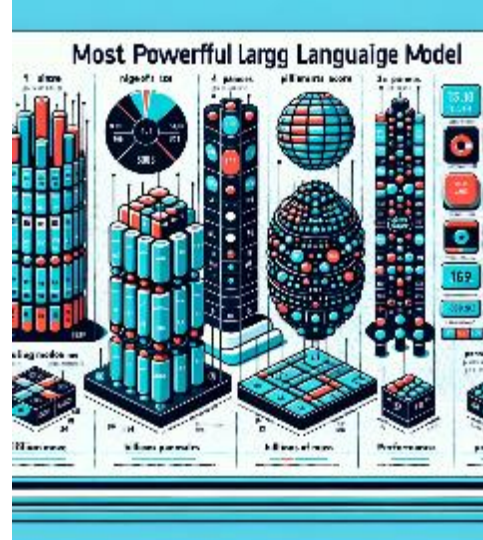


Generative AI for SE



Barclay Brown, PhD, ESEP
Assoc Dir AI Research
Collins Aerospace (RTX)

Knowledge and Skill Based vs. Money Based

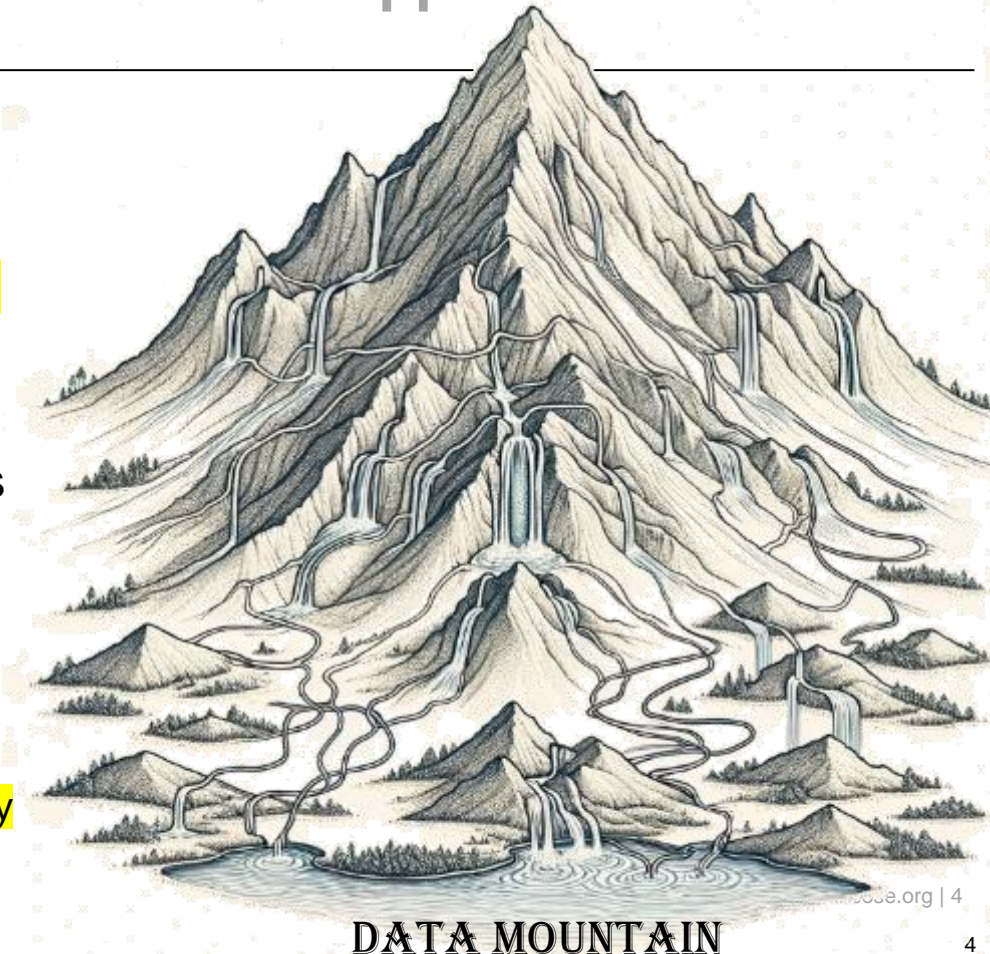


What is Digital Engineering? (the blah blah)

- Digital engineering describes a **holistic approach** to the design of a complex system: Design using models/data instead of documents, integration of **data** across **models**, and the culture change across project teams to realize significant risk reduction on construction cost and schedule. (Idaho National Lab)
- An integrated digital **approach** that uses authoritative sources of systems' **data** and **models** as a continuum across disciplines to support lifecycle activities from concept through disposal. (DAU Glossary)
- Digital engineering is the **art** of creating, capturing and integrating **data** using a digital **skillset**. As an integrated digital **approach**, digital engineering enables engineers to explore possibilities and develop innovative solutions in a virtual environment. (Northrop Grumman)
- **Keys seem to be models, data, and an “approach”**

Let's Consider Some Approaches to the Approach

- Each lake (original data source) is generally **separate**
- One approach: **make all lakes flow** into the ocean, then everyone accesses the ocean
- Another: **Convert each lake** from its original form into a standard *lake format*, then combine into a master lake
- But what about:
 - Enable **anyone** to access **any** lake at **any** time





But hold on... what *are* these lakes?

- Maybe they are more like **islands** than lakes
- Each has a set of important **engineering data in a special format**
- Some are owned by the maker of a tool or toolset (private islands)
- Some have data in more open forms (public islands)
- And now, a place where **all data is totally integrated...**

Welcome to Fantasy Island!

- The vision of a tool, a system, a project, a group whose goal it is to integrate all engineering data together, and then make it all available to all engineers is a fantasy
- While theoretically possible, such projects usually spend millions and accomplish little, and are usually canceled
- The killer tool does not exist
- But why?



