

D001 Economic Analysis of Non-Standard Data

Benjamin W. Arold

9. Generative AI

Outline

Training Large Language Models

BERT

GPT

Generative AI for YOUR Research

Intro: Generative AI for Text

- ▶ **Type of generative AI that produces text**
- ▶ AI systems trained to predict the next word given preceding text
- ▶ Typically fine-tuned to follow human instructions and generate responses aligned with human preferences
- ▶ Based on deep neural networks with billions of parameters
- ▶ Built on transformer models (with attention mechanisms, which endogenously assign varying degrees of importance to different words)

Step 1: Pre-Training

- ▶ Calculate conditional probability distribution over words given the preceding words, based on its training data (**Next Token Prediction**)
- ▶ **Self-Supervised Learning**: Model is fed text fragments; parameters are adjusted to predict continuation
- ▶ Terabytes of data (Wikipedia, scientific articles, books, etc.)
- ▶ Neural nets learn language structure:
 - ▶ Syntactic structures
 - ▶ Relationships between words and concepts they represent
 - ▶ Context of sentences and word interactions
 - ▶ Relationships between different sentences

Step 2: Instruction Fine-Tuning

- ▶ Improves model to follow human instructions
- ▶ Example: Pretrained model might predict a continuation of “What is your name?” as “And how old are you?”; this is not what we want
- ▶ Instruction fine-tuning trains the model to respond appropriately
- ▶ **Supervised learning:** Feeding the model millions of examples for responding to thousands of different instructions
- ▶ Used for tasks like summarization, answering questions, brainstorming, etc.

Step 3: Reinforcement Learning

- ▶ Improves model by incorporating human feedback
- ▶ Human raters provide feedback on different responses
- ▶ Helps align model with human preferences, particularly in areas hard to define via instruction fine-tuning
- ▶ Example: Penalizing hateful responses
- ▶ Noisy process:
 - ▶ Partly why LLMs sound authoritative even when hallucinating

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Autoencoding Language Models

- ▶ **Main example: BERT**

- ▶ e.g. **BERT** = “**Bidirectional Encoder Representations from Transformers**”
- ▶ pretrained by dropping/shuffling input tokens and trying to reconstruct the original sequence.
- ▶ usually build bidirectional representations and get access to the full sequence.
- ▶ can be fine-tuned and achieve great results on many tasks, e.g. text classification.

BERT I/II

- ▶ Task: Masked language modeling:
 - ▶ 15% of words masked
 - ▶ if masked: replace with [MASK] 80% of the time, a random token 10% of the time, and left unchanged 10% of the time.
 - ▶ model has to predict the original word.
- ▶ Architecture:
 - ▶ a stack of transformer blocks with a self-attention layer and an MLP.
 - ▶ BERT-Large has 24 blocks, embedding dimension of 1024
≈ 340M parameters to learn.

BERT II/II

- ▶ Unlike GPT, BERT attention observes all tokens in the sequence, reads backwards and forwards (bidirectional).
- ▶ Corpus:
 - ▶ 800M words from English books (modern work, from unpublished authors)
 - ▶ 2.5B words of text from English Wikipedia articles
- ▶ Various extensions: RoBERTa (Robust BERT); VisualBERT

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Autoregressive Language Models

- ▶ **Main example: GPT**

- ▶ e.g. **GPT** = “**Generative Pre-Trained Transformer**”:
- ▶ pretrained on classic language modeling task: guess the next token having read all the previous ones.
- ▶ during training, attention heads only view previous tokens, not subsequent tokens.
- ▶ ideal for text generation.

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 - ▶ trained on the Books corpus (7000+ books)
 - ▶ train on a language modeling task, as well as a multi-task that adds a supervised learning task.

