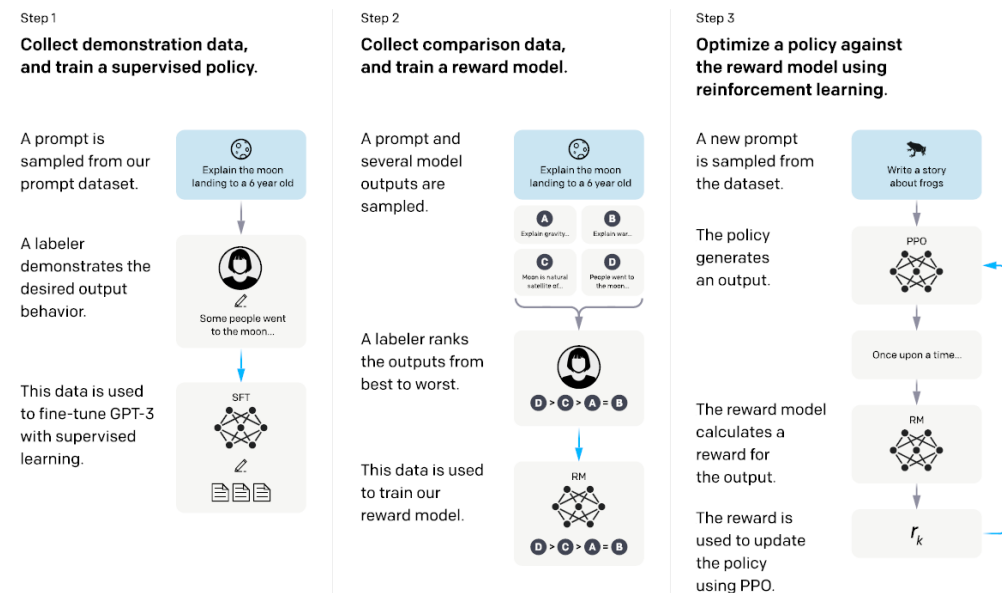
Predict the next token

To

Follow the user's instructions helpfully and safely

Training language models to follow instructions with human feedback

Long Ouyang* Jeff Wu* Xu Jiang* Diogo Almeida* Carroll L. Wainwright*
Pamela Mishkin* Chong Zhang Sandhini Agarwal Katarina Slama Alex Ray
John Schulman Jacob Hilton Fraser Kelton Luke Miller Maddie Simens
Amanda Askell† Peter Welinder Paul Christiano*†
Jan Leike* Ryan Lowe*
OpenAI



The three steps for achieving this as described in the paper

<https://arxiv.org/pdf/2203.02155.pdf>

Topic: Instruction tuned language models

Alignment as a reinforcement learning problem

We will not discuss these in detail here. These are for reference and later reading.

Scalable agent alignment via reward modeling: a research direction

Jan Leike	David Krueger*	Tom Everitt	Miljan Martic	Vishal Maini	Shane Legg
DeepMind	DeepMind Mila	DeepMind	DeepMind	DeepMind	DeepMind

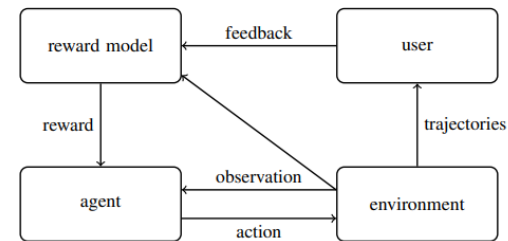


Figure 1: Schematic illustration of the reward modeling setup: a reward model is trained with user feedback; this reward model provides rewards to an agent trained with RL by interacting with the environment.