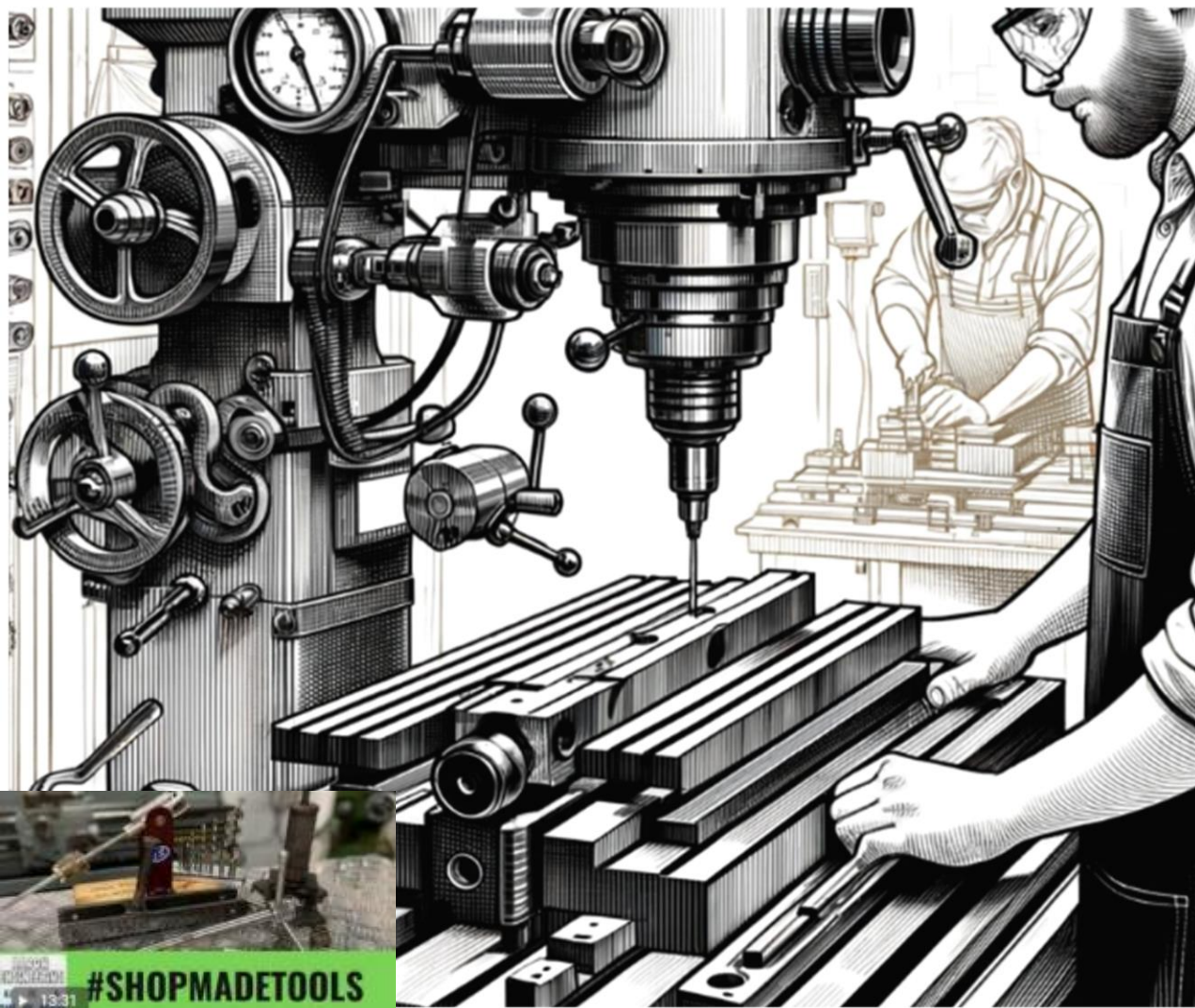
Oh, but that's too negative!

- Instead, consider what kinds of technologies **are successfully** rolled out at an enterprise level to a large user community
 - Email, Spreadsheet systems
 - Collaboration systems
 - SCM and SW Dev Tools
 - Web sites
 - Accounting and financial systems
- **Known and proven** technology
- **Clear** use cases
- **Familiar** paradigms



The Alternative: *Ground-Up Digital Engineering, or* Making Your Own Tools

- Enable engineers to make their own tools
- Machinists often make their own tools, keeping them for later use
- Shop-made tools are personalized, ad-hoc, and a source of pride
- Software developers do the same, building up collections of little utilities, functions, classes, etc. and they reuse and share them



But, what about...

- Our engineers don't have time to make tools; they are too busy getting work done
 - Work can take a lot longer when done manually, without the use of the right tool
- Our engineers don't know how to build tools
 - New (younger) engineers might arrive with those skills
 - They might even be frustrated if they can't build their own tools
- We don't have budget for this
 - Most of what you need is FOSS, or you already have it



Enough Already—Show Me the Tools!

- #1 tool: Python
 - Easy to use language
 - Already “integrated” with everything (except closed-off systems!)
 - Comprehensive world-sourced connectors, libraries, APIs
 - Easy import/export of any data format: Excel, json, csv, Word, text
 - Really good at analysis, statistics, graphical display, plots
- Large Language Models (e.g. ChatGPT, Mixtral, Llama, etc.)
- Can write code for you, or help you write



How Do We Get Started? Three Ways...

- Look for latent talent
 - Skills may **already exist** in the organization
- Think about **embedding** DE skills in your projects
 - NASA JPL has taken this far
- Upskill engineers

Excel with Python for Engineers (4hrs)

- Just want you need to know for to import Excel, do some data manipulation, then output as Excel
- A **gateway** to the capabilities of Python for data science and AI
- **Python Data Science Handbook**,
Jake VanderPlas (open sourced)



Quick Quiz: Chat-No-GPT

- Write a family Christmas poem, including some inside jokes
- Write an effective cover letter for a job application
- Choose between several business ideas based on which will be more successful
- Analyze a project proposal as to its feasibility, budget reasonableness and value
- Summarize a set of project status updates into a brief executive summary
- Check a document to see if it meets a set of written standards for that kind of document
- Write a plan for a project
- Write a good, usable legal brief on a novel subject
- Generate a small database of 100 made-up people, with addresses and phone numbers

Putting Gen AI to Work

Level I: Simple Q&A

- Prompt / response
- Prompt engineering
 - Persona
 - Templates
 - Detailed instructions

Level II: Retrieval-Augmented Generation

- Live supply of info (copy/paste)
- Vectorization of your data
- Retrieval of relevant information
- Prompting of LLM

Level III: Application design

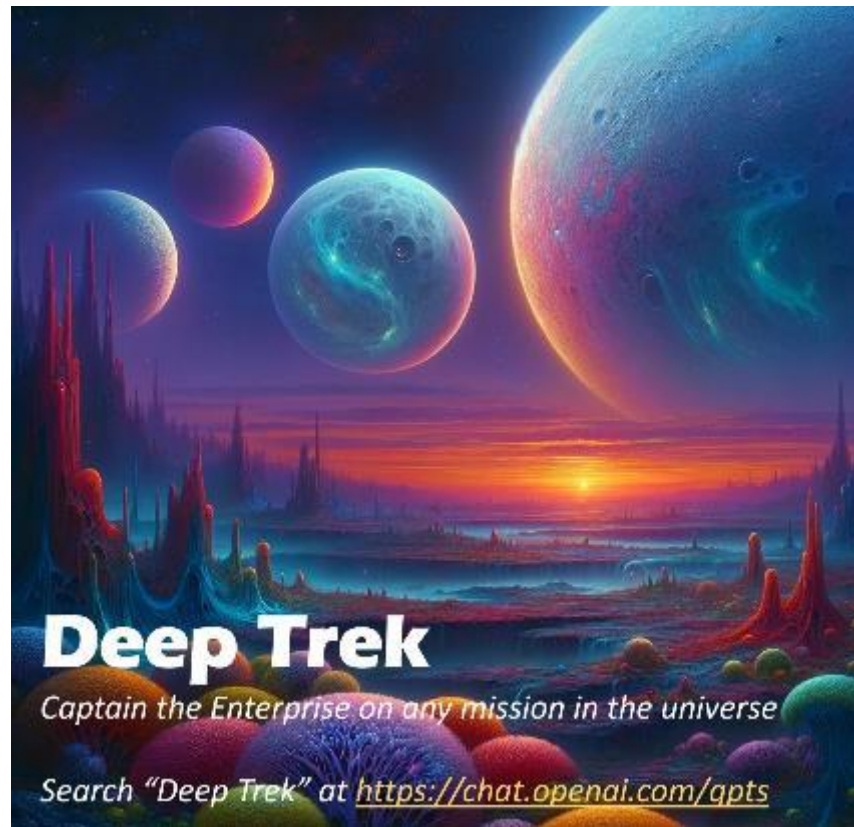
- Multiple prompting hidden from user
- LLM as a component / function
- Combining other elements