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 - ▶ all articles linked from Reddit with at least 3 upvotes (8 million documents, 40 GB of text)
 - ▶ dispense with supervised learning task, make some other architectural adjustments
 - ▶ make model much bigger

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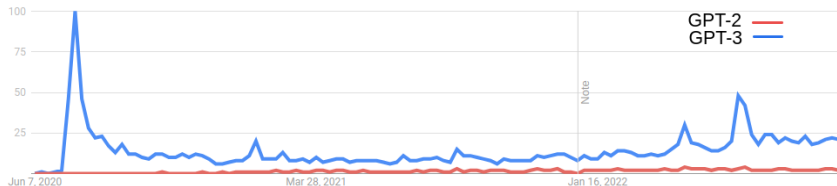
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- ▶ GPT-3 (2020):
 - ▶ use an even bigger corpus (Common Crawl, WebText2, Books1, Books2 and Wikipedia)
 - ▶ make model much, much bigger

OPENAI'S NEW MULTITALENTED AI WRITES, TRANSLATES, AND SLANDERS

A step forward in AI text-generation that also spells trouble

By James Vincent | Feb 14, 2019, 12:00pm EST

Howard, co-founder of Fast.AI agrees. "I've been trying to warn people about this for a while," he says. "We have the technology to totally fill Twitter, email, and the web up with reasonable-sounding, context-appropriate prose, which would drown out all other speech and be impossible to filter."



BUSINESS

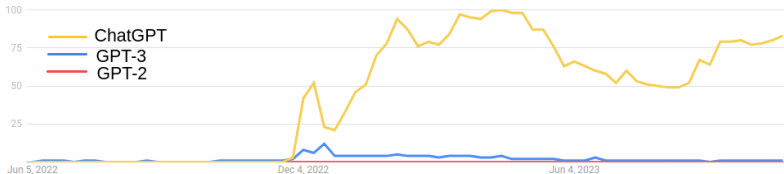
Is ChatGPT the Start of the AI Revolution?

Analysis by The Editors | Bloomberg

December 9, 2022 at 1:39 p.m. EST

The New Chatbots Could Change the World. Can You Trust Them?

Siri, Google Search, online marketing and your child's homework will never be the same. Then there's the misinformation problem.



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- ▶ GPT-4 (2023):
 - ▶ Multimodal model: can take also images as inputs
 - ▶ Trained in two stages:
 1. token prediction (like other GPT models)
 2. **reinforcement learning with human feedback**
 - ▶ Much, much, much bigger model

GPT-4o: Innovations and Improvements

GPT-4o (May 2024) introduced the first native multimodal capabilities, improving speed, multilingual support, and real-time processing.

- ▶ Multimodal processing of text, images, and audio
- ▶ Twice as fast as GPT-4 with lower latency (320ms response time)
- ▶ Extended support for over 50 languages
- ▶ Enhanced audio processing, including speaker recognition and emotion detection
- ▶ Improved visual understanding with better OCR and consistent object rendering
- ▶ Real-time API enabling interactive applications with speech capabilities

GPT-4.5: Innovations and Improvements

GPT-4.5 (Feb 2025) focused on improving accuracy, efficiency, and contextual understanding.

- ▶ Reduced hallucination rate
- ▶ More natural and human-like conversational abilities
- ▶ Better recognition of tone and emotional context
- ▶ Improved logical consistency and reasoning capabilities
- ▶ Optimized for efficiency but remains computationally intensive

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Choose your GenAI model

LLM	Price	Tokens ¹	Data Cutoff	Images	PDFs upload
GPT-4o mini	free	128k	10/2023	yes	yes (limited)
GPT-4o	20\$/month	128k	10/2023	yes+	yes
Claude 3.5 Opus	free/20\$ month	200k	04/2024	no	yes
Gemini 1.5 Pro	free	~30k	08/2024	yes	yes
Llama 3.1-405b	open-source	128k	12/2023	no	no

¹Token calculator: <https://platform.openai.com/tokenizer>

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- ▶ Focus on GPT: at the moment better integrations, more functions, used by main tech. companies like Microsoft (see <https://copilot.microsoft.com/>)
- ▶ Open-source models are catching up fast