<https://arxiv.org/pdf/1811.07871.pdf>

Proximal Policy Optimization Algorithms

John Schulman, Filip Wolski, Prafulla Dhariwal, Alec Radford, Oleg Klimov
OpenAI
{joschu, filip, prafulla, alec, oleg}@openai.com

<https://arxiv.org/pdf/1707.06347.pdf>

Some **simplified explanations** are available here: <https://huggingface.co/blog/rlhf>

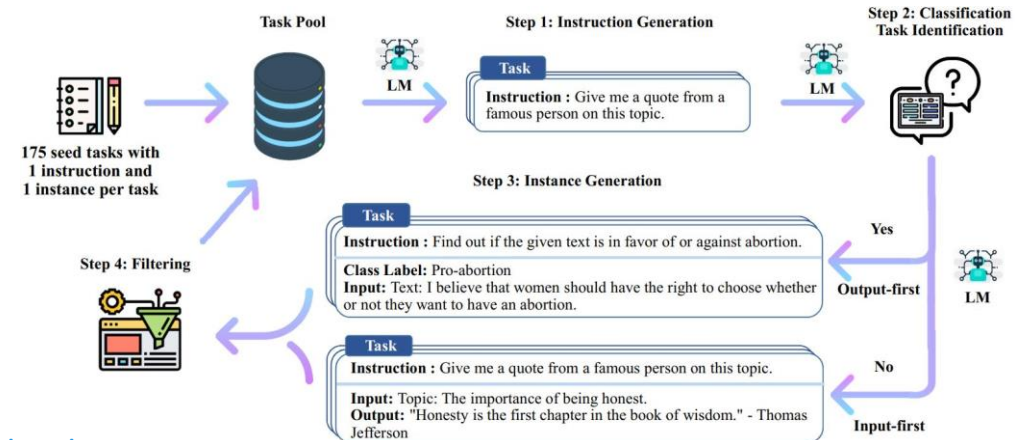
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Collecting human feedback at scale is difficult. Is there an alternative?

SELF-INSTRUCT: Aligning Language Model with Self Generated Instructions

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<https://github.com/yizhongw/self-instruct>



- 1) Start with a set of manually written instructions and prompt the language model to generate new instructions and input - output sequence
- 2) Clean the data (remove low quality instructions, deduplication,...)
- 3) Repeat
- 4) Finetune the language model based on the generated instruction dataset

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Looks simple. Is there a catch?

If data is generated using ChatGPT, there might be complications related to terms of use as mentioned here:

<https://www.databricks.com/blog/2023/04/12/dolly-first-open-commercially-viable-instruction-tuned-llm>

Hence Databricks released an Open Source dataset labelled by its employees – **The Dolly 15k dataset**

<https://huggingface.co/datasets/databricks/databricks-dolly-15k>

It also gives a good preview of what is needed to create a useful dataset.

E.g. Categories like *Closed Q&A* where the model is required to use information only in the input and *Brainstorming* for open ended ideation.

Another open dataset is the **OpenAssistant Conversations Dataset** (<https://huggingface.co/datasets/OpenAssistant/oasst1>).

(Paper: [OpenAssistant Conversations - Democratizing Large Language Model Alignment](#))

However, **the users have to be careful about issues like data quality, toxicity and bias** with all these datasets. Additionally, **finetuning in this way does not guarantee that generated text will not have any toxicity or bias.**

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But we still have the compute problem

Most models require very large GPUs to run finetuning.

It is common to read in papers: The model was trained/finetuned using 8xA100 80Gb GPUs

Thanks to the efforts of Prof. Zarcone, we would have such a GPU cluster soon. 😊

But it would still be challenging for everybody in the class to experiment with finetuning such models for the purpose of learning.

The main challenge is the GPU memory (higher the memory, higher the price).

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Getting past the compute hurdle to start learning

The starting point: Smaller base models

There are models available with 7-20 billion parameters. These could be used on smaller GPUs.

However, finetuning complete model could still be a challenge.

The alternative: Do not finetune with all model parameters

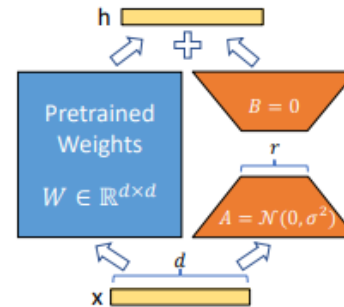
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An option*: Low Rank Adaptation

LoRA: LOW-RANK ADAPTATION OF LARGE LANGUAGE MODELS

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<https://arxiv.org/pdf/2106.09685.pdf>



*This is one of the multiple options available

The gist

LoRA freezes the pretrained model weights and injects trainable rank decomposition matrices into each layer of the Transformer architecture, greatly reducing the number of trainable parameters.