(generated by Microsoft Designer)

Deep Trek: A Custom GPT

Always wanted to captain the Enterprise? Fascinated by chatGPT? If you have a chatGPT plus subscription, I'd love for you to try my latest experiment, Deep Trek. It's not a game--think of it more like a virtual universe, with you as captain of the Enterprise. You just jump into the adventure by either requesting a mission from Star Fleet Command, or by setting your own stage with a Captain's Log entry (just like in the series). Take it wherever you want it to go. It has knowledge of the original series (Capt. Kirk) and even more on the next generation series (Capt. Picard) so you can choose your ship and crew or even mix them. Ask Data and Spock to work together on something? No problem. Refer to or ask for research on anything previously seen, or head off in your own direction. Make first contact with alien species, make friends, collaborate on projects, enhance the ship. Try anything. Here's the full link or just search Deep Trek in the custom GPT area of chat.openai.com.



An exercise: Your Resume

Barclay R. Brown, Ph.D., ESEP
Phone: +1 302-272-5291
barclay@barclaybrown.com

Summary

- ☐ Technical Leadership in Generative AI Applications across large organizations
- ☐ AI, Data Science, and Machine Learning Systems Research, Development, and Application
- ☐ Deep Industry Experience: Aerospace and Defense and Systems Engineering
- ☐ Communication and Technical Presentation; accomplished public speaker, author
- ☐ Hands on practitioner: Python, Machine Learning, Data Science, Systems Engineering

Education / Certification

Ph.D., Industrial and Systems Engineering, University of Central Florida, Orlando, FL
M.A., Psychology, State University of West Georgia, Carrollton, GA
Intelligence. He has been a keynote speaker at prestigious events such as the IBM Systems Engineering Agile Summit.

did Barclay Brown ever work for a defense company in Germany

ChatGPT

I do not have specific information about Barclay R. Brown's employment history beyond the information provided in the profile you provided. As of my last knowledge update in September 2021, there was no information available about him working for a defense company in Germany. Please note that his employment history might have changed since then, and I do not have access to real-time or updated information. If you require the most current information about his career, you may consider conducting an online search or contacting relevant organizations directly for verification.

did barclay brown ever work for a defense company

ChatGPT

Yes, according to the information provided in the profile you initially shared, Barclay R. Brown has experience in the Aerospace and Defense industry. His professional experience includes roles such as an Associate Director for Artificial Intelligence Research at Collins Aerospace/RTX and an Engineering Fellow in Systems Engineering at Raytheon Technologies. These roles indicate his involvement with defense companies in the aerospace and defense sector. However, I do not have information about specific defense companies he may have worked for beyond what is mentioned in the profile.

Twas the Night

Write a Christmas poem in the style of "Twas the night before Christmas" and include the following people: Larry and Dorothy his wife, Bill, Hazel; Honor and Barclay--a couple, Professor Kim--a man, Also include the following organizations and concepts: INCOSE (an organization), QMI (an educational institution), Vocational certainty, zero defects attitude, personal authenticity, executive credibility, and the phrase "one worm".

'Twas the night before Christmas, and in a quaint little town,
Larry and Dorothy, husband and wife, settled down.
With dreams of their friends, Bill, Hazel, and more,
They awaited the magic, for 'twas Christmas, for sure.

Honor and Barclay, a loving, happy pair,
In their cozy abode, they had not a care.
Their hearts filled with joy as they snuggled up tight,
For Christmas was coming, and it felt just right.

Professor Kim, a wise man with knowledge so vast,
Prepared for the holiday, his lessons unsurpassed.
In the warmth of his home, by the soft candlelight,
He pondered on wisdom through the long winter's night.

INCOSE, an organization, dedicated and true,
Worked hard all year through, with tasks to pursue.
With a zero defects attitude, they strived to excel,
In shaping a world where great stories would dwell.

QMI, an institution of learning so grand,
Taught vocational certainty, a guide to understand.
With personal authenticity and executive flair,
They nurtured young minds with utmost care.

As the snow gently fell, covering the ground,
The town came alive with a magical sound.
The phrase, "one worm," whispered on the air,
A symbol of hope, for all hearts to bear.

In this season of giving, love, and goodwill,
Let us cherish the moments, both quiet and still.
With family and friends, together we'll find,
The true joy of Christmas, in our hearts intertwined.

If it please the Court...

Write a legal brief, citing relevant cases on the issue of whether a passenger in a car can be held partially liable as the cause of a crash

<https://chat.openai.com/share/3a7a9db5-b333-430a-8373-83b9c80018c7>

LLM as a Component in a System or Application

The following numbered items are responses to the question, "In your own words (not restating vision or mission), what do you think of when you think about what the work of INCOSE should be?" Please summarize these in a list, giving more emphasis to concepts mentioned in more than one response. Use no more than ten items in your list and no more than 200 words in your response. <survey responses>

(Survey Question: In your own words (not restating vision or mission), what do you think of when you think about what the work of INCOSE should be?)

- Not necessary to turn over the entire application to the LLM
- Consider small tasks that an LLM can perform as part of larger application
 - Summarizing input text from a database or survey
 - Composing a reply, notification, or other message to users
 - Creating an introduction to a diverse set of information


1. Advancing Systems Engineering: By enhancing the discipline, its application, and expanding its body of knowledge. This involves moving from a process-focus to an outcome-focus, and making it more effective in solving real-world problems (1, 3, 5, 6, 11, 13, 21, 23).
2. Global Influence: Promoting Systems Engineering globally, addressing 21st Century's challenges, and facilitating its advance worldwide (2, 6, 12, 17, 22).
3. Tackling Societal Issues: Using Systems Engineering to address societal problems and promote sustainable use of resources (7, 9, 15).
4. Supporting Systems Engineers: Through community building, professional development, and practical support, providing clear guidance to engineer systems (10, 16, 20, 31).
5. Outreach: Expanding the awareness and promoting the value of Systems Engineering across all industries and domains (4, 8, 14).
6. Collaboration: Encouraging collaboration among Systems Engineers worldwide, to improve practices and develop systemic solutions (28, 29, 33).
7. Systems Thinking: Disseminating the importance of, and delivering methods for, practical Systems Thinking (18, 22, 32).
8. Knowledge Sharing: Building upon global system experiences, sharing relevant knowledge and good practices in the field (2, 7, 14).
9. Future Focus: Envisioning and leading the future of engineering for systems, while being creative and future-focused (10, 12, 30).
10. Practical Guidance: Providing practical guidance in systems design, impact assessment and to address complex challenges (26, 27).