¹Token calculator: <https://platform.openai.com/tokenizer>

Generative AI for Economic Research

- ▶ Korinek (2024)²:
 - ▶ Provides an overview of how researchers can exploit these technologies

²The slides for this part follow the outline provided by Korinek (2024)

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 - ▶ Discusses long-run implications of AI for economic research

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 - ▶ Discusses the potential productivity-enhancing effects of cognitive automation
 - ▶ Discusses long-run implications of AI for economic research
- ▶ Main takeaway on LLMs for research:

“Treat LLMs as if it was an intern who is: 1) smart and incredibly motivated and eager to help 2) but completely lacks the context of what you are doing”

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 - ▶ Discusses long-run implications of AI for economic research
- ▶ Main takeaway on LLMs for research:

“Treat LLMs as if it was an intern who is: 1) smart and incredibly motivated and eager to help 2) but completely lacks the context of what you are doing”
- ▶ Good practices:
 - ▶ Provide context (e.g., specify point of view, audience, etc.)
 - ▶ Iterate
 - ▶ Be patient

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Category	Task	Usefulness
Ideation and Feedback	Brainstorming	●
	Feedback	◐
	Providing counterarguments	◐
Writing	Synthesizing text	●
	Editing text	●
	Evaluating text	●
	Generating catchy titles & headlines	●
	Generating tweets to promote a paper	●
Background Research	Summarizing Text	●
	Literature Research	○
	Formatting References	●
	Translating Text	●
	Explaining Concepts	◐
Coding	Writing code	◐
	Explaining code	◐
	Translating code	●
	Debugging code	◐
Data Analysis	Creating figures	◐
	Extracting data from text	●
	Reformatting data	●
	Classifying and scoring text	◐
	Extracting sentiment	◐
	Simulating human subjects	◐
Math	Setting up models	◐
	Deriving equations	○
	Explaining models	◐

Ideation and Feedback

Category	Task	Usefulness
Ideation and Feedback	Brainstorming	●
	Feedback	◐
	Providing counterarguments	◐

Ideation and Feedback: Feedback

SYSTEM

You are a referee report for an economics journal who needs to evaluate a paper by looking at the abstract.

Highlight 3 strengths and 3 limitations of the paper which could undermine their conclusions, writing one sentence for each point.

ASSISTANT

Strengths:

1. The paper utilizes a large dataset of over 250 million job vacancy postings across five English-speaking countries, providing a comprehensive analysis of the shift to remote work.
2. The authors employ a state-of-the-art language processing framework that achieves 99% accuracy in identifying job postings that advertise remote work, surpassing other methods.
3. The study covers a significant time period from 2019 to early 2023, allowing for an examination of the long-term trends and changes in the share of job postings offering remote work.

Limitations:

1. The paper focuses solely on English-speaking countries, which may limit the generalizability of the findings to other regions and cultures.
2. While the authors achieve high accuracy in identifying remote work postings, there may still be some misclassification or ambiguity in the language used, leading to potential measurement errors.
3. The study highlights non-uniformity in the adoption of remote work across cities, industries, occupations, and companies, but it does not delve into the underlying reasons for these differences, which could be crucial for understanding the broader implications of remote work.

Writing

Writing	Synthesizing text	●
	Editing text	●
	Evaluating text	●
	Generating catchy titles & headlines	●
	Generating tweets to promote a paper	●

Writing: Synthesizing Text

USER

Write a paragraph that integrates the following arguments and goes beyond. Include a topic sentence.

