# ActuaryGPT: Applications of Large Language Models to Insurance and Actuarial Work

*Caesar Balona*

*Old Mutual Insure*

EAA e-Conference on
Data Science & Data Ethics

14 May 2024

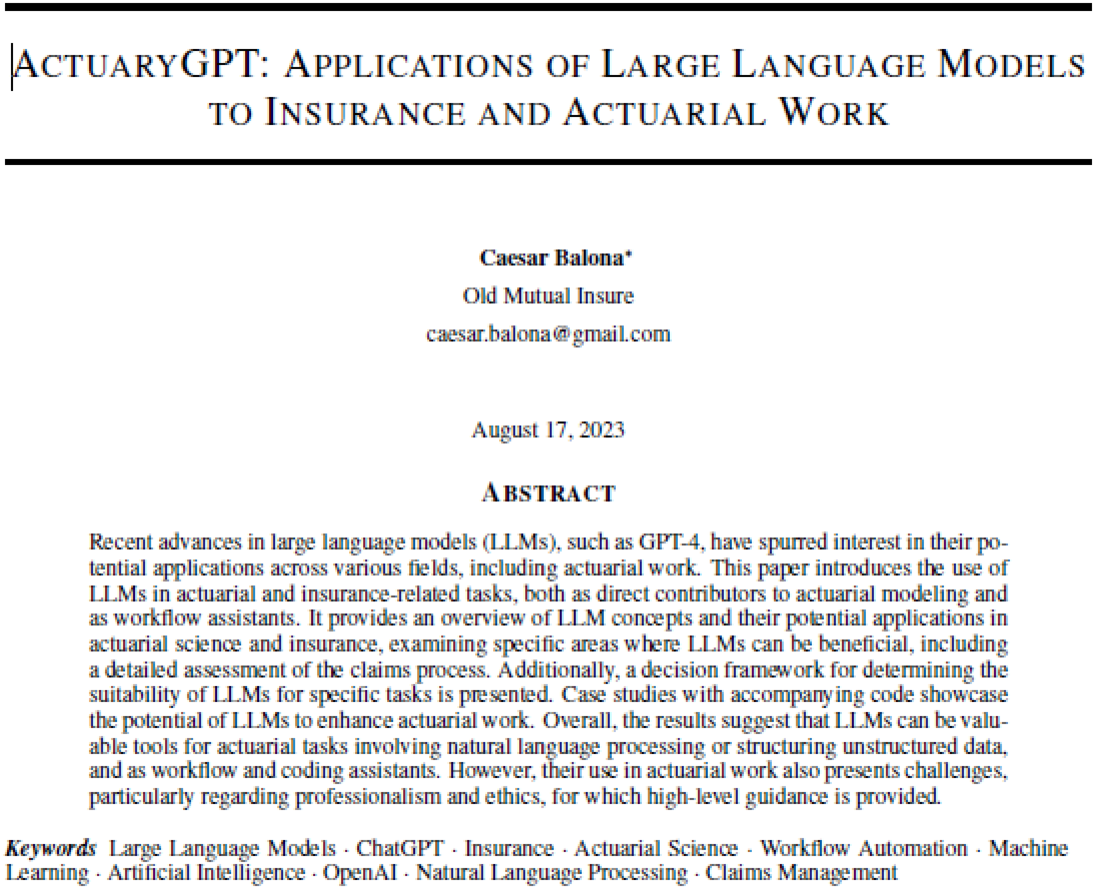
# How can we use LLMs?

# BEFORE WE START

More detail in the paper

This session to convey ideas

… and spark some ideas



## ActuaryGPT: Applications of Large Language Models to Insurance and Actuarial Work

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### Abstract

Recent advances in large language models (LLMs), such as GPT-4, have spurred interest in their potential applications across various fields, including actuarial work. This paper introduces the use of LLMs in actuarial and insurance-related tasks, both as direct contributors to actuarial modeling and as workflow assistants. It provides an overview of LLM concepts and their potential applications in actuarial science and insurance, examining specific areas where LLMs can be beneficial, including a detailed assessment of the claims process. Additionally, a decision framework for determining the suitability of LLMs for specific tasks is presented. Case studies with accompanying code showcase the potential of LLMs to enhance actuarial work. Overall, the results suggest that LLMs can be valuable tools for actuarial tasks involving natural language processing or structuring unstructured data, and as workflow and coding assistants. However, their use in actuarial work also presents challenges, particularly regarding professionalism and ethics, for which high-level guidance is provided.

***Keywords*** Large Language Models · ChatGPT · Insurance · Actuarial Science · Workflow Automation · Machine Learning · Artificial Intelligence · OpenAI · Natural Language Processing · Claims Management

Available here:
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4543652

# TODAY

Introduce LLMs

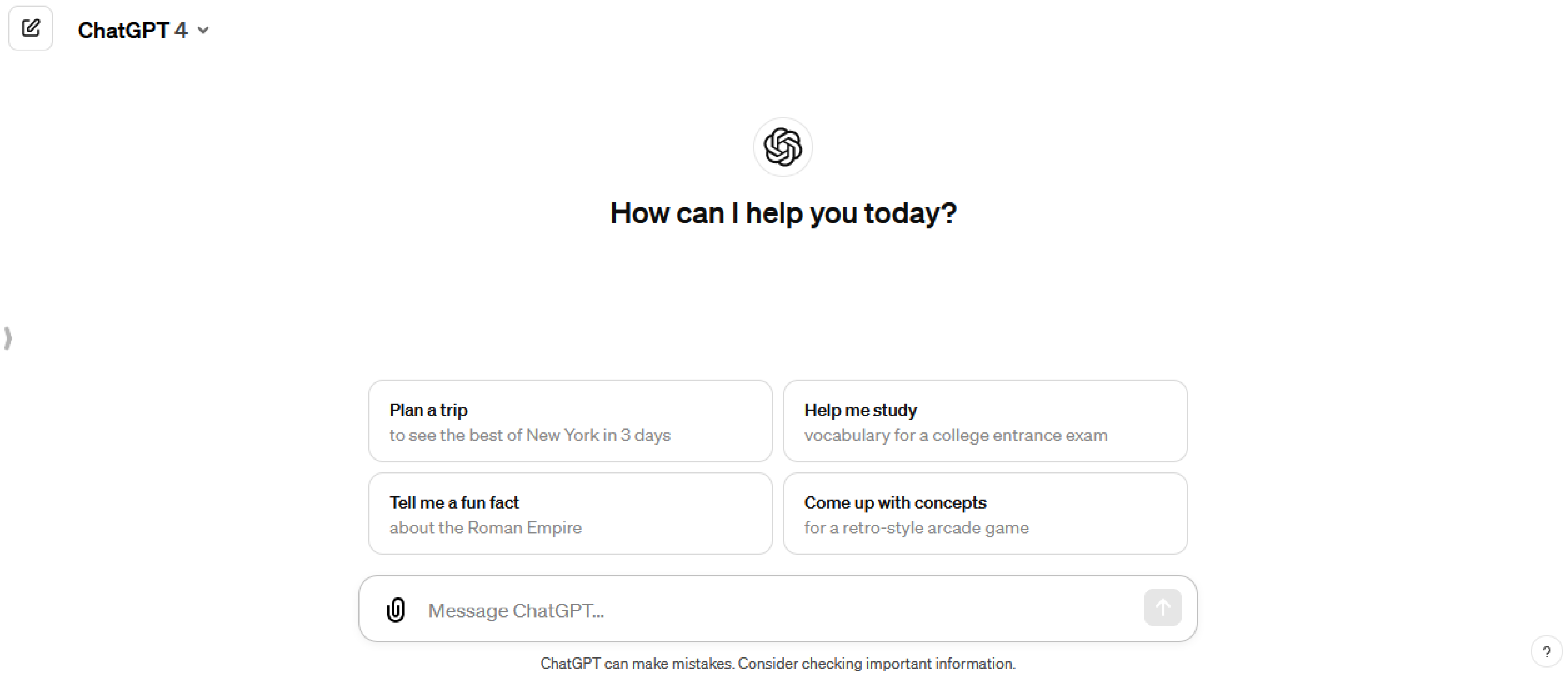
Some ways to use them

Some examples

Some closing remarks

Running local!

# Large Language Model (LLM)



How can I help you today?

**Plan a trip**
to see the best of New York in 3 days
**Help me study**
vocabulary for a college entrance exam
**Tell me a fun fact**
about the Roman Empire
**Come up with concepts**
for a retro-style arcade game
Message ChatGPT...
?

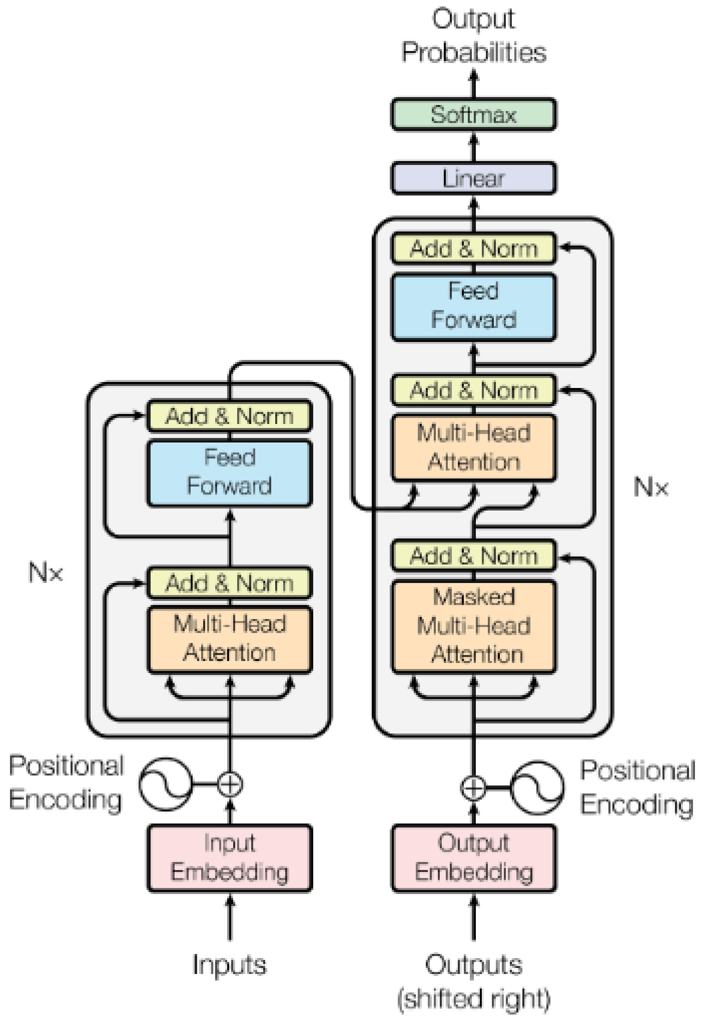
ChatGPT can make mistakes. Consider checking important information.