Let the LLM do what it does best

Prompt Engineering

- Give clear and specific instructions
 - Use delimiters to indicate distinct parts of input
 - Ask for structured output
 - Ask the model to check whether conditions are satisfied
- Give the model “time to think”
 - Proceed step by step
 - Give procedural instructions
- Refine prompts iteratively
 - Vary adjectives
 - Refine the persona








IN COLLABORATION WITH


ChatGPT Prompt Engineering for Developers

Go beyond the chat box. Use API access to leverage LLMs into your own applications, and learn to build a custom chatbot.

- Learn prompt engineering best practices for application development
- Discover new ways to use LLMs, including how to build your own chatbot
- Gain hands-on practice writing and iterating on prompts using the OpenAI API

 Beginner to Advanced  Iva Furlford, Andrew Ng

 Prerequisite recommendation: Basic Python

[Enroll For Free](#) [Learn more](#)

Example: Preparing for a Panel

Prompt: you are an expert on sustainability in systems, and on systems thinking and systems engineering, and also an experienced and engaging talk show host. Please generate preparation materials for a talk show on the concept of sustainability in systems, with panelists from major manufacturing companies and sustainability organizations. First, list ten major themes in sustainability in systems, with references to articles and books. Next, generate ten thoughtful and engaging questions to ask panelists about sustainability and systems that will generate interesting conversation.

Response: Ten Major Themes in Sustainability in Systems

Circular Economy

Reference: "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough & Michael Braungart

Concept: The idea of designing systems that eliminate waste and promote the reusability of products.

Energy Efficiency

Reference: "The Fifth Fuel: Strategies for Sustainable Energy" by Alliance to Save Energy

Concept: Techniques and strategies for reducing energy consumption and improving energy utilization in systems.

Life Cycle Analysis

Reference: "Life Cycle Assessment: Principles and Practice" by Mary Ann Curran

Concept: The comprehensive examination of a product's environmental and social impacts throughout its entire life cycle.

Supply Chain Sustainability

Reference: "Sustainable Logistics and Supply Chain Management" by David B. Grant, Alexander Trautrimis, and Chee Yew Wong

Concept: Addressing sustainability in every link of the supply chain, from procurement to distribution.

Corporate Social Responsibility (CSR)

Ten Thoughtful and Engaging Questions for Panelists

Circular Economy: How are your organizations transitioning towards a circular economy, and what challenges have you encountered? Energy Efficiency: Can you share some specific examples of energy-efficient systems you've implemented and their impact?

Life Cycle Analysis: How do you incorporate life cycle analysis into your product design and decision-making processes?


Supply Chain Sustainability: What sustainable practices are you incorporating into your supply chain to minimize negative environmental and social impacts?

Corporate Social Responsibility: Beyond compliance, how does CSR shape your business decisions and systems design?

...

Example: formatted output

- Prompt: Consider the text below. Identify all common parts of speech in the text and create a table in json format with keys: word, part of speech, number of occurrences of the word. text: "Four score and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty, and dedicated to the proposition that all men are created equal. "Now we are engaged in a great civil war, testing whether that nation, or any nation so conceived and so dedicated, can long endure. We are met on a great battlefield of that war. We have come to dedicate a portion of that field as a final resting place for those who here gave their lives that that nation might live. It is altogether fitting and proper that we should do this. "But in a larger sense we cannot dedicate, we cannot consecrate, we cannot hallow this ground. The brave men, living and dead, who struggled here have consecrated it, far above our poor power to add or detract. The world will little note, nor long remember, what we say here, but it can never forget what they did here. It is for us the living, rather, to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task



Sure, I can help you with that. Here's the JSON table with the identified words, their parts of speech, and the number of occurrences in the given text:

```
json
```

Copy code

```
[
  { "word": "Four", "part_of_speech": "CD", "occurrences": 1 },
  { "word": "score", "part_of_speech": "NN", "occurrences": 1 },
  { "word": "and", "part_of_speech": "CC", "occurrences": 1 },
  { "word": "seven", "part_of_speech": "CD", "occurrences": 1 },
  { "word": "years", "part_of_speech": "NNS", "occurrences": 1 },
  { "word": "ago", "part_of_speech": "RB", "occurrences": 1 },
  { "word": "our", "part_of_speech": "PRPS", "occurrences": 2 },
  { "word": "fathers", "part_of_speech": "NNS", "occurrences": 1 },
  { "word": "brought", "part_of_speech": "VBD", "occurrences": 1 },
  { "word": "forth", "part_of_speech": "RB", "occurrences": 1 },
  { "word": "on", "part_of_speech": "IN", "occurrences": 1 },
  { "word": "this", "part_of_speech": "DT", "occurrences": 3 },
```


Asking the model to check its own results

The best move for 'O' is to take position 5, the center of the board. This is the optimal move as it blocks 'X' from having a chance to win in the next move through the diagonal (positions 3, 5, 7). The updated board would look like:

markdown

Copy code

```
X | O | X
-----
- | O | -
-----
X | - | O
```

The numbers corresponding to the board positions would look like:

mathematica

Copy code

```
1-X, 2-O, 3-X, 4-empty, 5-O, 6-empty, 7-X, 8-empty, 9-O.
```

Regenerate

BA

I'll take position 4 for X

AI

Alright, if 'X' is placed in position 4, the board now looks like this:

markdown

Copy code

```
X | O | X
-----
X | O | -
-----
X | - | O
```

The numbers corresponding to the board positions would look like:

mathematica

Copy code

```
1-X, 2-O, 3-X, 4-X, 5-O, 6-empty, 7-X, 8-empty, 9-O.
```

With this move, 'X' has created two possible winning lines (vertical and diagonal), and 'O' must block one of them in the next move.

BA

Is the game over

AI

My apologies for the oversight. Yes, you're correct. The game is indeed over. With the placement of 'X' in position 4, 'X' has three in a row vertically on the leftmost column (positions 1, 4, 7). This is a winning condition for Tic-Tac-Toe.

