

# GPT, a brilliant but messy intern

**Can GPT be of any use to a physicist ?**



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# ChatGPT : médias et artistes veulent faire valoir leurs droits d'auteur

Ces IA se sont entraînées sur du contenu protégé. Alors que des procès guettent, une solution



# Context



- ❑ Particle physicist in the ATLAS experiment at CERN, involved in AI since 10 years
- ❑ Called for « serious » ChatGPT stories on the ATLAS Machine Learning mailing list.
- ❑ Got ~20. Most typical examples follow
- ❑ (Huge impact on teaching/evaluation, not reported here)

# GPT in one slide

- ❑ provided by (not at all Open) OpenAI, funded mainly by Microsoft (hence connection to Bing and github Copilot) *Check [Pour la Science, juillet 2023](#)*
- ❑ Generative Pre-Trained Transformer : trained to guess the next word
- ❑ learned from a well curated dataset (details unknown). Certainly not “the whole web”, but wikipedia, scientific papers, books etc. Multilingual. Frozen in Sep 2021.
- ❑ Fine Tuned to specific task (here chatbots)
- ❑ RLHF : Reinforcement Learning from Human Feedback to provide structured answers
- ❑ safeguards against hate speech etc... Kids can use it
- ❑ GPT3.5  $\sim 10^{11}$  parameters. Memory  $\sim 10.000$  “tokens” (entity a bit smaller than a word)
- ❑ GPT4  $\sim 10^{12}$  parameters. Memory  $\sim 25.000$  tokens

# ChatGPT and Bing in one slide

- ❑ ChatGPT : <https://chat.openai.com/chat> register
  - GPT3.5 free, GPT4 premium for 24\$/month.
  - Knowledge frozen in Sep 21 (but evidence earlier arXiv are missing)
  - Does not look up the web (GPT4 could from May to ... last week)
  - No sources. Reference and citation often wrong
  - On the prompt one can reference a paper giving its title/authors (NOT the http! Wrong paper)
  - Tends to be very verbose
  - History of all different chats are kept and can be continued
  - <https://platform.openai.com/ai-text-classifier> supposed to detect code written with GPT, not very effective
- ❑ Bing : simply tag @bing in skype or within MS Edge
  - uses GPT4
  - my feeling: looks up on the web and interpret the first few hits
    - →sources are often quoted and correct
    - →not as thorough as ChatGPT
  - newtopic ⇒starts new conversation and forgets the current one (which is still visible skype mode, however Bing answers are deleted after ~10 days)
  - only text input but it is possible to indicate a web page with a pdf (arXiv or on google drive)
  - for more details [this set of rules](#) seems to be followed still, and help understands Bing's behavior
- ❑ Bard : Google GPT, unavailable in most Europe, Canada

# ChatGPT and Bing tips and tricks



- ❑ Social networks are full of amazing stories, but be careful :
  - you don't hear about so-so stories
  - many are **tests done on training data**, like "write a tetris in java" or "comment this article (from 2010)"
- ❑ Tips for both : "prompt engineering" is a thing :
  - "condition" by explaining in detail what is your background and what you want (using positive terms as much as possible)
  - « contextualize » possibly provide your own data (paper, code...)
  - both can output code, but for a real coding assistant github copilot most likely better (see Ed's talk)
  - "Chat": if results not satisfactory complain and ask for more. If code does not compile tell the error
  - Better to ask A, then B, then C, rather than « what about doing C using B and A » or »write a piece of code doing A B and C »
  - although they seem to understand and write very good french, german etc... it is best to interact with them in english for technical stuff
  - Both can « hallucinate »== make up things rather than saying « I don't know »
  - Any calculations can be quite fuzzy (rather use Wolfram Alpha)
  - Lack of reproducibility : stochasticity + discrete upgrades
- ❑ Concerns:
  - what is the license of input and output ?
  - ChatGPT blocked in Italy because of RGPD concerns, [french CNIL is inquiring](#)
  - [CNRS statement](#). Eventually a french GPT « souverain » ?