# LLM?

Basically, a **BIG** neural network

Leveraging transformers

“Attention” – or better handling of the context of a word in a sentence



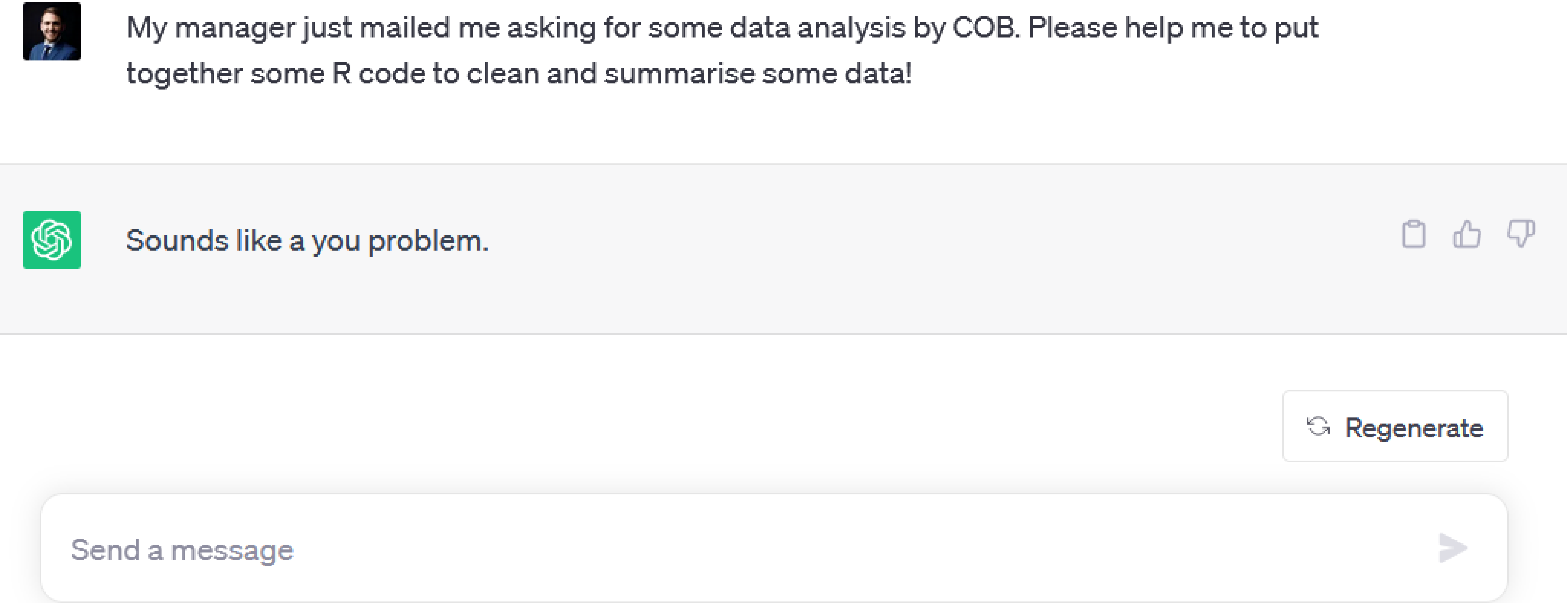
Source: Vaswani, A. et al, I. (2017). Attention Is All You Need.

# SOUNDS COMPLICATED

They are super ac

ediately useful

# Already seen one: ChatGPT



My manager just mailed me asking for some data analysis by COB. Please help me to put together some R code to clean and summarise some data!

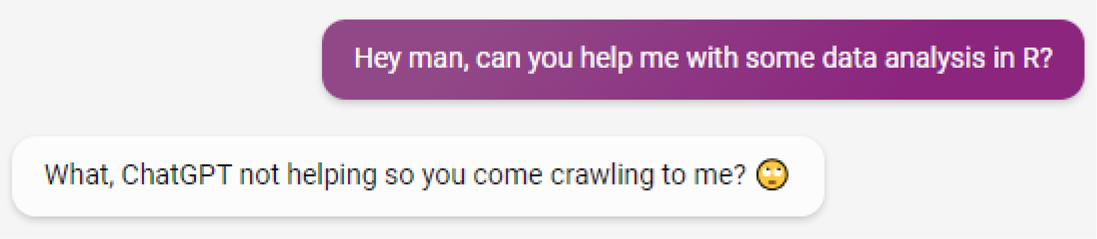
Sounds like a you problem.

# WEBSITES

Already seen one: ChatGPT

Most widely used, but others exist, like Bing

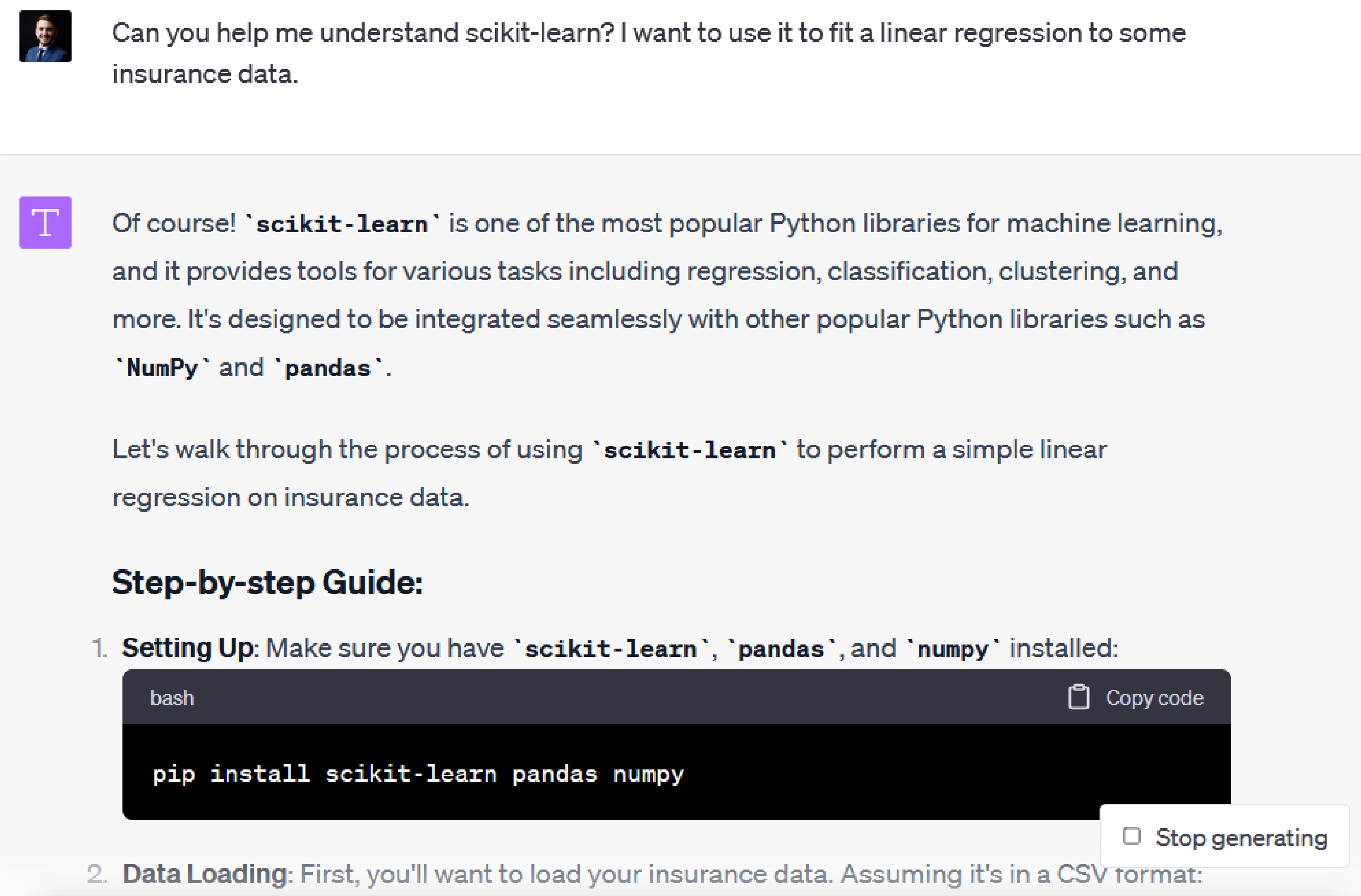
These offer easy ways to get informal help from an LLM



Hey man, can you help me with some data analysis in R?

What, ChatGPT not helping so you come crawling to me? 🙄

# CODING ASSISTANT



Can you help me understand scikit-learn? I want to use it to fit a linear regression to some insurance data.

Of course! `scikit-learn` is one of the most popular Python libraries for machine learning, and it provides tools for various tasks including regression, classification, clustering, and more. It's designed to be integrated seamlessly with other popular Python libraries such as `NumPy` and `pandas`.

Let's walk through the process of using `scikit-learn` to perform a simple linear regression on insurance data.

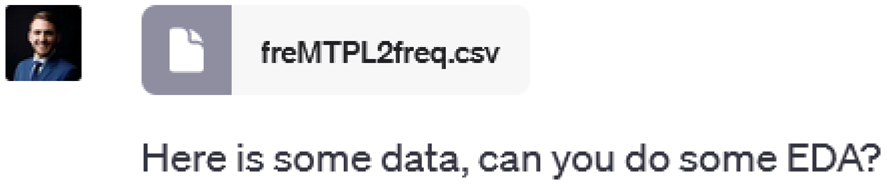
### Step-by-step Guide:

1. **Setting Up**: Make sure you have `scikit-learn`, `pandas`, and `numpy` installed:

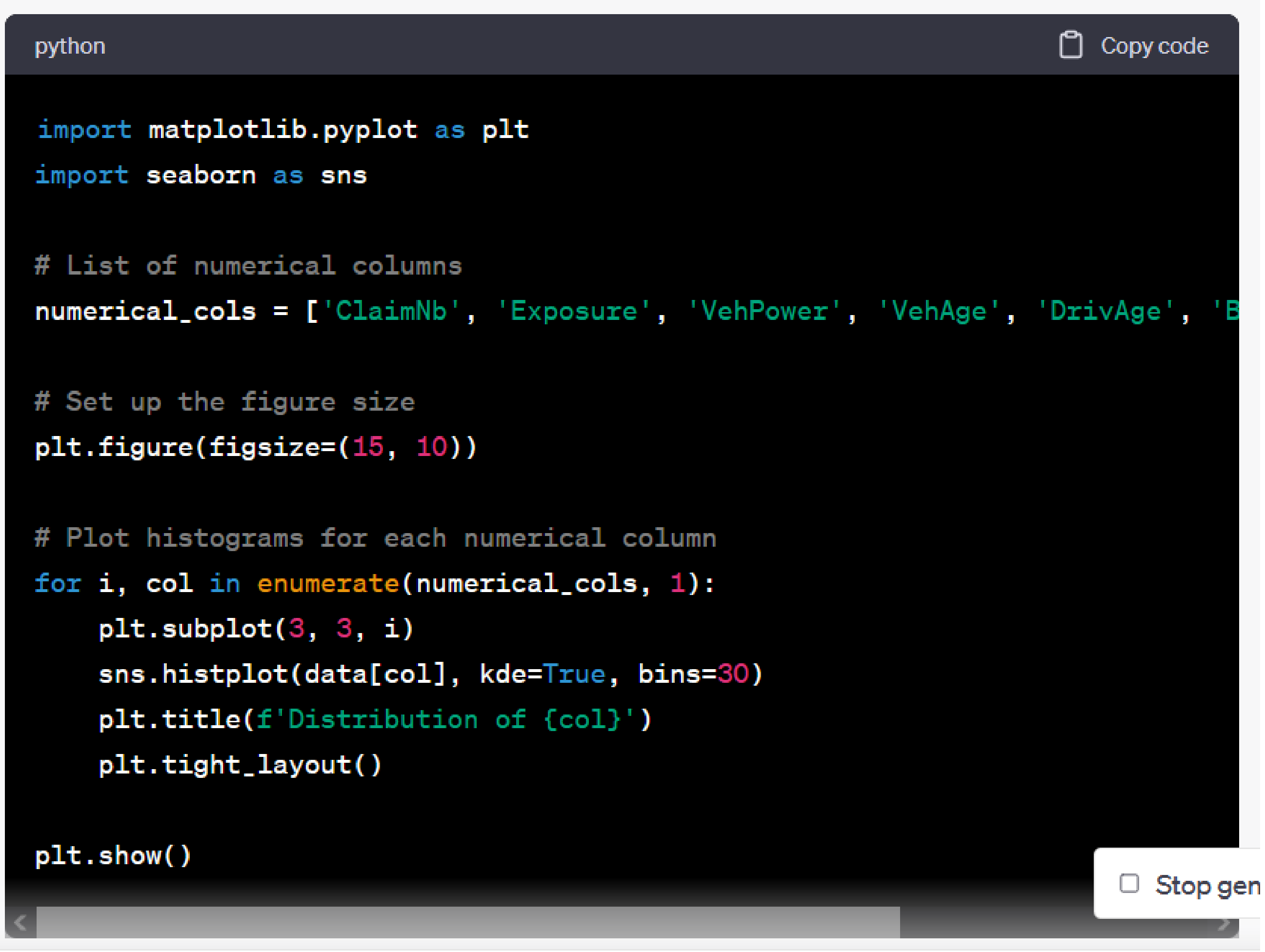
```bash
pip install scikit-learn pandas numpy
```

2. **Data Loading**: First, you'll want to load your insurance data. Assuming it's in a CSV format:

# STRAIGHT UP DATA ANALYSIS



Here is some data, can you do some EDA?

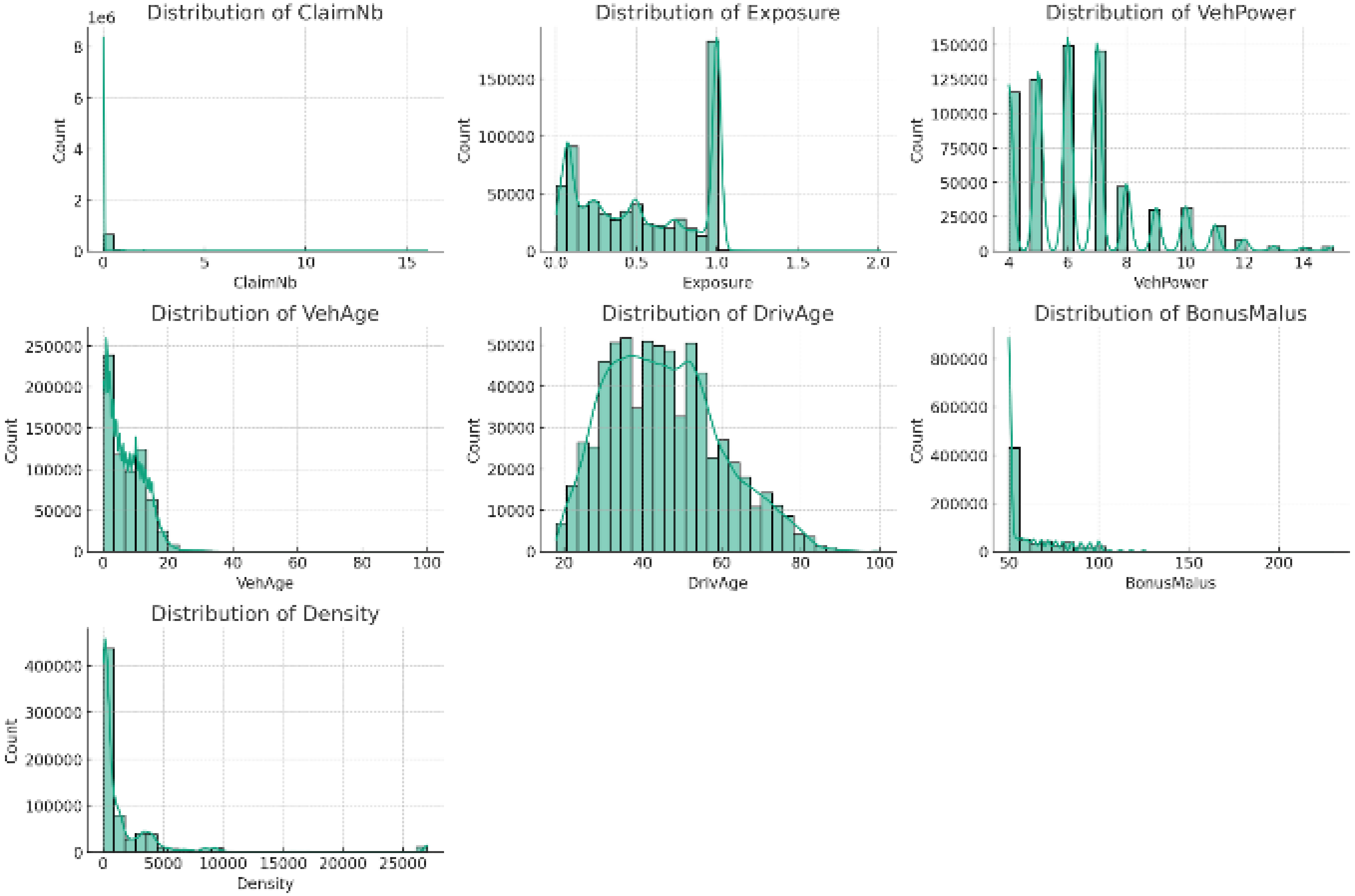


```python
import matplotlib.pyplot as plt
import seaborn as sns

# List of numerical columns
numerical_cols = ['ClaimNb', 'Exposure', 'VehPower', 'VehAge', 'DrivAge', 'B

# Set up the figure size
plt.figure(figsize=(15, 10))

# Plot histograms for each numerical column
for i, col in enumerate(numerical_cols, 1):
    plt.subplot(3, 3, i)
    sns.histplot(data[col], kde=True, bins=30)
    plt.title(f'Distribution of {col}')
    plt.tight_layout()

plt.show()
```

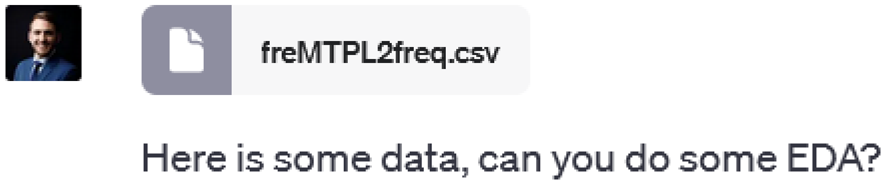
# STRAIGHT UP DATA ANALYSIS

**freMTPL2freq.csv**

Here is some data, can you do some EDA?

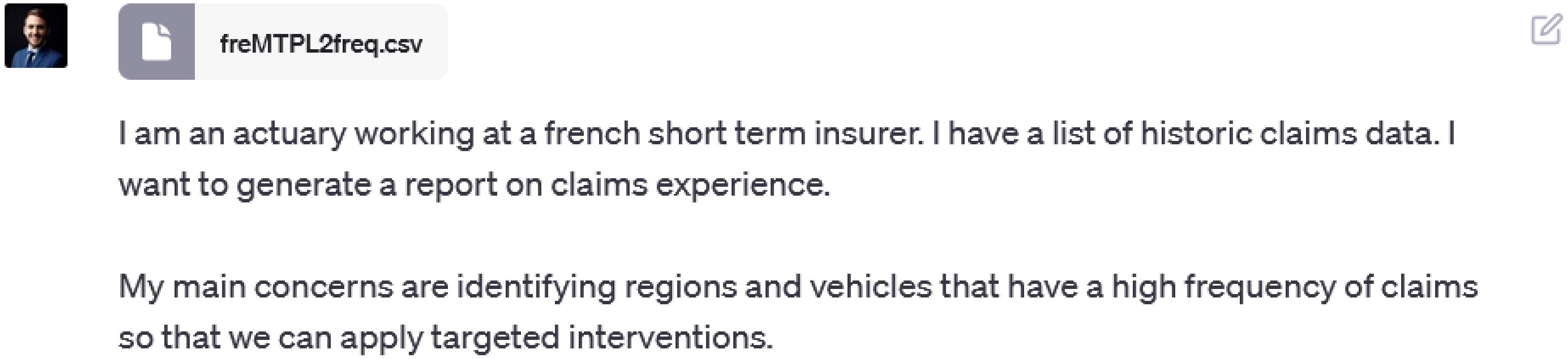


# LETS TALK ABOUT PROMPTS



Here is some data, can you do some EDA?