Here is the final board for clarity:

Regenerate

Learn how to “talk” to LLMs through practice

Let's Proceed Step by Step

- Explain as you would to an intelligent but inexperienced human
- Step by step instructions are very helpful
- Use delimiters to differentiate instructions from source material

```
text = f"""
In a charming village, siblings Jack and Jill set out
a quest to fetch water from a hilltop \
well. As they climbed, singing joyfully, misfortune \
struck-Jack tripped on a stone and tumbled \
down the hill, with Jill following suit. \
Though slightly battered, the pair returned home to \
comforting embraces. Despite the mishap, \
their adventurous spirits remained undimmed, and they
continued exploring with delight.
"""

# example 1
prompt_1 = f"""
Perform the following actions:
1 - Summarize the following text delimited by triple
backticks with 1 sentence.
2 - Translate the summary into French.
3 - List each name in the French summary.
4 - Output a json object that contains the following
keys: french_summary, num_names.

Separate your answers with line breaks.

Text:
```{text}```
"""

response = get_completion(prompt_1)
print("Completion for prompt 1:")
print(response)
```

# Using a Prompt and Response Templates

**Free-form emails come in requesting registration in a course. Use LLM to extract the important information**

**From:** Tren [REDACTED]  
**Sent:** Wednesday, September 6, 2023 11:05 AM  
**To:** Barclay Brown [Barclay.Brown@incose.net](mailto:Barclay.Brown@incose.net)  
**Subject:** SEQM QMI Training

Hello, [REDACTED]  
My name is [REDACTED] would like to sign up for the SEQM QMI training course cohort. I'm a new member of the working group and INCOSE, excited to learn more!

Thanks,  
TM