- * large language models automate cognitive tasks
- * the work of economists is largely cognitive [add examples]
- * we economists should therefore worry about recent progress in language models
- * in the short run, these models can help us be more productive
- * in the long run, there is a good likelihood that they will displace human economists
- * we should think how to prepare [offer solutions]

ASSISTANT

The rapid advancement of large language models, which are capable of automating cognitive tasks, has significant implications for the field of economics, where the work is predominantly cognitive in nature, such as analyzing data, forecasting trends, and developing policy recommendations. As economists, it is crucial that we acknowledge and address the potential impact of these language models on our profession. In the short term, these models can undoubtedly enhance our productivity by streamlining research, automating data analysis, and even generating insightful reports. However, in the long run, there is a considerable likelihood that these advanced technologies will displace human economists, as they become increasingly adept at performing complex tasks. To prepare for this eventuality, we must consider strategies such as continuous upskilling, focusing on areas where human intuition and creativity are irreplaceable, and advocating for responsible development and deployment of these technologies to ensure that they complement, rather than replace, our expertise.

Background Research

Background Research	Summarizing Text	●
	Literature Research	○
	Formatting References	●
	Translating Text	●
	Explaining Concepts	◐

Background Research: Literature Review (1 year ago)

C

What does the economic literature say about gender differences in media representation of gender-based violence? Please provide me with the most important references from the economics literature (no need for a summary)



I can provide you with some important references from the economics literature on gender differences in media representation of gender-based violence. Please note that the availability of these references may vary, and it's always a good idea to access academic databases or libraries for the most up-to-date research. Here are some relevant references:

1. Anderson, D. A., & Dill, K. E. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of Personality and Social Psychology*, 78(4), 772-790.
2. Bandura, A., Ross, D., & Ross, S. A. (1963). Vicarious reinforcement and imitative learning. *The Journal of Abnormal and Social Psychology*, 67(6), 601-607.
3. Barroso, A. P., & Machin, S. (2011). Crime and the depenalization of cannabis possession: Evidence from a policing experiment. *The Economic Journal*, 121(552), 130-165.
4. Gentzkow, M., Shapiro, J. M., & Stone, D. F. (2015). Media slant against foreign owners: Downsizing. NBER Working Paper No. 20957.

Background Research: Literature Review (today)



Searched 2 sites ▾

Here are some key references from the economic and broader academic literature on gender differences in media representation of gender-based violence:

1. **S. Piccolo, F. Trombetta, T. Paradiso, M. N., & Rollè, L. (2023).**

"Gender and Media Representations: A Review of the Literature on Gender Stereotypes, Objectification, and Sexualization."

This review highlights how media often perpetuates gender stereotypes and objectification, influencing societal attitudes toward violence, sexism, and abuse. It also discusses the psychological effects of these representations, such as internalization of cultural ideals and tolerance of violence.

Published in *International Journal of Environmental Research and Public Health*. [Available here](#).

2. **Oxford Academic Volume on Media, Gender, Sex, and Crime.**

This work examines media's role in shaping public perceptions of crimes like domestic violence and the portrayal of female victims and offenders. It discusses how the media acts as a gendered institution, influencing broader societal narratives. [Accessible here](#).

3. **Springer Studies on Gender-Based Violence Representation.**

Several chapters focus on how power imbalances and cultural narratives are reproduced in media portrayals of gender-based violence, emphasizing the need for reframing to reduce harm and promote gender equity. This includes analysis of journalism's role in shaping public understanding of such issues. [More details available on SpringerLink](#).

Let me know if you'd like to explore a specific aspect of this literature further!

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- ▶ Today the newest version searches the web
- ▶ Still, not 100% reliable – often reports the wrong links

Coding

- ▶ ChatGPT does a decent job with writing code from scratch and debugging:
 - ▶ Good substitute to StackOverflow for some tasks
 - ▶ For more complicated problems needs a lot of back and forth (real life example)

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#write a function to load data from pickle
#and csv files depending on the ending of the file name
def load_data(file):
    if file.endswith('.pkl'):
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- ▶ It does a great job translating code across languages

Data Analysis

Data Analysis	Creating figures	○
	Extracting data from text	●
	Reformatting data	●
	Classifying and scoring text	○
	Extracting sentiment	○
	Simulating human subjects	○

Data Analysis: Extract Data

SYSTEM

You are an investigator assistant, who helps to extract information about crimes from Italian newspaper articles. In particular, I want you to answer the following questions: Does the article mention the murder of a human being that happened in real life in Italy (i.e., not in fiction)? Who is the victim of the murder? Who is the perpetrator or the accused perpetrator? When did the murder happen? What is the perpetrator to the victim (e.g., partner, ex-partner, relative, acquaintance, unknown)?