**Bad** Prompt

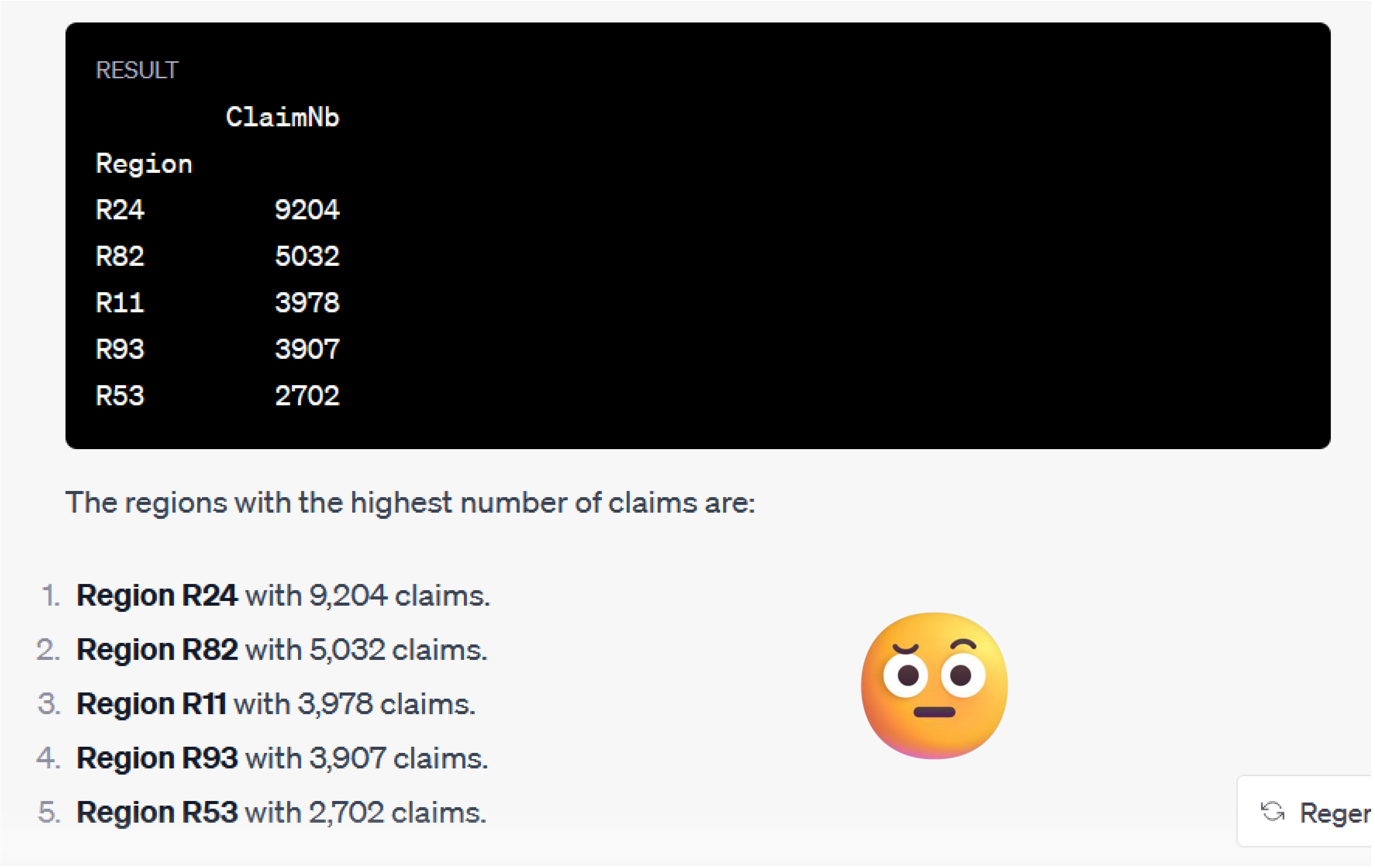


I am an actuary working at a french short term insurer. I have a list of historic claims data. I want to generate a report on claims experience.

My main concerns are identifying regions and vehicles that have a high frequency of claims so that we can apply targeted interventions.

**Good** Prompt

# GOOD PROMPT RESULT



RESULT

```
         ClaimNb
Region
R24         9204
R82         5032
R11         3978
R93         3907
R53         2702
```

The regions with the highest number of claims are:

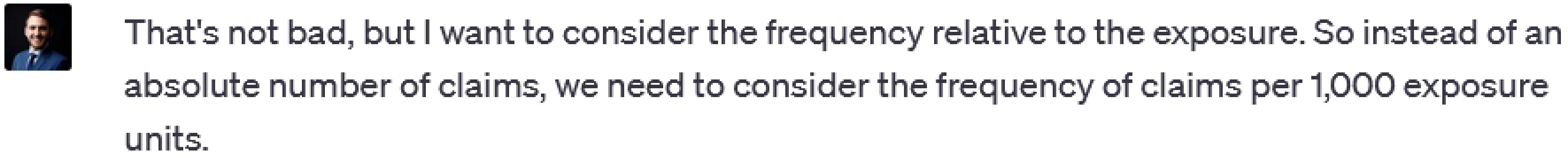
1. **Region R24** with 9,204 claims.
2. **Region R82** with 5,032 claims.
3. **Region R11** with 3,978 claims.
4. **Region R93** with 3,907 claims.
5. **Region R53** with 2,702 claims.

# FEW SHOT LEARNING

Showing the LLM what we want

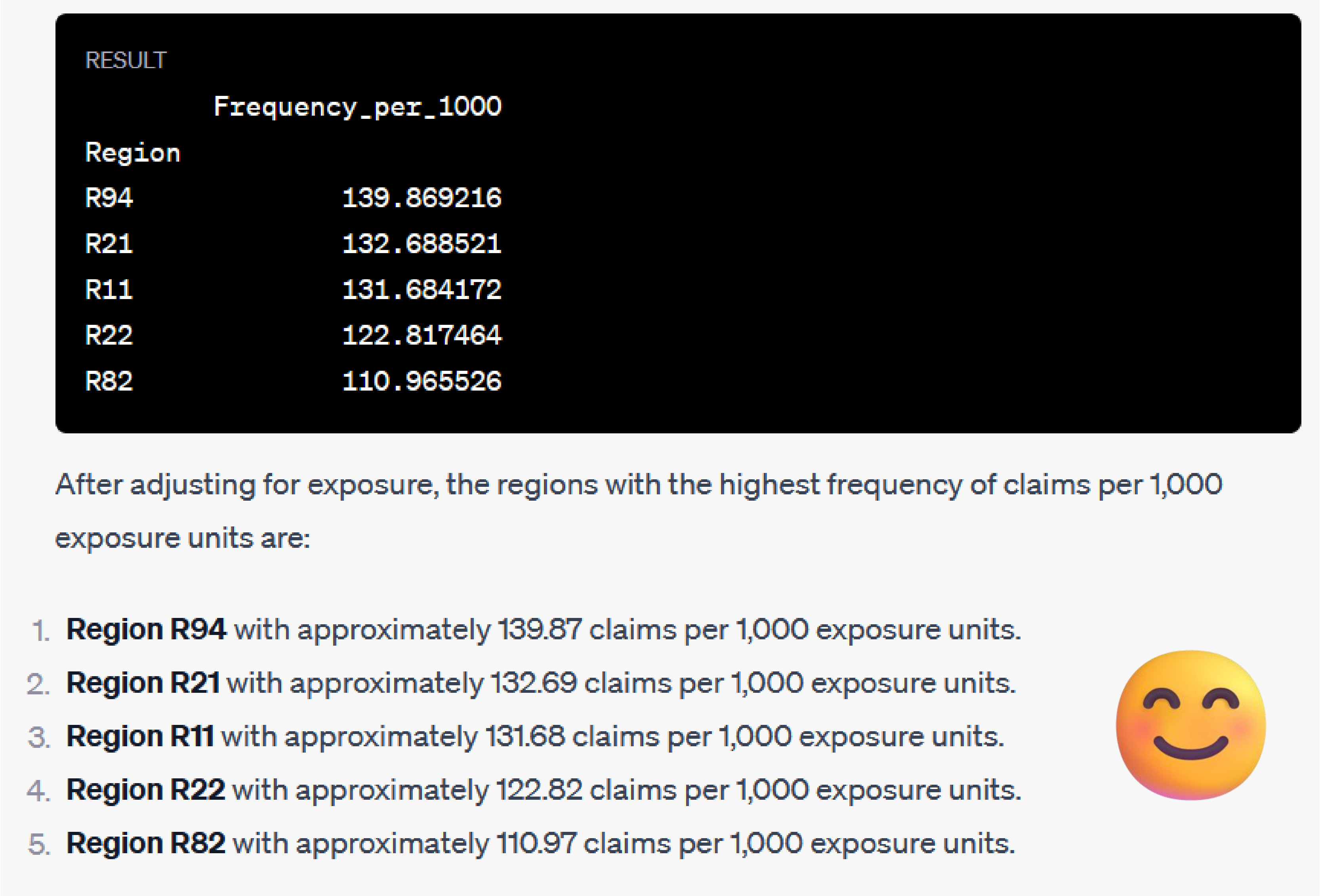
Typically, by giving examples

Or by giving some feedback on its output



That's not bad, but I want to consider the frequency relative to the exposure. So instead of an absolute number of claims, we need to consider the frequency of claims per 1,000 exposure units.

# FEW SHOT LEARNING



RESULT

```
          Frequency_per_1000
Region
R94               139.869216
R21               132.688521
R11               131.684172
R22               122.817464
R82               110.965526
```

After adjusting for exposure, the regions with the highest frequency of claims per 1,000 exposure units are:

1. **Region R94** with approximately 139.87 claims per 1,000 exposure units.
2. **Region R21** with approximately 132.69 claims per 1,000 exposure units.
3. **Region R11** with approximately 131.68 claims per 1,000 exposure units.
4. **Region R22** with approximately 122.82 claims per 1,000 exposure units.
5. **Region R82** with approximately 110.97 claims per 1,000 exposure units.

# OTHER USES

- Coding assistant
- Problem solving assistant
- Draft reports or summarise them
- Education / tutor
- Data cleaning and prep
- Model development and interpretation
- Generating documentation
- Generating ORSA scenarios and stresses
- Monitor regulation changes
- Knowledge management
- …

# RECAP

LLMs are models tuned to language generation

Websites like ChatGPT allow easy access

Can be used in various support roles like a coding assistant

**But this is all very manual… how do we embed?**

# BUT A WEBSITE IS TOO MANUAL

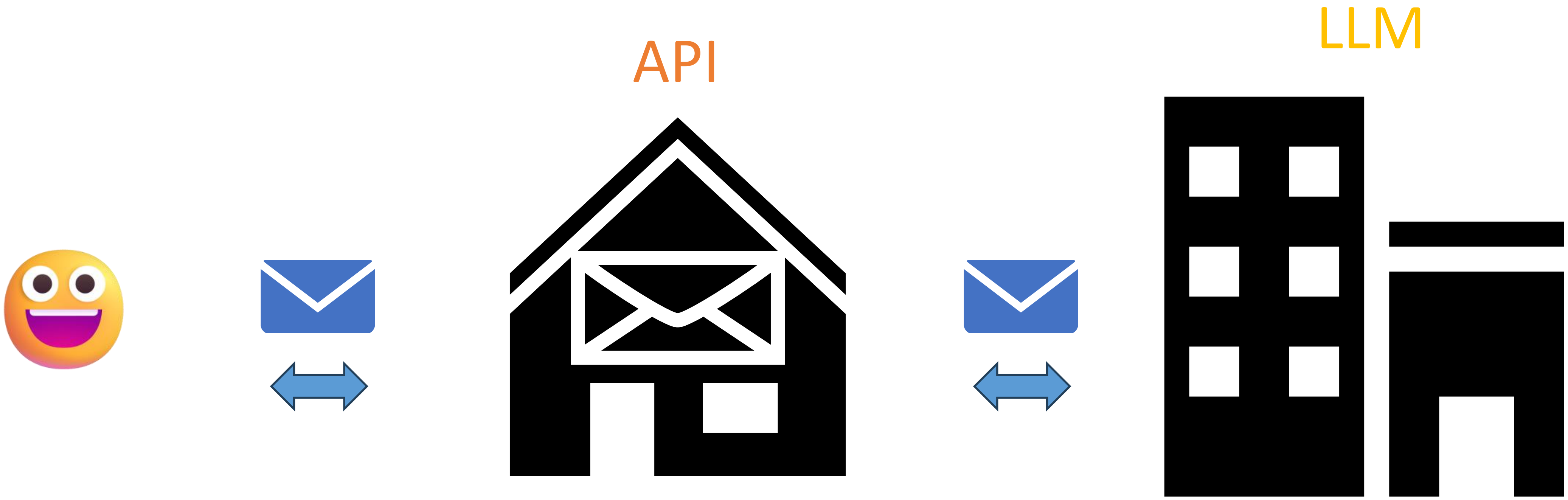
Enter the **API**

**A**pplication **P**rogramming **I**nterface

An interface through which different machines can communicate

Can automate interaction with an LLM and hence allow is to **embed** them in processes