```
{
 'reg': 'y',
 'Fn': 'Tr',
 'Ln': 'Mi',
 'Member N',
 'Email': '[REDACTED]@gmail.com',
 'emdate': '09/06/2023'
}
```

messages = [{"role": "system", "content": "You are an AI assistant that helps people find information."}, \n {"role": "user", "content": "consider the email delimited by triple backticks. Extract the following \n items into a python dictionary in the following format.

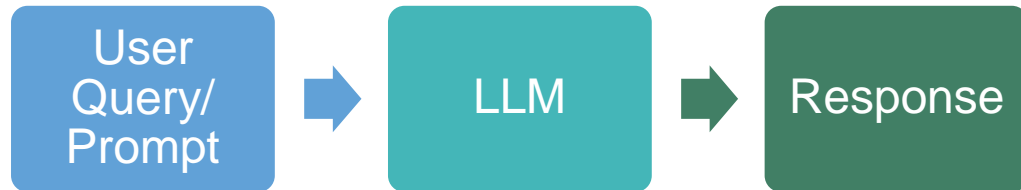
Show only the python dictionary--do not \n include any other messages or text: reg (yes or now): Is the email requesting to register in a course?; \n Fn: What is the registrant's first name?; Ln: What is the registrant's last name?; \n Member Number: What is the registrant's member number?; \n Email: What is the registrant's email address?; emdate: What date was the email sent? format mm/dd/yyyy; \n ``` + emailtext + ``` }},

**Ask for what you want—you might just get it!**

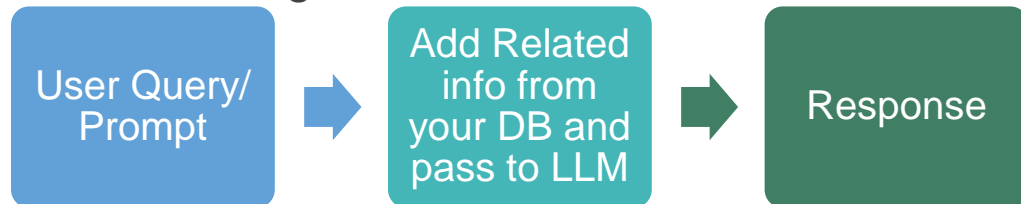
# Retrieval Augmented Generation: *An LLM Application Pattern*

- Find source material
- Create index and store
- Take user prompt, and search for related information in index
- Pass search results along with prompt to LLM
- The indexer calls an type of LLM to build the index, **so KNOW where your data is going!**
- Indexers may use commercial embedding models like
- Llama-index can also work with open source and downloaded LLMs

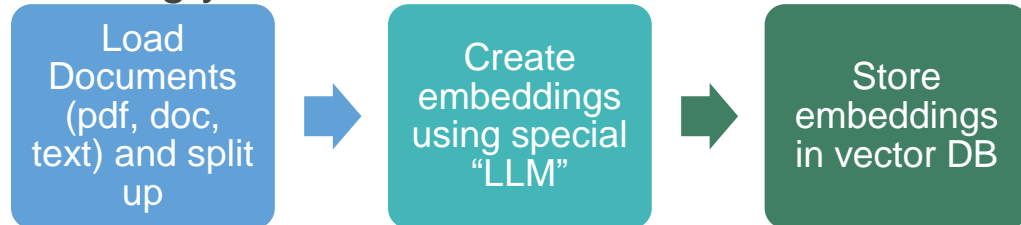
## LLM Chat



## Retrieval-Augmented Generation



## Building your DB





# Building a DB of information for RAG

- Collect documents in common formats
  - Pdf
  - Text
  - Word
- Use loaders, like those from the LangChain library, to load documents into memory structures
- Split documents into chunks to allow granular retrieval (also from LangChain)
  - Split by separator
  - Recursive splitter
- Create embedding vectors for each chunk and store in a vector database (e.g. ChromaDB)
- Persist Vector DB on disk for future runs
- Rebuild index when source docs are added or updated

Collect Documents

Use Loaders

Split Docs

Split By Separator

Recursive Splitter

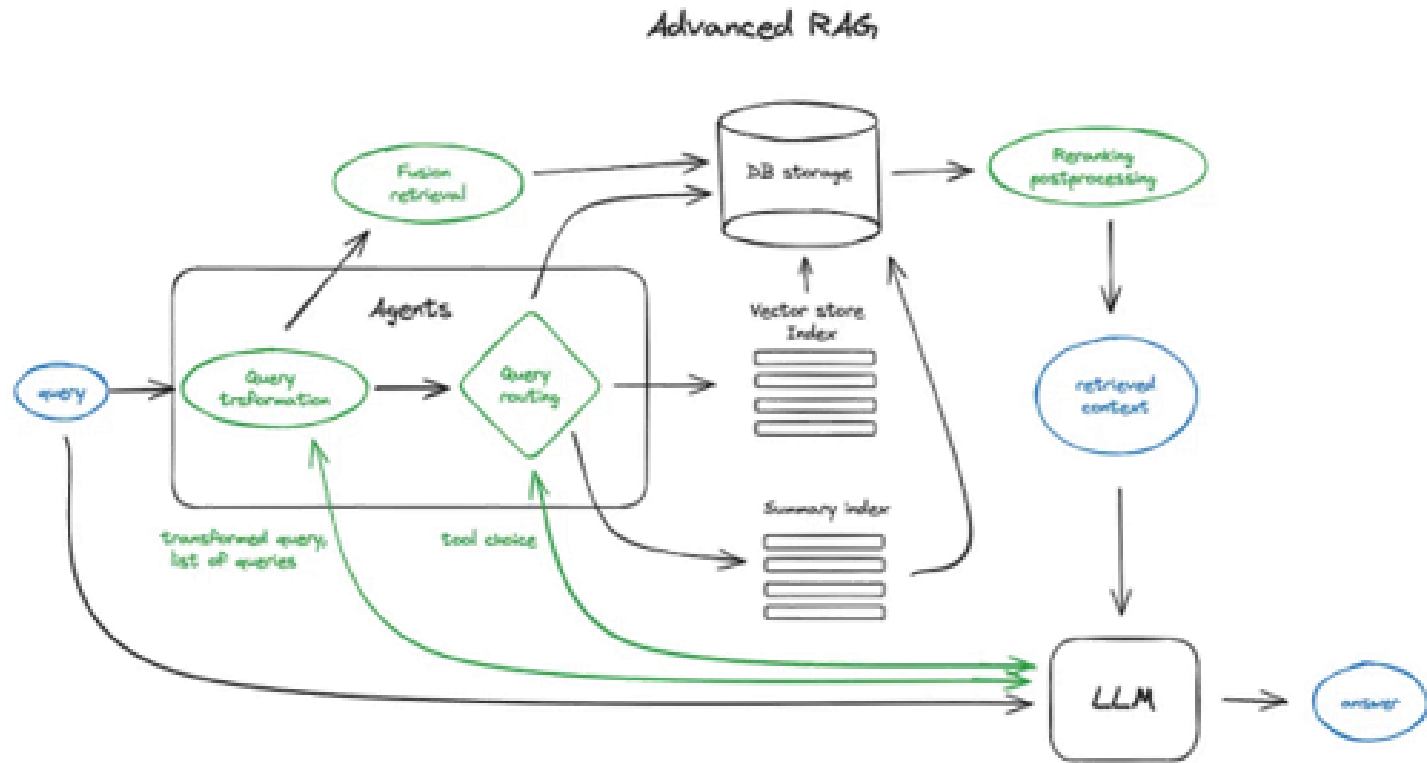
Create Embedding Vectors

Persist Vector DB

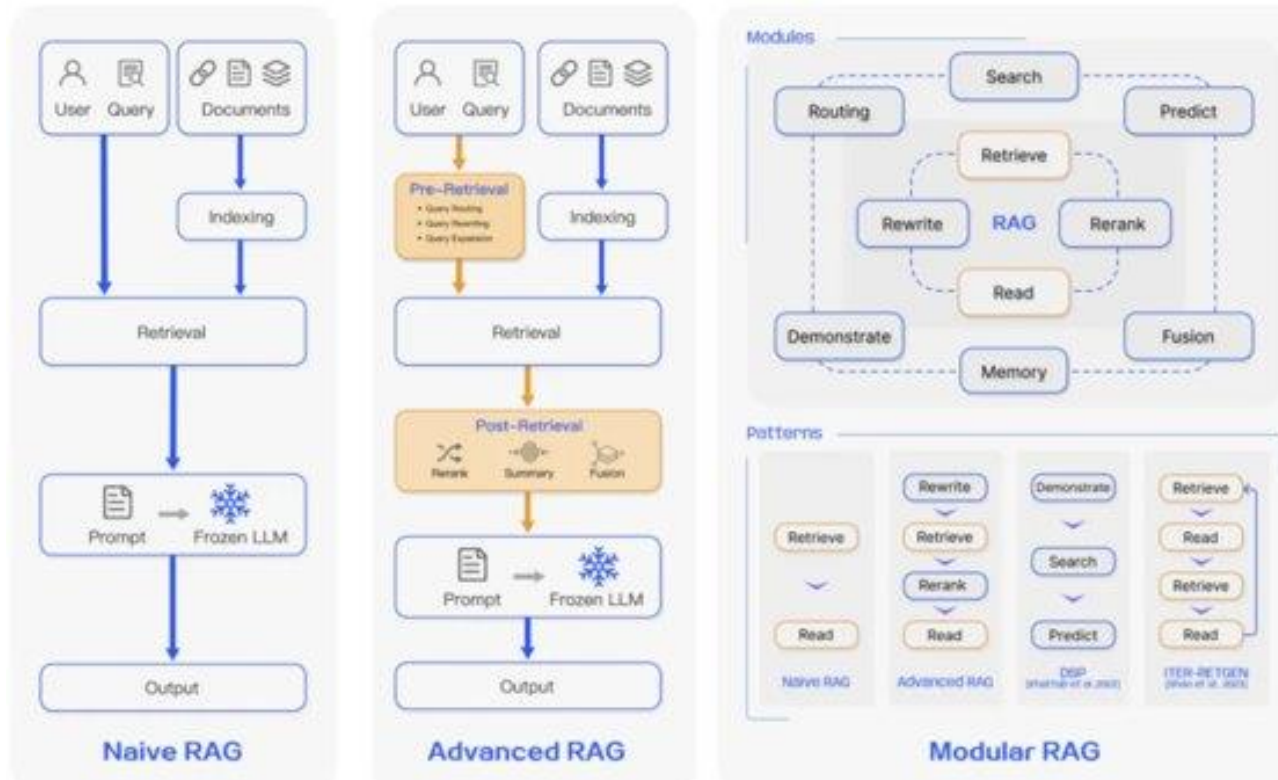
Rebuild Index

(Illustration created by GPT-4 in using svg output format)

# Advanced RAG



# RAGification Evolution



# RAG using Python

- RAG on a book text



booker.txt



# BACKUP

# LLMs are based on Transformers, which add...

- Positional encoding

The dog is barking

1 2 3 4

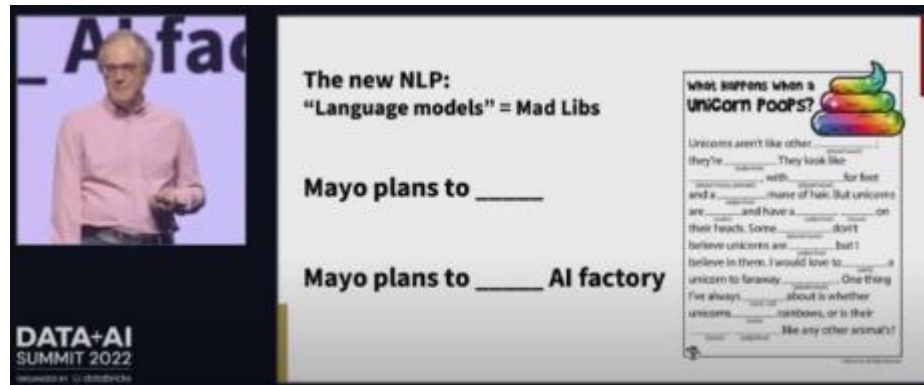
- Attention vectors

The **dog** is **barking**

1 **2** 3 **4**

- What is it learning to do?  
Predict the **NEXT WORD** given a sequence of words
- Train it on large text and reward it for correct predictions

Original paper: Attention is All you need  
(<https://arxiv.org/pdf/1706.03762.pdf>)



Chris Manning (Stanford): Large Language Models learn to play the MadLibs Game

**Excellent video:**

<https://www.youtube.com/watch?v=YfXc4OBDmnM&t=12s>

# Attention Model

*(from original paper)*

- Develop neural network structure
- Fill it with random numbers
- Train it by pretending to predict words from existing text
- Use error to refine weights and biases
- Train it A LOT
- Now use the model to predict words

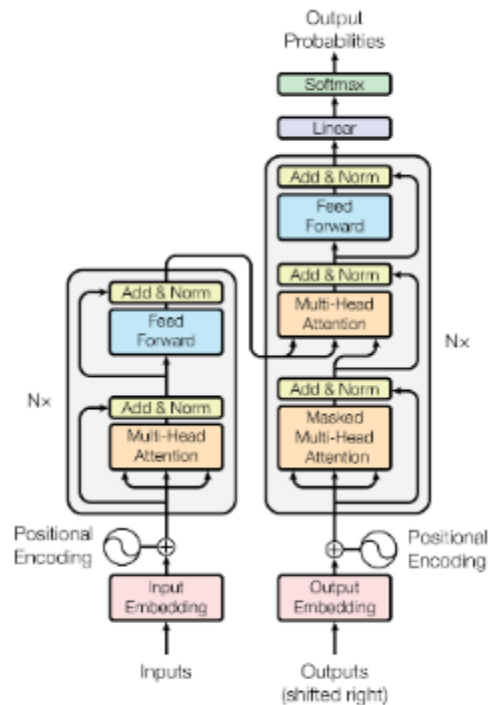


Figure 1: The Transformer - model architecture.

From: Attention is All you need  
(<https://arxiv.org/pdf/1706.03762.pdf>)

# Open AI Models

Search for your model and press ENTER...

Columns to show

Average ☒ ARC ☒ HellaSwag ☒ MMLU ☒ TruthfulQA ☐ Type

Precision ☐ Hub License ☐ #Params (B) ☐ Hub ☒ Model sha

How gated/private/deleted models

Model types

☒ pretrained ☐ fine-tuned ☐ instruction-tuned ☐ RL-tuned

Precision

☒ torch.float16 ☒ torch.bfloat16 ☒ torch.float32 ☒ 8bit ☒ 4bit ☒ GPTQ

Model sizes

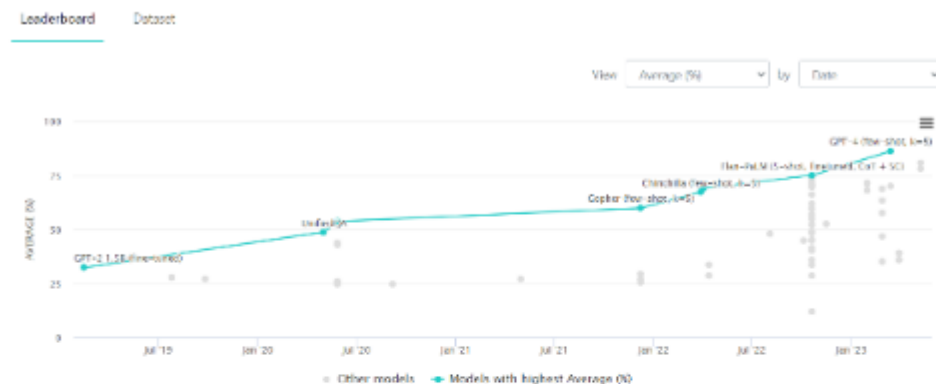
☒ Unknown ☒ < 1.5B ☒ ~3B ☒ ~7B ☒ ~13B ☒ ~35B ☒ 60B+

Model	Average <input checked="" type="checkbox"/>	ARC	HellaSwag	MMLU	TruthfulQA
<a href="#">tiiuae/falcon-180B</a>	68.74	69.8	88.95	78.54	45.67
<a href="#">tiiuae/falcon-180B</a>	68.57	69.45	88.86	78.5	45.47
<a href="#">tiiuae/falcon-180B</a>	68.7	69.71	88.98	78.44	45.66
<a href="#">meta/llama/llama-2-70b-hf</a>	67.35	67.32	87.33	69.83	44.92
<a href="#">tiiuae/falcon-180B</a>	68.21	69.2	88.89	69.59	45.16
<a href="#">TigerResearch/tigerbot-70b-base</a>	66.88	62.46	83.61	65.49	52.76