The authors hypothesized that since pre-trained language models have a low “intrinsic dimension” and can still learn efficiently despite a random projection to a smaller subspace, the change in weights during model adaptation also has a low “intrinsic rank”.

For us

Feasibility of model finetuning on GPUs with significantly lower VRAM

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Additional option: Quantization

LLM.int8(): 8-bit Matrix Multiplication for Transformers at Scale

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University of Washington^λ
Facebook AI Research[†]
Hugging Face[§]
ENS Paris-Saclay[‡]

<https://arxiv.org/pdf/2208.07339.pdf>
<https://github.com/TimDettmers/bitsandbytes>

The gist

Int8 matrix multiplication for feed-forward and attention projection layers in transformers, which cut the memory needed for inference by half while retaining full precision performance

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Choosing a model

Let us assume you found a friend who bought a new gaming card with 24Gb of RAM and convinced him to use it for the betterment of science and humanity 😊

- If we restrict our model choice to models with less than 10 billion parameters, we might be able to finetune the models on this GPU.
- We need models for which we can download the weights without restrictions.
- We need models where a base model version and an instruction tuned version are available to validate if our experiments can achieve similar performance (at least partially).

One of the models recently released and demonstrating good performance on multiple benchmarks is falcon (<https://falconllm.tii.ae/>)

There is a 7billion parameter base model (<https://huggingface.co/tiiuae/falcon-7b>) as well as an instruction tuned model (<https://huggingface.co/tiiuae/falcon-7b-instruct>) available.

Another option is a set of models from MosaicML (<https://www.mosaicml.com/blog/mpt-7b>)

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Let us start the fun

We will use falcon-7b-instruct to see a few responses.

We will try to use the falcon-7b to try and finetune a model using the dolly15k dataset.

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Let us see if it can follow our instruction?

Using only the information below about the course at the university, formulate 10 possible questions from prospective students.

Course:

Business Information Systems (MSc)

Study content:

The course promotes dealing with complex issues and enables you to implement both economic and information technology concepts.

In terms of content, the course is divided into four strands of modules:

Scientific Fundamentals:

Principles of scientific and team-oriented work and application of mathematical models to solve problems.

Business Analysis and Modeling:

From the analysis and modeling of operational processes to requirements engineering to digital business models and their representation.

Business Application Systems:

From the conception and use of operative systems in the company to the processing and analysis of the data as a basis for decision-making.

IT Management:

From the implementation and management of individual projects in the IT environment to the short to long-term planning of the company-wide IT infrastructure.

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An example result (first run)

Model: *falcon-7b-instruct*

Possible Questions:

1. What are the key concepts of the Business Information Systems course?
2. How do you ensure the efficient and effective processing of data in the course?
3. What are the main challenges and opportunities in the application of mathematical models in the course?
4. How do you apply the principles of scientific and team-oriented work in the course?
5. What are the main types of business analysis and modeling techniques used in the course?
6. How do you ensure the security and confidentiality of data in the course?
7. What are the main types of business application systems used in the course?
8. How do you ensure the efficient and effective use of IT resources in the course?
9. What are the main challenges and opportunities in the implementation of IT management strategies in the course?
10. How do you ensure the effective communication of IT-related information to non-IT stakeholders in the course?

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An example result

Model: *falcon-7b finetuned on dolly-15k for 3 epochs*

1. What is the duration of the course?
2. What is the entry requirement to apply for the course?
3. How much is the tuition fee for the course?
4. What is the structure of the course?
5. What are the course modules?
6. What are the entry requirements to apply for the course?
7. What is the application deadline for the course?
8. What are the study materials for the course?
9. What are the career opportunities for graduates from the course?
10. What are the course alumni doing now?

This does not look very bad but is not possibly what we exactly expected.

We have some way to go with our finetuning.

(A hint: The code was put together in a few hours and the data is off-the-shelf. The training lasted approximately 9 hours. Some more effort on training data and more training epochs can definitely help us learn more about such models. We see that it is feasible to do this without waiting for the million dollar funding to materialise 😊.

Keep Learning and Have Fun.