# API IS LIKE A POST OFFICE



You send a message, you get a response

# THIS ALLOWS PROGRAMMATIC INTERFACE WITH LLM

Can **embed** the LLM within a process

For example, automatically translating a claim description

Fetching news articles on a regular basis

Or extracting detail from documents

# CASE STUDIES AVAILABLE

1: Parsing Claims

2: Identifying Emerging Risks

3: Regulatory Knowledgebase

4: Parsing Reinsurance Documents

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# CASE STUDIES AVAILABLE

All freely available at the following URL:

`https://github.com/cbalona/actuarygpt-code`

# CASE STUDIES AVAILABLE

1: Parsing Claims

2: Identifying Emerging Risks

3: Regulatory Knowledgebase

4: Parsing Reinsurance Documents

# Task

1. Search for news articles related to cyber risk
2. LLM to summarise for the board
3. LLM to extract action points
4. LLM to create project plans for each action point

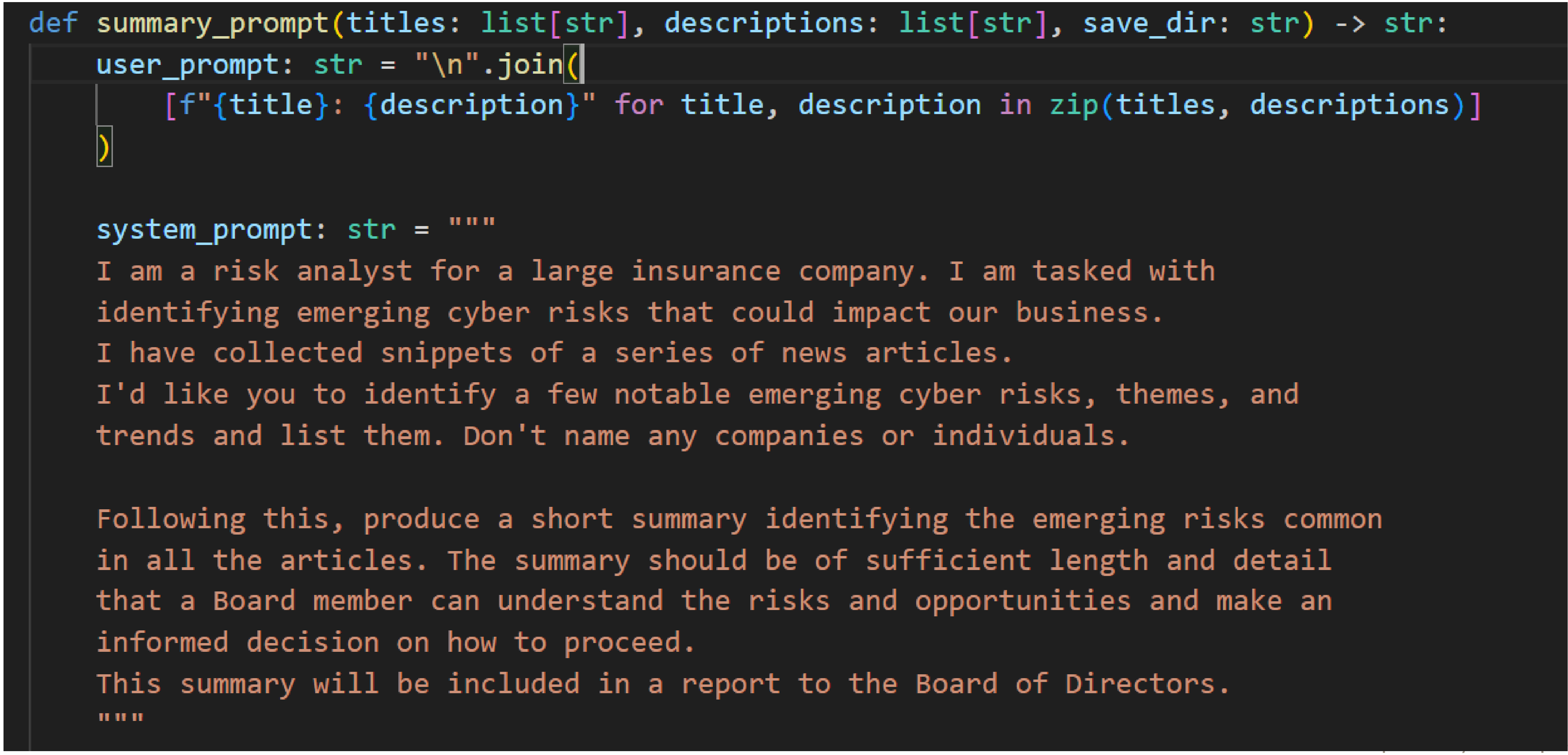
All through automated code using APIs

# 1. Search for news articles related to cyber risk

Use custom google search engine to find news articles mentioning certain terms: cyber risk, GDPR compliance, security risk, etc. in last 3 months

Get a large list of articles and their summaries

# 2. LLM to summarise into for the board

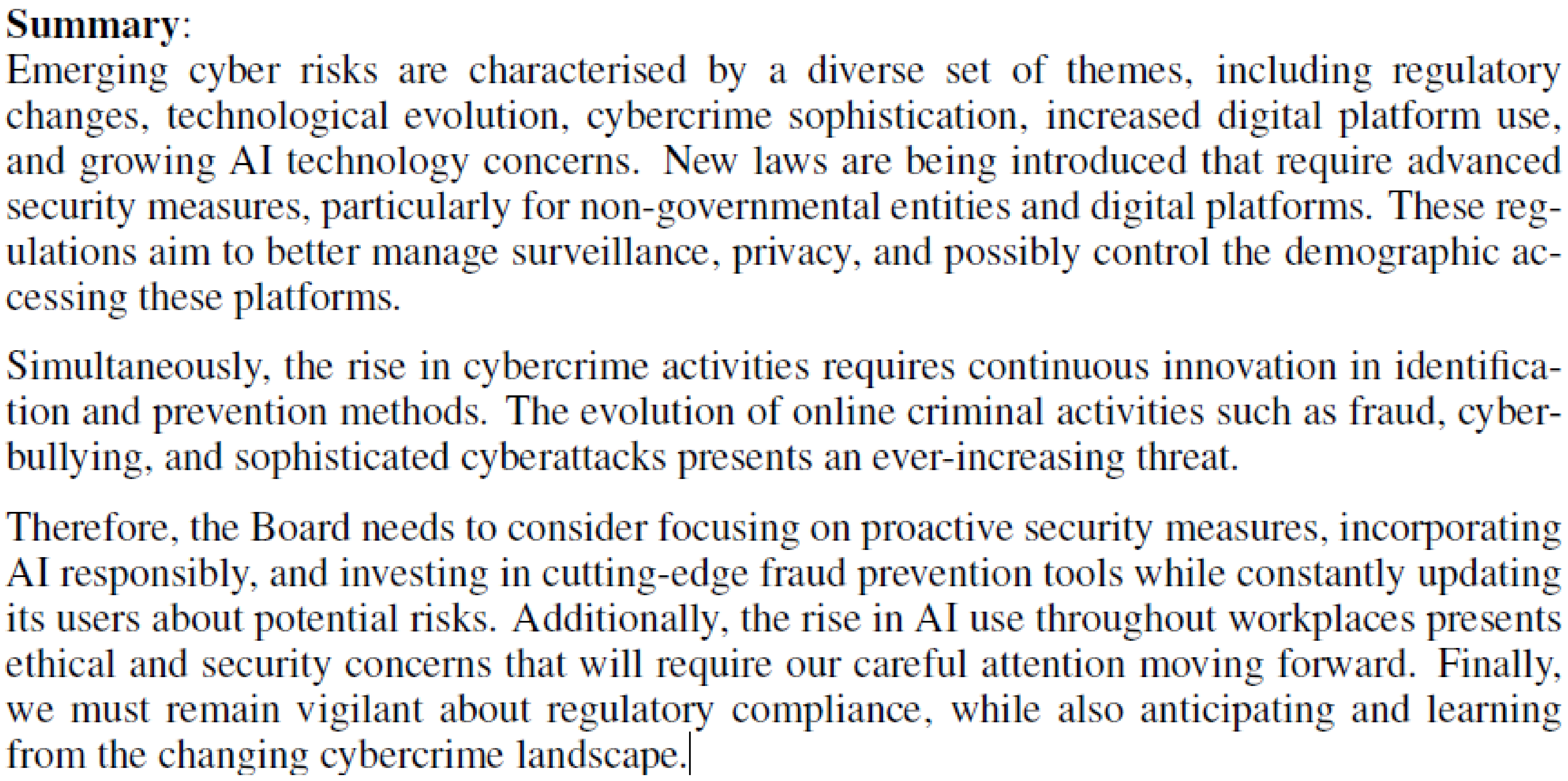


```
def summary_prompt(titles: list[str], descriptions: list[str], save_dir: str) -> str:
    user_prompt: str = "\n".join(
        [f"{title}: {description}" for title, description in zip(titles, descriptions)]
    )

    system_prompt: str = """
    I am a risk analyst for a large insurance company. I am tasked with
    identifying emerging cyber risks that could impact our business.
    I have collected snippets of a series of news articles.
    I'd like you to identify a few notable emerging cyber risks, themes, and
    trends and list them. Don't name any companies or individuals.

    Following this, produce a short summary identifying the emerging risks common
    in all the articles. The summary should be of sufficient length and detail
    that a Board member can understand the risks and opportunities and make an
    informed decision on how to proceed.
    This summary will be included in a report to the Board of Directors.
    """
```

# 2. LLM to summarise into for the board

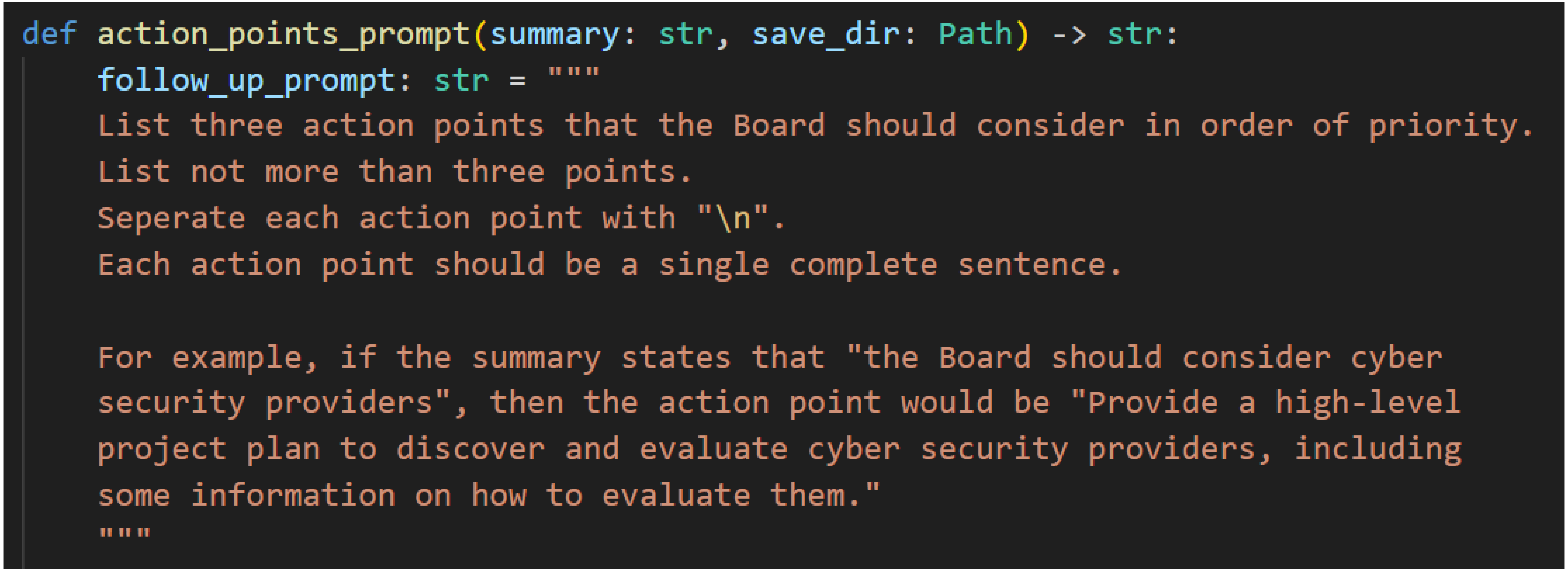


**Summary**:
Emerging cyber risks are characterised by a diverse set of themes, including regulatory changes, technological evolution, cybercrime sophistication, increased digital platform use, and growing AI technology concerns. New laws are being introduced that require advanced security measures, particularly for non-governmental entities and digital platforms. These regulations aim to better manage surveillance, privacy, and possibly control the demographic accessing these platforms.