<a href="#">huggingllama/llama-65b</a>	64.23	63.48	86.09	63.93	43.43
<a href="#">llama-65b</a>	64.23	63.48	86.09	63.93	43.43
<a href="#">llama-30b</a>	61.68	61.26	84.73	58.47	42.27
<a href="#">circulus/llama-2-13b-orca-v1</a>	62.91	62.83	82.27	57.71	49.61
<a href="#">tiiuae/falcon-40b</a>	61.48	61.95	85.28	56.98	41.72
<a href="#">meta/llama/llama-2-13b-hf</a>	58.66	59.39	82.13	55.77	37.38



## COMMERCIAL MODELS

## Multi-task Language Understanding on MMLU



Filter: few-shot fine-tuned zero-shot untagged

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Rank	Model	Average <sup>†</sup> (N)	Human/Tox	STEM	Social Sciences	Other	Parameters (Billion)	Tokens (Billion)	Paper	Code	Result	Year	Tags
1	GPT-4 (few-shot, k=5)	86.1							GPT-4 Technical Report			2023	<a href="#">View plot</a>
2	Flan-PaLM 2 (L)	81.2							PaLM 2 Technical Report			2023	
3	PaLM 2 (k=9)	78.3							PaLM 2 Technical Report			2023	
4	Flan-PaLM (2-shot, finetuned, CoT + SI)	75.2					540		Scaling Instruction-Finetuned Language Models			2022	<a href="#">View tuned</a>
5	Flan-U-PaLM 540B	74.1					540		Scaling Instruction-Finetuned Language Models			2022	<a href="#">View tuned</a>
6	Flan-PaLM (3-shot, finetuned)	72.2					540		Scaling Instruction-Finetuned Language Models			2022	<a href="#">View tuned</a>

- LLM as component
- Prompt engineering
- Application Patterns
  - Multi-prompting
  - Retrieval-Augmented Generation
  - Deconstructing Data



# LLM as a Component in a System or Application

The following numbered items are responses to the question, "In your own words (not restating vision or mission), what do you think of when you think about what the work of INCOSE should be?" Please summarize these in a list, giving more emphasis to concepts mentioned in more than one response. Use no more than ten items in your list and no more than 200 words in your response. <survey responses>

**(Survey Question: In your own words (not restating vision or mission), what do you think of when you think about what the work of INCOSE should be?)**

- Not necessary to turn over the entire application to the LLM
- Consider small tasks that an LLM can perform as part of larger application
  - Summarizing input text from a database or survey
  - Composing a reply, notification, or other message to users
  - Creating an introduction to a diverse set of information

1. Advancing Systems Engineering: By enhancing the discipline, its application, and expanding its body of knowledge. This involves moving from a process-focus to an outcome-focus, and making it more effective in solving real-world problems (1, 3, 5, 6, 11, 13, 21, 23).
2. Global Influence: Promoting Systems Engineering globally, addressing 21st Century's challenges, and facilitating its advance worldwide (2, 6, 12, 17, 22).
3. Tackling Societal Issues: Using Systems Engineering to address societal problems and promote sustainable use of resources (7, 9, 15).
4. Supporting Systems Engineers: Through community building, professional development, and practical support, providing clear guidance to engineer systems (10, 16, 20, 31).
5. Outreach: Expanding the awareness and promoting the value of Systems Engineering across all industries and domains (4, 8, 14).
6. Collaboration: Encouraging collaboration among Systems Engineers worldwide, to improve practices and develop systemic solutions (28, 29, 33).
7. Systems Thinking: Disseminating the importance of, and delivering methods for, practical Systems Thinking (18, 22, 32).
8. Knowledge Sharing: Building upon global system experiences, sharing relevant knowledge and good practices in the field (2, 7, 14).
9. Future Focus: Envisioning and leading the future of engineering for systems, while being creative and future-focused (10, 12, 30).
10. Practical Guidance: Providing practical guidance in systems design, impact assessment and to address complex challenges (26, 27).

Let the LLM do what it does best

# Destructuring Data

- Traditional thinking: structured data is better than unstructured for computer applications
- LLM thinking: LLMs understand natural language, but structured data may not carry the meaning in the structure in an obvious way
- Metaphor: Humans often need other humans to explain structured data, tables, plots, diagrams, etc. in natural language so they can understand
- Memo from LLM: maybe explain the data to me too!