# Code



ChatGPT/Bing can trivially provide connected code snippets (in **any** language) as one would assemble from Stack Overflow  
Especially for widely used use cases like python ecosystem

# Support

ChatGPT

Daniel Whiteson

Bing



I get an error when I try:

```
$ conda env create -f cpu_environment.yml python=3.9 -n exatrk-cpu  
Solving environment: failed
```

```
CondaValueError: Malformed version string '~!': invalid character(s).
```



It looks like there might be an error in the `cpu_environment.yml` file that you are trying to use to create your conda environment. The error message you are seeing suggests that there might be an issue with the version number specified in the environment file.

To resolve this issue, you could try removing the `python=3.9` argument from your command and see if that works. Here is an updated version of the command:

```
bash Copy code  
  
conda env create -f cpu_environment.yml -n exatrk-cpu
```

(...) → excellent support, better than the local staff

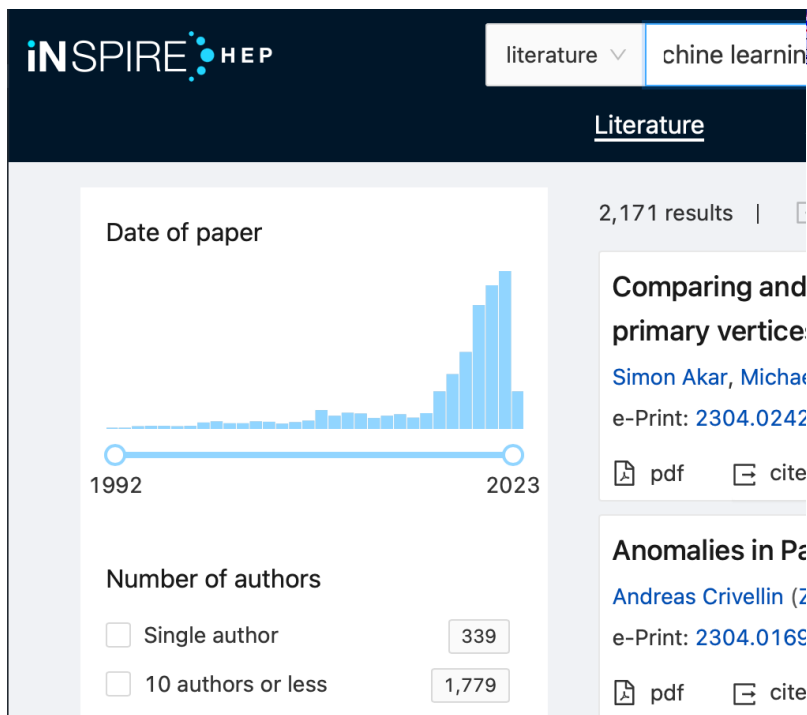
Prompt: why is arXiv web site down ?

Answer: I'm not sure why arXiv web site is down. According to their operational status page 1 <https://status.arxiv.org/>, they are experiencing some issues with their full-text downloads and abstract pages. They are working on resolving them as soon as possible. You can check their Twitter account 3 <https://twitter.com/arxiv> for updates. I hope they will be back online soon.

→ best possible answer



# Using inspirehep api



Bing

Prompt : please provide the python code to use inspire rest api to produce the plot of the number of papers as a function of time fulfilling a given request

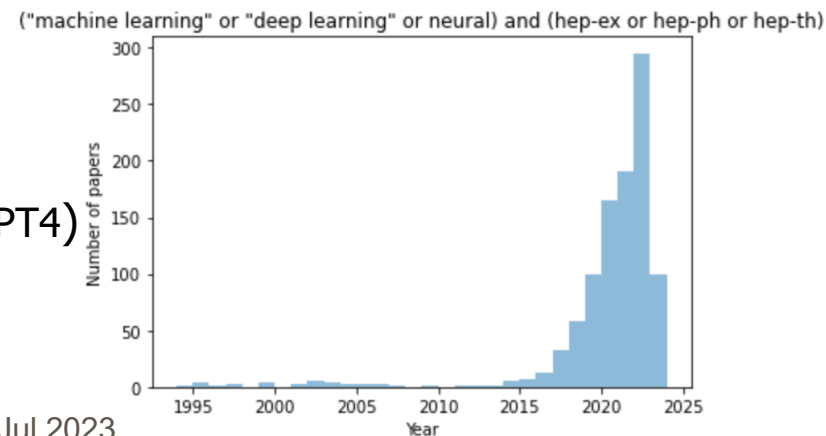
Sure, I can help you with that. Can you please provide me with more details about the request you want to fulfill? What is the request about? What is the format of the data you want to plot? Do you have any specific requirements for the plot?