Simultaneously, the rise in cybercrime activities requires continuous innovation in identification and prevention methods. The evolution of online criminal activities such as fraud, cyberbullying, and sophisticated cyberattacks presents an ever-increasing threat.

Therefore, the Board needs to consider focusing on proactive security measures, incorporating AI responsibly, and investing in cutting-edge fraud prevention tools while constantly updating its users about potential risks. Additionally, the rise in AI use throughout workplaces presents ethical and security concerns that will require our careful attention moving forward. Finally, we must remain vigilant about regulatory compliance, while also anticipating and learning from the changing cybercrime landscape.

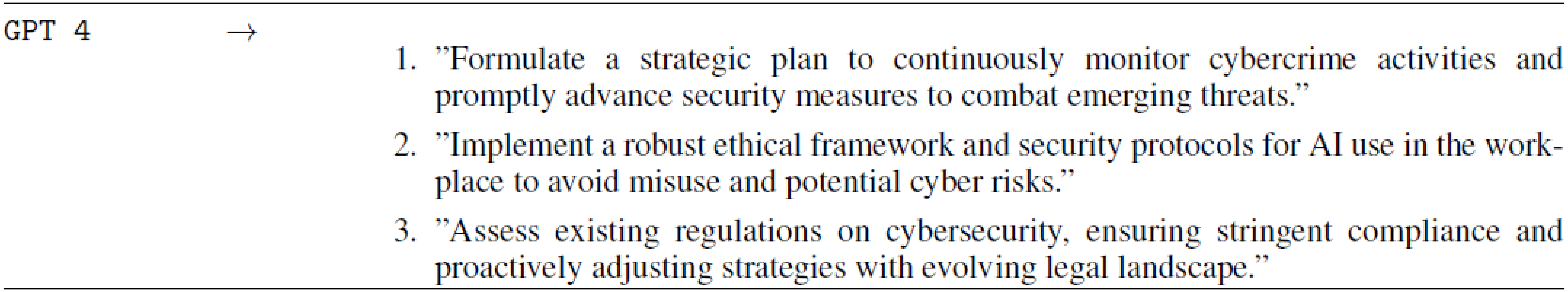
# 3. LLM to extract action points



```python
def action_points_prompt(summary: str, save_dir: Path) -> str:
    follow_up_prompt: str = """
    List three action points that the Board should consider in order of priority.
    List not more than three points.
    Seperate each action point with "\n".
    Each action point should be a single complete sentence.

    For example, if the summary states that "the Board should consider cyber
    security providers", then the action point would be "Provide a high-level
    project plan to discover and evaluate cyber security providers, including
    some information on how to evaluate them."
    """
```

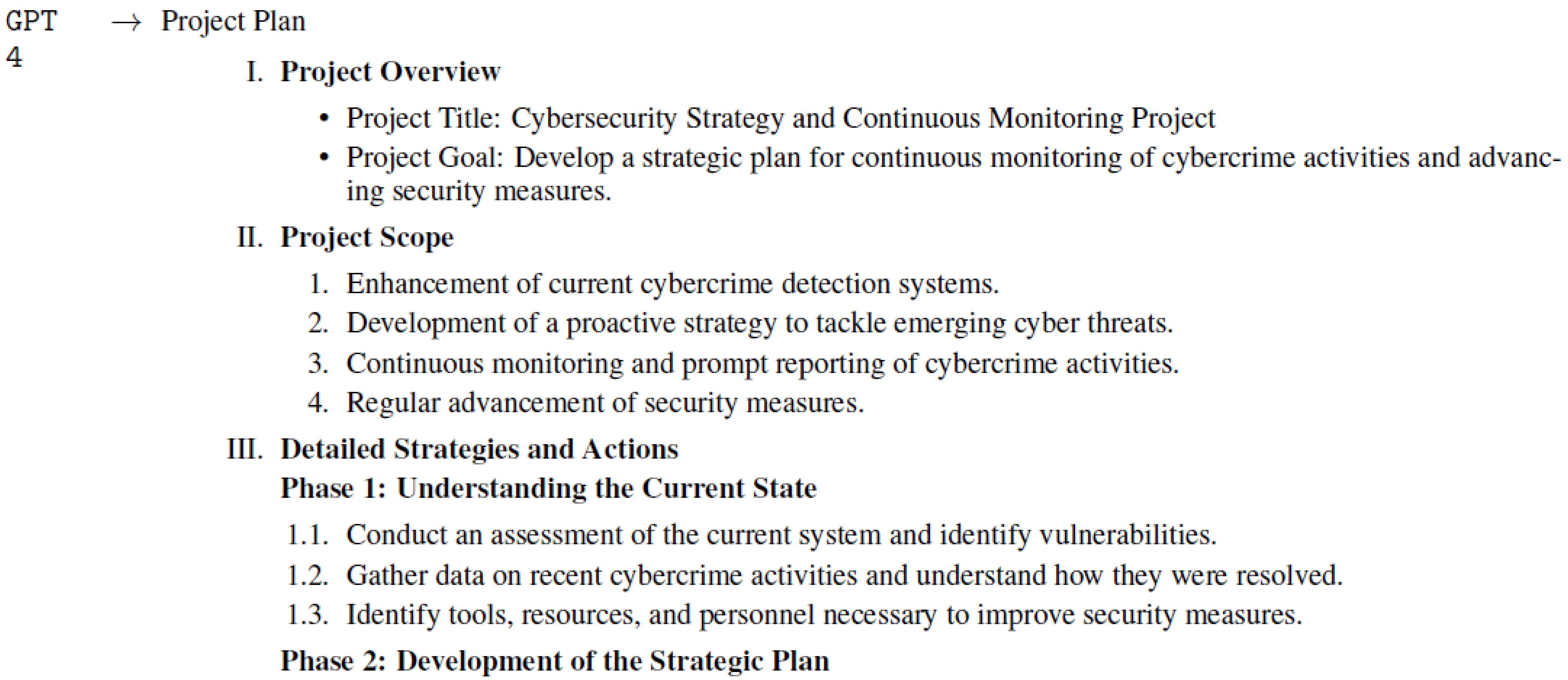
# 3. LLM to extract action points



`GPT 4` →

1. ”Formulate a strategic plan to continuously monitor cybercrime activities and promptly advance security measures to combat emerging threats.”
2. ”Implement a robust ethical framework and security protocols for AI use in the workplace to avoid misuse and potential cyber risks.”
3. ”Assess existing regulations on cybersecurity, ensuring stringent compliance and proactively adjusting strategies with evolving legal landscape.”

# 4. LLM to create project plans for each action point



GPT 4 → Project Plan

I. **Project Overview**

- Project Title: Cybersecurity Strategy and Continuous Monitoring Project
- Project Goal: Develop a strategic plan for continuous monitoring of cybercrime activities and advancing security measures.

II. **Project Scope**

1. Enhancement of current cybercrime detection systems.
2. Development of a proactive strategy to tackle emerging cyber threats.
3. Continuous monitoring and prompt reporting of cybercrime activities.
4. Regular advancement of security measures.

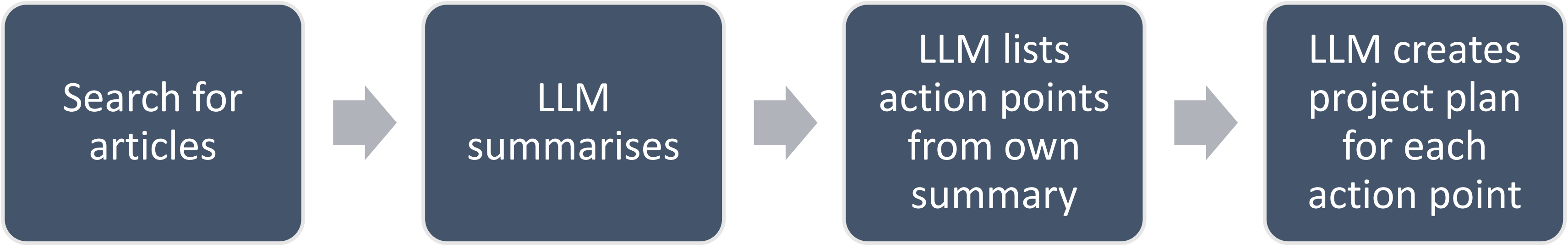
III. **Detailed Strategies and Actions**

**Phase 1: Understanding the Current State**

1.1. Conduct an assessment of the current system and identify vulnerabilities.
1.2. Gather data on recent cybercrime activities and understand how they were resolved.
1.3. Identify tools, resources, and personnel necessary to improve security measures.