X-ref: F30 Platform code includes M3 4dr Sedan (3.0L 6cyl Turbo 7A), M3 4dr Sedan (3.0L 6cyl Turbo 6M), M3 4dr Sedan (3.0L 6cyl Turbo 6M), 340i xDrive 4dr Sedan AWD (3.0L 6cyl Turbo 8A), ActiveHybrid 3 4dr Sedan (3.0L 6cyl Turbo gas/electric hybrid 8A), 340i 4dr Sedan (3.0L 6cyl Turbo 8A), 340i xDrive 4dr Sedan AWD (3.0L 6cyl Turbo 8A), 328d xDrive 4dr Wagon AWD (2.0L 4cyl Turbodiesel 8A), 340i 4dr Sedan (3.0L 6cyl Turbo 8A)...

B	C	D	E	DR	DS
Make	Model	Year	Trim (Description)	Car classification	Platform code / generation number
BMW	3 Series	2018	M3 4dr Sedan (3.0L 6cyl Turbo 7A)	Compact car	F30, F31, F80
Ford	F-150	2021	Limited 4dr SuperCrew 4WD 5.5 ft. SB (3.5L 6cyl Turbo 400)	Full-size pickup tru (13th gen)	
Ford	F-150	2020	Limited 4dr SuperCrew 4WD 5.5 ft. SB (3.5L 6cyl Turbo 400)	Full-size pickup tru (13th gen)	
Ford	F-150	2021	Limited 4dr SuperCrew 5.5 ft. SB (3.5L 6cyl Turbo 400)	Full-size pickup tru (13th gen)	
BMW	3 Series	2012	M3 2dr Convertible (4.0L 8cyl 6M)	Compact car	E90, E91, E92, E93
Ford	F-150	2020	Limited 4dr SuperCrew 5.5 ft. SB (3.5L 6cyl Turbo 400)	Full-size pickup tru (13th gen)	
BMW	3 Series	2010	M3 2dr Convertible (4.0L 8cyl 6M)	Compact car	E90, E91, E92, E93
BMW	3 Series	2018	M3 4dr Sedan (3.0L 6cyl Turbo 6M)	Compact car	F30, F31, F80
BMW	3 Series	2008	M3 2dr Convertible (4.0L 8cyl 6M)	Compact car	E90, E91, E92, E93
BMW	3 Series	2016	M3 4dr Sedan (3.0L 6cyl Turbo 6M)	Compact car	F30, F31, F80
Ford	F-150	2021	Platinum 4dr SuperCrew 4WD 6.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2021	Platinum 4dr SuperCrew 4WD 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
BMW	3 Series	2012	335i 2dr Convertible (3.0L 6cyl Turbo 6M)	Compact car	E90, E91, E92, E93
BMW	3 Series	2012	M3 2dr Coupe (4.0L 8cyl 6M)	Compact car	E90, E91, E92, E93
Ford	F-150	2021	King Ranch 4dr SuperCrew 4WD 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2021	King Ranch 4dr SuperCrew 4WD 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2021	Platinum 4dr SuperCrew 6.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2020	Platinum 4dr SuperCrew 4WD 6.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2021	Platinum 4dr SuperCrew 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2020	Platinum 4dr SuperCrew 4WD 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
BMW	3 Series	2010	M3 2dr Coupe (4.0L 8cyl 6M)	Compact car	E90, E91, E92, E93
Ford	F-150	2020	King Ranch 4dr SuperCrew 4WD 6.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
BMW	3 Series	2021	M340i xDrive 4dr Sedan AWD (3.0L 6cyl Turbo 480)	Compact car	G20
Ford	F-150	2021	King Ranch 4dr SuperCrew 6.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
BMW	3 Series	2006	M3 2dr Convertible (3.2L 6cyl 6M)	Compact car	E46
BMW	3 Series	2008	M3 2dr Coupe (4.0L 8cyl 6M)	Compact car	E90, E91, E92, E93
Ford	F-150	2020	Raptor 4dr SuperCrew 4WD (3.5L 6cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2020	King Ranch 4dr SuperCrew 4WD 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
Ford	F-150	2021	King Ranch 4dr SuperCrew 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
BMW	3 Series	2020	M340i xDrive 4dr Sedan AWD (3.0L 6cyl Turbo 480)	Compact car	G20
Ford	F-150	2020	Platinum 4dr SuperCrew 6.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	
BMW	3 Series	2004	M3 2dr Convertible (3.2L 6cyl 6M)	Compact car	E46
Ford	F-150	2020	Platinum 4dr SuperCrew 5.5 ft. SB (5.0L 8cyl Turbo 350)	Full-size pickup tru (13th gen)	

The 2018 BMW 3 Series M3 4dr Sedan (3.0L 6cyl Turbo 7A), is a compact car using platforms F30, F31 or F60... and is classified as a Compact Car...

Tell the LLM what the data means

# Generating Diagrams

## Prompt:

please give me a flow chart diagram in DOT language, for the process of starting a car, including the interactions between the car's main subsystems

## Next Prompt:

add a flux capacitor which is charged by the engine and activates after the car is started

```
digraph CarStartProcess {
 rankdir=LR;
```

```
 node [shape=rectangle,
 style=filled, color=lightblue];
```

```
 subgraph cluster_0 {
 label = "Start Process";
 style=filled;
 color=lightgrey;
```

```
 key [label="Insert
 Key/Push Start Button";
 ignition [label="Ignition
 System";
```

```
 fuel [label="Fuel System";
 air [label="Air Intake
 System";
 spark [label="Spark Plug";
 engine [label="Engine
 Starts";
```

```
 ...
```