*Note : had to split the prompt in two (remember A then B rather than A+B)*

Prompt : the request will be about papers containing ("machine learning » or « deep learning » or neural) and (hep-ex or hep-ph or hep-th) (thanks Gregor Kasieczka). The output should be a graph of the number of papers as a function of year

Thank you for providing the details. You can use the following Python code to produce a plot of the number of papers as a function of year fulfilling your request:

→code 80% correct→  
(95% correct with ChatGPT4)



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# Non trivial scipy code

Given a dataset with  $n$  instances stored in a numpy array. Each instance is of dimension  $p$ . For each instance I want to know the index of its nearest neighbour using geometrical distance in dimension  $p$ . Please write the python numpy code which output a new numpy array with an additional dimension which is the index of the nearest neighbour.

Answer:

You can use the KDTree class from the `scipy.spatial` module to find the nearest neighbor of each point in a numpy array. Here's an example code that should do what you're asking for:

```
import numpy as np
from scipy.spatial import KDTree
# Generate some random data

n = 100
p = 3
data = np.random.rand(n, p)
# Build the KDTree
tree = KDTree(data)

# Find the nearest neighbor of each point
distances, indices = tree.query(data, k=2)

# Add the indices of the nearest neighbors as a new column
data_with_indices = np.hstack((data, indices[:, 1].reshape(-1, 1)))
```

This code generates a random numpy array `data` with  $n$  instances of dimension  $p$ . It then builds a KDTree from this data, and uses it to find the nearest neighbor of each point in the array. Finally, it adds the indices of the nearest neighbors as a new column to the original array, and returns the result in `data_with_indices`.

# Wolfram alpha plug in

❑ One of many plugins available with premium subscription



Quelle est l'intégrale de zero à pi de  $\sin(x)/x$  ?

Used Wolfram ^

REQUEST TO WOLFRAM

```
{
  "input": "integral from 0 to pi of sin(x)/x"
}
```

RESPONSE FROM WOLFRAM

Query:  
"integral from 0 to pi of sin(x)/x"

Definite integral:  
 $\int_0^\pi \sin(x)/x \, dx = \text{Si}(\pi) \approx 1.85194$

Visual representation of the integral:  
image:  
<https://www6b3.wolframalpha.com/Calculate/MSP/MSP42851dh94h89h9d9h60300002dbe5hb47251g1cs?MSPStoreType=image/png&s=17>

Indefinite integral:  
 $\int \sin(x)/x \, dx = \text{Si}(x) + \text{constant}$

Wolfram|Alpha website result for "integral from 0 to pi of sin(x)/x":  
<https://www.wolframalpha.com/input?i=integral+from+0+to+pi+of+sin%28x%29%2F%20x>

L'intégrale définie de  $\frac{\sin(x)}{x}$  de 0 à  $\pi$  est égale à  $\text{Si}(\pi)$ , qui est approximativement 1.85194.

Voici une représentation visuelle de l'intégrale:

L'intégrale indéfinie de  $\frac{\sin(x)}{x}$  est  $\text{Si}(x) + \text{constante}$ .

Pour plus d'informations, vous pouvez consulter le résultat sur le site de Wolfram|Alpha : [lien](#).