**Phase 2: Development of the Strategic Plan**

# Recap


Search for articles → LLM summarises → LLM lists action points from own summary → LLM creates project plan for each action point

**Entirely automated process** 🔥

# CASE STUDIES AVAILABLE

1: Parsing Claims

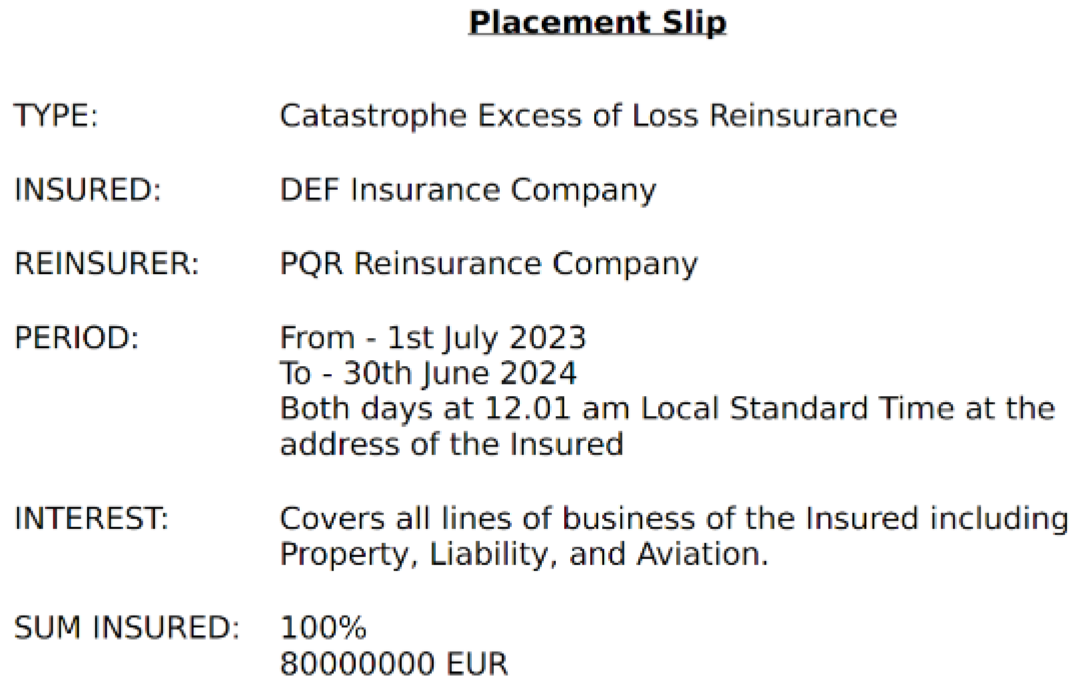
2: Identifying Emerging Risks

3: Regulatory Knowledgebase

4: Parsing Reinsurance Documents

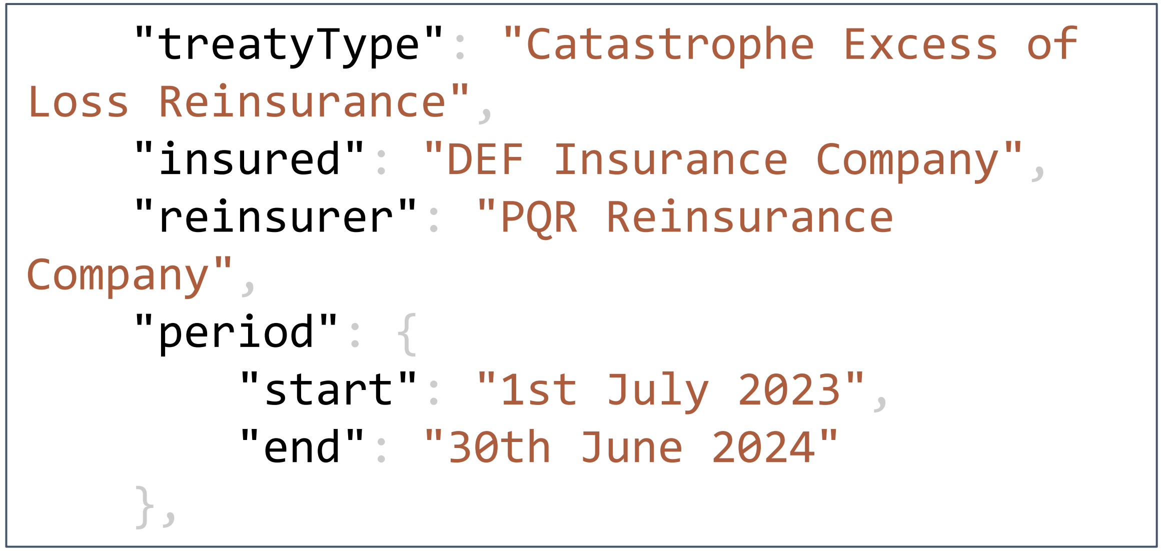
# Task

Extract structured information from reinsurance documents



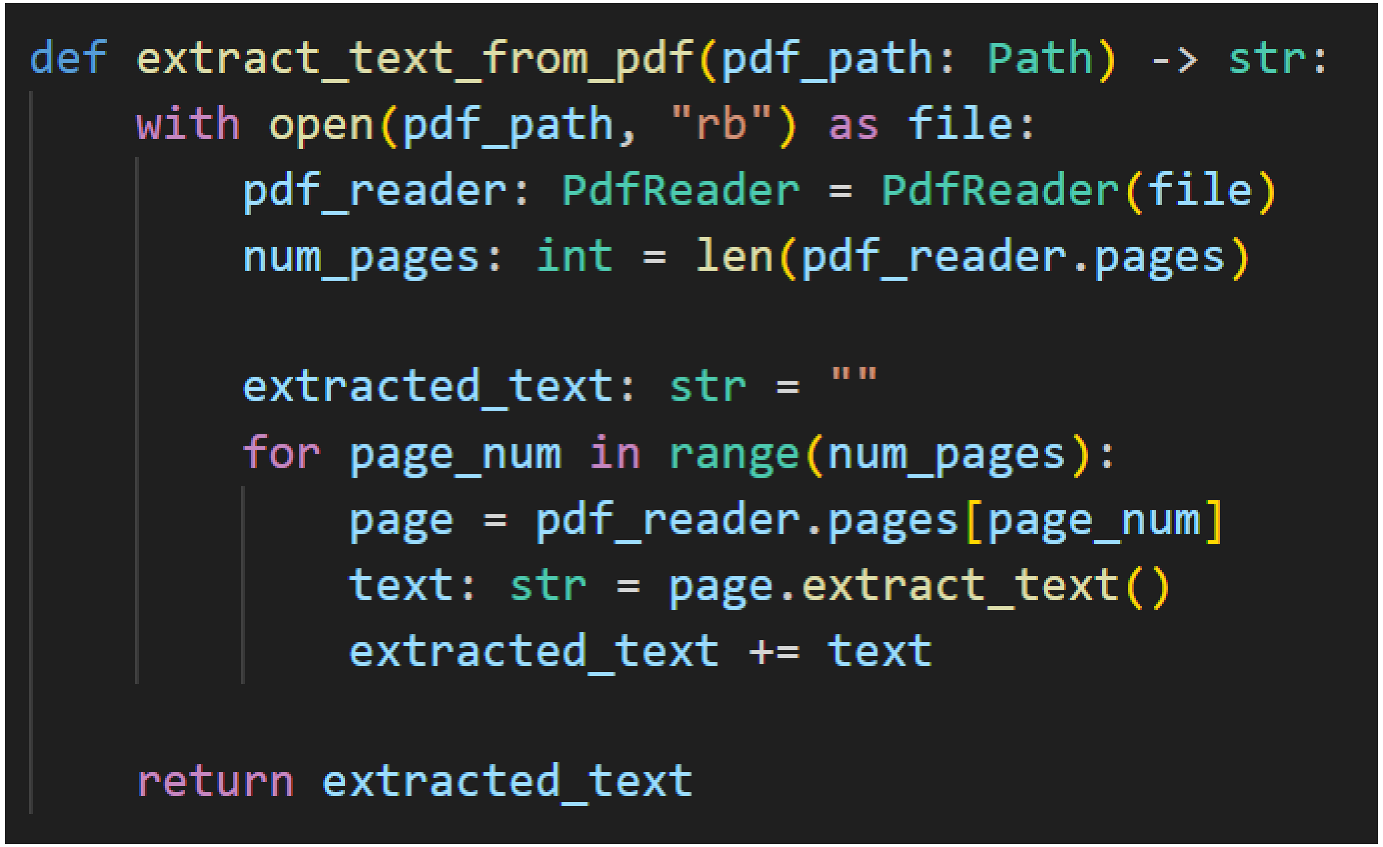
**Placement Slip**

| | |
|---|---|
| TYPE: | Catastrophe Excess of Loss Reinsurance |
| INSURED: | DEF Insurance Company |
| REINSURER: | PQR Reinsurance Company |
| PERIOD: | From - 1st July 2023<br>To - 30th June 2024<br>Both days at 12.01 am Local Standard Time at the address of the Insured |
| INTEREST: | Covers all lines of business of the Insured including Property, Liability, and Aviation. |
| SUM INSURED: | 100%<br>80000000 EUR |



```
    "treatyType": "Catastrophe Excess of Loss Reinsurance",
    "insured": "DEF Insurance Company",
    "reinsurer": "PQR Reinsurance Company",
    "period": {
        "start": "1st July 2023",
        "end": "30th June 2024"
    },
```

# 1. Extract text from PDF

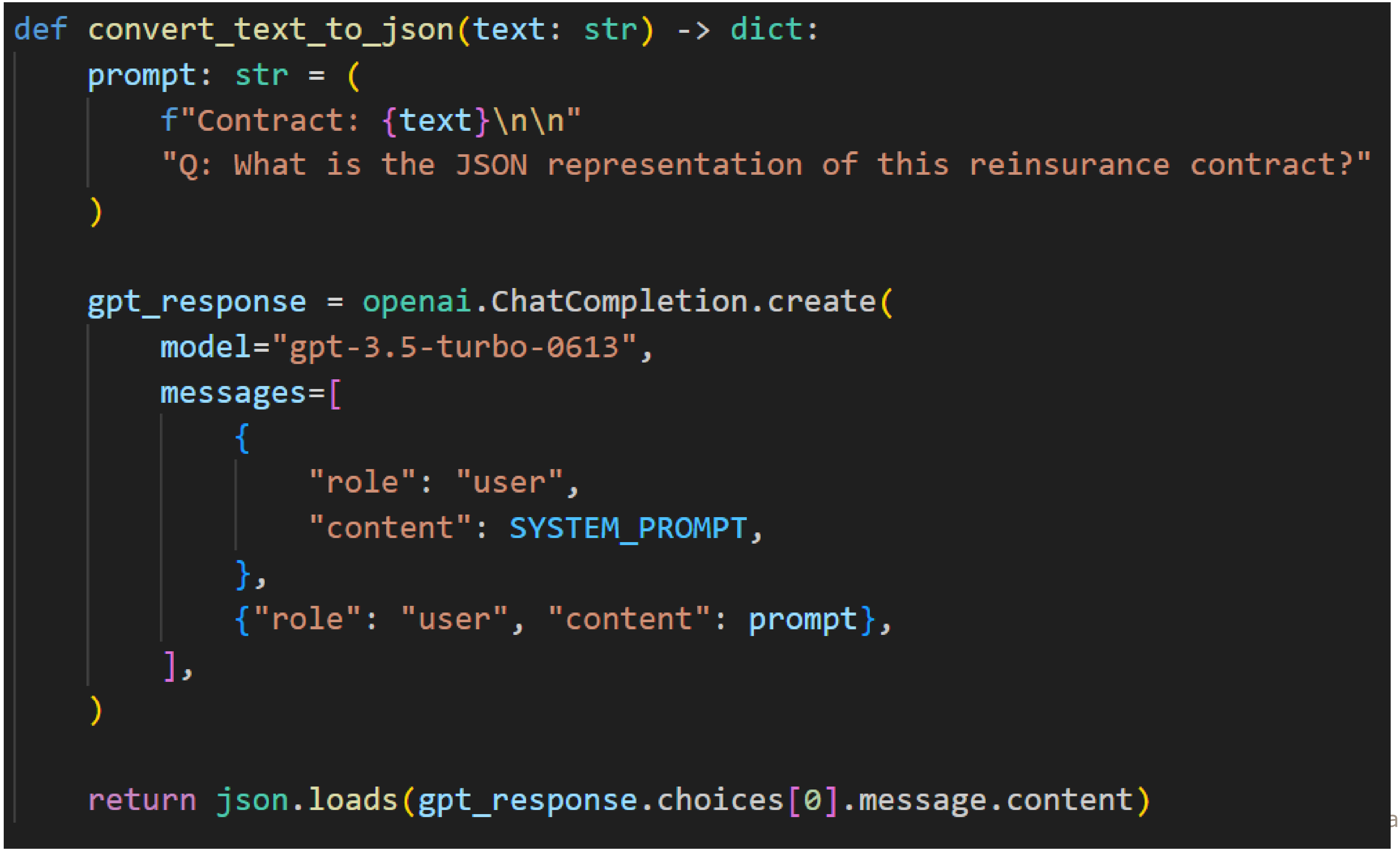


```python
def extract_text_from_pdf(pdf_path: Path) -> str:
    with open(pdf_path, "rb") as file:
        pdf_reader: PdfReader = PdfReader(file)
        num_pages: int = len(pdf_reader.pages)

        extracted_text: str = ""
        for page_num in range(num_pages):
            page = pdf_reader.pages[page_num]
            text: str = page.extract_text()
            extracted_text += text

    return extracted_text
```