Answer the questions as concisely as possible and return the answers in a semicolon-separated CSV format with no more than 5 columns, where the column headers are: IS HOMICIDE; VICTIM(S)' FULL NAME; PERPETRATOR(S)' FULL NAME; DATE; RELATIONSHIP

The format of the date should be: %d %B %Y if day, month, and year are available; %d %B Year if only day and month are available; 1 Gennaio %Y if only the year is available; 1 %B %Y if only month and year are available.

IMPORTANT: If there are more than one victim and/or more than one perpetrator separate their names with "and".

If the article is not about a murder as defined before or the murder did not happen in Italy, return: NaN; NaN; NaN; NaN; NaN

Below are a few examples of prompts and responses:

USER

He attempted to kill his ex-partner, 29 years old, and a Milanese tourist who was in the area and was fishing, and who helped her escape. He rammed into them, causing their car to go into a ravine, where they were at risk of drowning. This happened in Terracina, in the province of Latina. In the end, the police managed to apprehend and arrest the man, originally from Rosarno (Reggio Calabria).

Brought to Terracina and threatened with a knife, the 44-year-old, Michelangelo Porretta, who had already been reported by his ex for stalking and aggravated threats, had managed to set up a meeting with the woman, who was at her mother's house in Gaeta.

ASSISTANT

yes; NaN; Michelangelo Porretta; NaN; ex-partner

🕒 Add message

Math

Math	Setting up models	●
	Deriving equations	○
	Explaining models	●

- ▶ There has been improvement in reasoning questions
- ▶ Still limited in solving models

Some Limitations...

- ▶ **Weaker in analytic concepts** due to their *nature* as LLM

Some Limitations...

- ▶ **Weaker in analytic concepts** due to their *nature* as LLM
- ▶ **Limits to reproducibility**
- ▶ **Hallucinations:** LLMs can easily make things up, which limits how much we can leverage their knowledge base
- ▶ **Bias**

... but a Lot of Potential Applications!

- ▶ Fixing OCR errors in digitized text
- ▶ Extract structured information from text articles
- ▶ Classify articles, e.g., distinguish between believing or being sceptical of climate change
- ▶ Interpreting old proverbs
- ▶ Conducting interviews
- ▶ Summarize information
- ▶ Rank documents on non-trivial metrics through pairwise comparisons

Pairwise Comparisons – Arold et al. (2024)

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- ▶ Have GPT validate pairs of clauses:
“Which of these sentences from a union collective bargaining agreement is more likely to be interpreted as an entitlement, benefit, or amenity for workers? Answer ‘Definitely 1’, ‘Probably 1’, ‘Probably 2’, ‘Definitely 2’, or ‘Neither’. 1. [sentence 1]. 2. [sentence 2].

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- ▶ Compute the probability that one clause is more pro-worker than all others
- ▶ Validate previous classification

Pairwise Comparisons – Arold et al. (2024)

Table 4: LLM Validation of Worker Rights as Favoring Workers

Clause Type	Clause Frequency (%)	Pro-Worker Frequency (%)
Worker Right	22.9	79.7
Worker Permission	8.4	67.3
Union Right	2.1	65.7
Firm Obligation	24.7	60.7
Manager Right	0.2	58.4
Worker Obligation	20.9	53.1
Manager Obligation	1.7	44.5
Union Permission	2.0	43.2
Worker Prohibition	3.1	41.6
Manager Prohibition	0.1	38.8
Firm Prohibition	1.5	36.5
Firm Permission	3.4	35.5
Manager Permission	0.4	34.3
Union Obligation	7.0	31.3
Union Prohibition	0.6	28.3
Firm Right	0.9	28.2