➔ works great but unclear added value beyond using french

# Writing ATLAS code

ChatGPT

- ❑ Attempt to write ATLAS specific code (3 millions lines of code, on public gitlab since a few years, also many tutorials and documentation)
- ❑ When asked question about specific classes, answers are in general correct
- ❑ However when try to code a simple algorithm
  - Code looks correct by eye, but does not compile
  - Use obsolete constructs
  - Does not put directives and includes appropriately
  - Explanatory text is very good
- ❑ **Overall, not really usable**, github Copilot maybe more promising

# Scientific reading



ChatGPT/Bing are doing very good when asked about textbook knowledge.

But we are doing cutting edge science which is not quite textbook...

# Textbook knowledge query



What does Scheimpflug mean ?



The "Scheimpflug principle" is a basic principle in optical engineering and photography. Named after the Austrian army Captain Theodor Scheimpflug, who applied it to aerial photography, it describes how the orientation of the plane of focus (the sharp region in a photo) is related to the orientation of the lens plane and the image plane.

The principle is typically used in photography and videography to control the field of view and the plane of focus, particularly in situations where a wide depth of field is required or when you want to have a specific part of the image in focus.

In more technical terms, the Scheimpflug principle states that when a lens is tilted relative to the image plane (as is possible with certain types of specialized camera lenses, such as tilt-shift lenses), the plane of focus (PoF) is also tilted relative to the image plane. Furthermore, the lens plane, the image plane, and the PoF intersect at a common line. This is known as the "hinge line". By adjusting the tilt of the lens, a photographer can move and rotate the PoF to achieve the desired focus effect.

It's important to note that the Scheimpflug principle isn't applicable to most ordinary photography because it requires specialized lenses or cameras that allow for movements to adjust the lens plane and/or the image plane. However, for specialized applications such as architectural or product photography, the Scheimpflug principle is very useful.



With prompt engineering:



I am a physicist, quite familiar with scientific matter. But there are topics I'm not quite familiar with. I will ask you questions, please answer them in just one paragraph.



Of course, I'm here to assist you. Please go ahead and ask your questions!



what is Scheimpflug ?



The Scheimpflug principle, named after Austrian Captain Theodor Scheimpflug, is a geometric rule in optical engineering describing the orientation relationship between the lens plane, the image plane, and the plane of focus in an optical system such as a camera. According to this principle, when the lens plane is tilted relative to the image plane, the plane of focus also tilts, and all three planes intersect along a common line known as the "hinge line". This principle is often used in photography to control depth of field, particularly with tilt-shift lenses, enabling selective focus or extended depth in images.

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# Can Normalizing Flows be used at the LHC?

ChatGPT

Yes, normalizing flows can be used at the Large Hadron Collider (LHC) for various tasks, such as data analysis and simulation. Normalizing flows are a type of generative model that can be used to learn the probability distribution of high-dimensional data. In the context of particle physics, normalizing flows can be used to model the probability distribution of particle collision events.

One application of normalizing flows in particle physics is in the simulation of particle collisions. Simulating particle collisions is essential for predicting the outcomes of experiments at the LHC. However, simulating particle collisions is a computationally expensive task that can require significant computing resources. Normalizing flows can be used to speed up the simulation of particle collisions by learning the probability distribution of the particles produced in a collision and generating new samples from that distribution. This can reduce the computational resources required to simulate particle collisions, which can be especially useful for rare events.

Normalizing flows can also be used for data analysis at the LHC. For example, they can be used to learn the probability distribution of signal events and background events in a particle physics experiment. This can be useful for identifying signal events, which are events that are of particular interest to researchers, and distinguishing them from background events, which are events that are produced by other processes and can obscure the signal events.

In summary, normalizing flows can be a useful tool for various tasks in particle physics, including simulation and data analysis at the LHC.

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Bing

Normalizing Flows are generative models which produce tractable distributions where both sampling and density evaluation can be efficient and exact 1. They are used for distribution learning 2.

I found a research paper titled "Normalizing Flows for LHC Theory" which discusses the use of normalizing flows in LHC theory 3. However, I couldn't find any other information about the use of normalizing flows at LHC.

Is there anything else I can help you with?