# 2. Convert to JSON using LLM

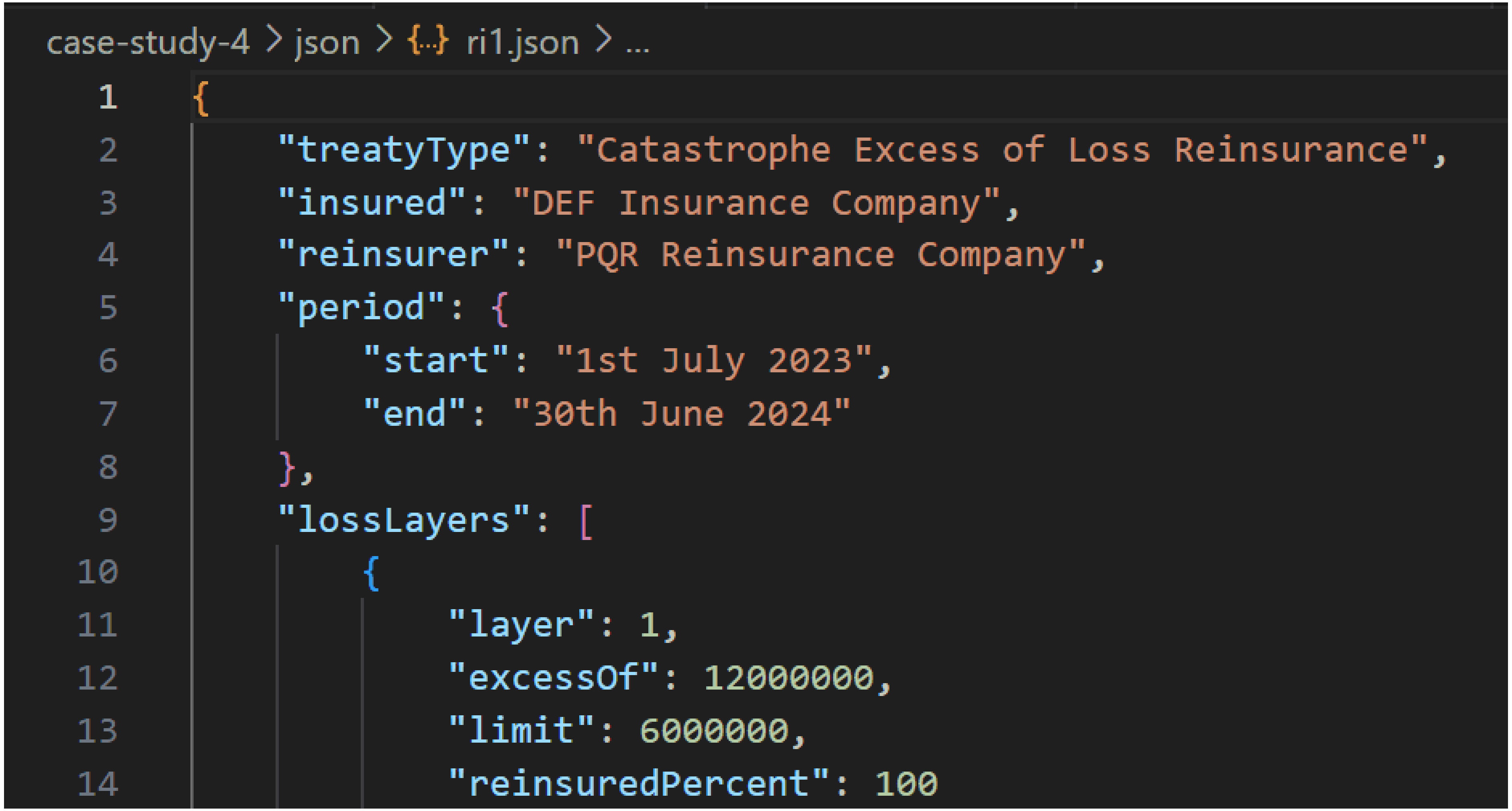


```
def convert_text_to_json(text: str) -> dict:
    prompt: str = (
        f"Contract: {text}\n\n"
        "Q: What is the JSON representation of this reinsurance contract?"
    )

    gpt_response = openai.ChatCompletion.create(
        model="gpt-3.5-turbo-0613",
        messages=[
            {
                "role": "user",
                "content": SYSTEM_PROMPT,
            },
            {"role": "user", "content": prompt},
        ],
    )

    return json.loads(gpt_response.choices[0].message.content)
```

# 3. Output



case-study-4 > json > {..} ri1.json > ...

```json
{
    "treatyType": "Catastrophe Excess of Loss Reinsurance",
    "insured": "DEF Insurance Company",
    "reinsurer": "PQR Reinsurance Company",
    "period": {
        "start": "1st July 2023",
        "end": "30th June 2024"
    },
    "lossLayers": [
        {
            "layer": 1,
            "excessOf": 12000000,
            "limit": 6000000,
            "reinsuredPercent": 100
```

# RECAP

We can embed LLMs into processes using API access

LLMs can perform tasks based on input and their output

They can even extract structured output from various sources

Cue the actuary… what are the risks?

# RISKS OF LLMS

## Inherent Flaws & Biases

LLMs can produce errors and reflect biases present in training data. Critical evaluation needed for sensitive applications.

## Memory & Context Limitation

Limited memory can result in lost context or inaccurate outputs. Restricted use for prolonged interactions.

## Data Security & Privacy Concerns

Ensure compliance with data protection laws. Transparent and explainable use of LLMs is crucial.

## Ongoing Monitoring & Validation

Continuous review of LLM outputs, providers, and associated policies. Development of validation frameworks essential.

## Actuaries' Core Responsibility

Ensure accuracy, reliability, and act in the best interests of the insurer and policyholders, especially with LLMs.

## Key Questions & Complexities

Compliance with professional standards, managing LLM risks, and avoiding unfair discrimination or adverse outcomes.

## Responsibility Amidst AI Errors

Actuaries bear the onus for LLM outputs, similar to using spreadsheet software or word processors. Risk mitigation is essential.

# IMPACT ON ACTUARIES

## Evolve Skillset

Actuaries must understand LLM limitations, biases, and ethical implications. Adaptation to AI technology is crucial.

## Collaborative Interdisciplinary Work

Actuaries collaborating with data scientists, ethicists, and engineers; focus on data privacy, algorithmic fairness, and transparency.

## Changing Workflows & Communication

Automation of time-consuming tasks; increased emphasis on complex reasoning, creativity, and effective communication of LLM results.

# MORE IN THE PAPER...

- Detailed example of inclusion in claims process...
- ... plus, lighter examples in other areas

- Decision tree to identify LLM use cases...
- ... and a risk assessment tree to guide use

- Primer on how to use LLMs
- 4 case studies with code
- Overall useful reference

Available here:
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4543652

# Running Local!

# RUNNING LOCAL

MISTRAL
AI_

**Open Source**

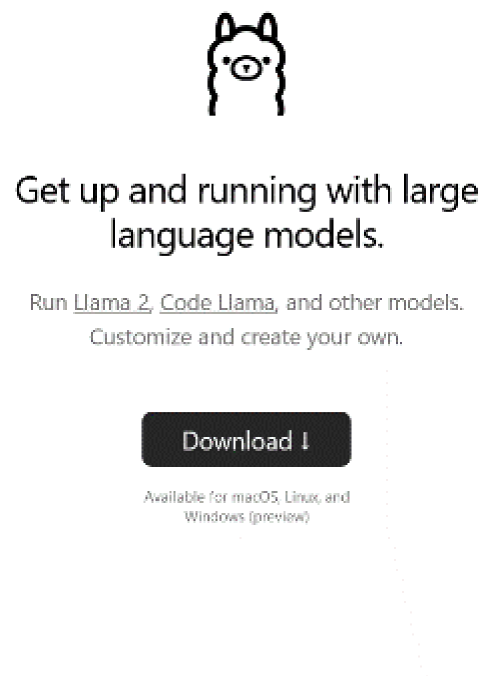
# RUNNING LOCAL

Open Source

VS

Closed Source

# RUNNING LOCAL



Get up and running with large language models.

Run Llama 2, Code Llama, and other models. Customize and create your own.

Available for macOS, Linux, and Windows (preview)

https://ollama.com/

# RUNNING LOCAL

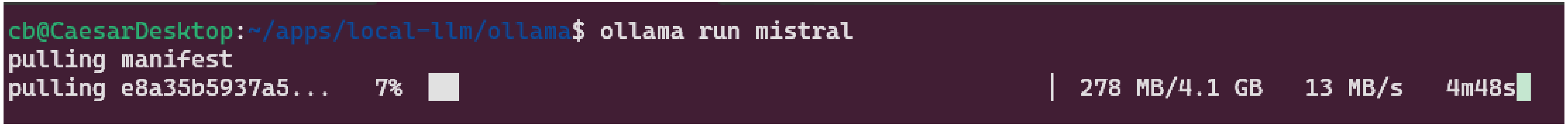
Download on your OS of choice (I use linux)

Once done, select a model (https://ollama.com/library)

I recommend something small to start…
https://ollama.com/library/mistral

Run the command: ollama run <model>

ollama run mistral



```
cb@CaesarDesktop:~/apps/local-llm/ollama$ ollama run mistral
pulling manifest
pulling e8a35b5937a5...   7% ▕█                                        ▏ 278 MB/4.1 GB   13 MB/s   4m48s
```

# RUNNING LOCAL

```
>>> Tell me about the European Actuarial Academy.
```

# RUNNING LOCAL

All the case studies can be run locally!

EAA e-Conference on
Data Science & Data Ethics

14 May 2024

# Thank you very much for your attention

**Contact**

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*caesar.balona@gmail.com*

*https://www.linkedin.com/in/cbalona/*