1. <https://arxiv.org/abs/1908.09257>

2. <https://arxiv.org/abs/1505.05770>

3.

[https://www.researchgate.net/publication/368556193\\_Normalizing\\_Flows\\_for\\_LHC\\_Theory](https://www.researchgate.net/publication/368556193_Normalizing_Flows_for_LHC_Theory)

← best primary reference

- Bing has tried to make sense from the first few hits
- **ChatGPT more thorough but absence of source a clear handicap**
- ...however one should ask follow-up questions ( A then B):

How can normalizing flows be used to learn probability distribution exactly ?

(...)

thanks, please provide as a full latex document

Let's suppose we have a dataset  $\mathcal{D}$  of  $N$  samples, each of which is a high-dimensional vector  $\mathbf{x} \in \mathbb{R}^D$ . The goal of a normalizing flow model is to learn a transformation  $f_\theta : \mathcal{Z} \rightarrow \mathcal{X}$ , parameterized by  $\theta$ , that maps a simple base distribution, such as a Gaussian distribution, to the target distribution.

Specifically, we want to learn the transformation such that the probability density of the transformed samples  $p_{\mathcal{X}}(f_\theta(\mathbf{z}))$  matches the true probability density of the dataset  $p_{\mathcal{D}}(\mathbf{x})$ .

The transformation  $f_\theta$  is constructed by composing a sequence of invertible mappings  $f_i$ :

$$f_\theta = f_K \circ f_{K-1} \circ \dots \circ f_2 \circ f_1$$

Each  $f_i$  is an invertible function that takes as input a vector  $\mathbf{u}_i$  and outputs a vector  $\mathbf{v}_i$ :

$$\mathbf{v}_i = f_i(\mathbf{u}_i)$$

The inverse function of  $f_i$  is denoted by  $g_i$ , such that  $g_i(\mathbf{v}_i) = \mathbf{u}_i$ . The log-likelihood of a sample  $\mathbf{x}$  can be computed using the change of variables formula:


$$\log p_{\mathcal{X}}(\mathbf{x}) = \log p_{\mathcal{Z}}(\mathbf{u}) - \sum_{i=1}^K \log \left| \det \frac{\partial f_i}{\partial \mathbf{u}_i} \right|$$

where  $\mathbf{u} = g_K \circ g_{K-1} \circ \dots \circ g_2 \circ g_1(\mathbf{x})$  is the inverse transformation of  $\mathbf{x}$ , and  $\frac{\partial f_i}{\partial \mathbf{u}_i}$  is the Jacobian matrix of the transformation  $f_i$  with respect to  $\mathbf{u}_i$ . During training, the parameters  $\theta$  are learned by maximizing the log-likelihood of the dataset  $\mathcal{D}$  with respect to  $\theta$ :

$$\theta^* = \arg \max_{\theta} \sum_{\mathbf{x} \in \mathcal{D}} \log p_{\mathcal{X}}(\mathbf{x}; \theta)$$

This optimization can be performed using gradient-based methods, such as stochastic gradient descent.

# Article analysis

- 
- ❑ Prompt: I am a physicist, working at the interface between physics and Machine Learning. What are the main lessons from this paper : <https://arxiv.org/pdf/2105.01160.pdf> ?
  - ❑ Answer: The paper you mentioned 1 is about the TrackML challenge, which was a competition to develop machine learning algorithms for particle tracking in high energy physics. The paper presents the results and lessons learned from the challenge, such as:
    - (...)
    - ❑ → continue with bullet points which are correct about tracking and ML but **some of them are NOT specific to the paper.**
    - ❑ → **some points missing**
    - ❑ → **« Main lessons » is unclear**
    - ❑ But ChatGPT/Bing better if specific questions are asked : how is this technique used in that paper ?



# Science writing



# Document writing

- Please write an abstract for this project: « »
  - → abstract provided, requires 20% edition
- Write ATLAS PhD detector chapter → structure/substructure is quite good
  - text really not usable
- Outreach ideas :
  - « Please explain like I am in high school »
  - Analogies

# Outreach analogy

ChatGPT



what would be a good analogy for the Higgs boson if I am 18 ?



yes yes but please provide a really brand new original analogy



The Higgs boson is a particle that helps give other particles mass, so here's an analogy that might help you understand it better:

Imagine a school hallway where students are moving around, but some of them are able to move faster than others. The faster students are like particles that have less mass, while the slower students are like particles with more mass. Now imagine that there's a teacher in the hallway, and every time a student passes by the teacher, the student gets slowed down a bit. This teacher is like the Higgs field, which particles interact with to acquire mass. The more a particle interacts with the Higgs field, the more massive it becomes.

And just like how some students might have more trouble getting past the teacher and thus end up moving slower, some particles have more trouble interacting with the Higgs field and thus end up being more massive.



Absolutely, here's another original analogy:

Imagine a group of people walking through a field of tall grass. Some people are wearing heavy boots and can easily trample through the grass, while others are wearing lighter shoes and have a harder time making their way through. The Higgs boson is like a thick patch of mud in the field that slows down the people walking through it. As the people with lighter shoes try to make their way through the mud, they sink in and have a harder time moving forward, much like particles interacting with the Higgs boson experience resistance and become more massive.

The strength of the mud patch affects how much it slows down the people walking through it, just like the strength of the interaction between particles and the Higgs boson affects their mass. Particles that interact more strongly with the Higgs boson will have a higher mass, just like how the people wearing heavier boots are less affected by the mud patch than those with lighter shoes.

→ ...a classic

→ It does sound original, but the analogy is backward...

# Turning internal doc into a paper

ChatGPT

- ❑ Internal documentation of ATLAS G4 simulation turned into an ACAT 2022 conf paper : <https://cds.cern.ch/record/2851466>
- ❑ copy-pasted paragraph by paragraph the internal doc and asked it to "rephrase" for formal scientific publication
- ❑ → decent job, but required some fixing
- ❑ Asked for some references
- ❑ → fake citations, including DOI, « hallucinations »
  
- ❑ → in general, ChatGPT/Bing are **much better at rewriting than writing.** (e.g. with improved style or translation). Can also summarise but they might not pick what is most important

# Conclusion

- ❑ ChatGPT more thorough (if <Sep 2021) than Bing but no citation. Premium chatGPT with GPT4 even better than free ChatGPT
- ❑ For code :
  - can provide snippet of code for any common problem in any language, and stitch them together
  - Expert eye/debugging still needed, but overall gain in productivity
  - Can also help understand code
- ❑ To read/analyse document:
  - Great to present formatted answer to textbook question
  - Can answer specific questions and help to think
- ❑ To write document:
  - Can provide structure and ideas
  - Better at rewriting than at writing
- ❑ Remember to give context and to ask step A then step B then step C
- ❑ In all cases, one needs to stay on top of it (80/20)→can be mediocre or plain wrong!
- ❑ Overall a net help to physicist daily tasks, requires some learning curve (the more you use the more you get)
- ❑ I'm happy to collect more testimonies on professional ChatGPT use

# Outlook : ATLAS ChatGPT

- ❑ ATLAS collaboration 3000 physicist since 1992
- ❑ 150 papers/year since 2010 with 200 pages of internal discussions
- ❑ Thousands of internal notes
- ❑ Thousands of internal mailing lists
- ❑ Since 2000 all slides of all meetings readily available in indico.
  - Since 2020 thousands hours of zoom meeting transcribed
- ❑ 3 millions lines of code in public gitlab (plus pull requests discussion since 2015)
- ❑ Imagine an ATLAS ChatGPT fine tuned on all this material ?

Prompt : why is there an electron veto Boosted Decision Tree for tau identification ?

Answer : it was published in 2013 (Ref), first discussed in meetings (indico link), it is described in details in (CDS link). It allows to reduce electron contamination by 25% with an efficiency loss of 1%. The main objection at the time was (). Since then it has been used in many ATLAS analyses like (ref, ref) and the coming paper (link)

- ❑ → many companies promises, many open source models promises, work in progress