TaxSense Detailed Report

March 3, 2025

1 Design and Implementation of TaxSense

Note: "LegalSense" and "TaxSense" refer to the same system and are used interchangeably throughout this document.

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Contents

1.1 Importing Required Libraries

```
[ ]: import json
import os
import shutil
from io import BytesIO
from pathlib import Path
from urllib.parse import urljoin

import requests
import torch
import fitz
import pandas as pd
from PIL import Image
from bs4 import BeautifulSoup
from IPython.display import display, Image as IPyImage

from langchain.text_splitter import RecursiveCharacterTextSplitter
import pinecone
from sentence_transformers import SentenceTransformer

from transformers import AutoModelForCausalLM, AutoTokenizer, GenerationConfig,␣
  ↪TrainingArguments
from peft import prepare_model_for_kbit_training, LoraConfig, PeftModel
from trl import SFTTrainer

from huggingface_hub import HfApi, create_repo, upload_folder
```

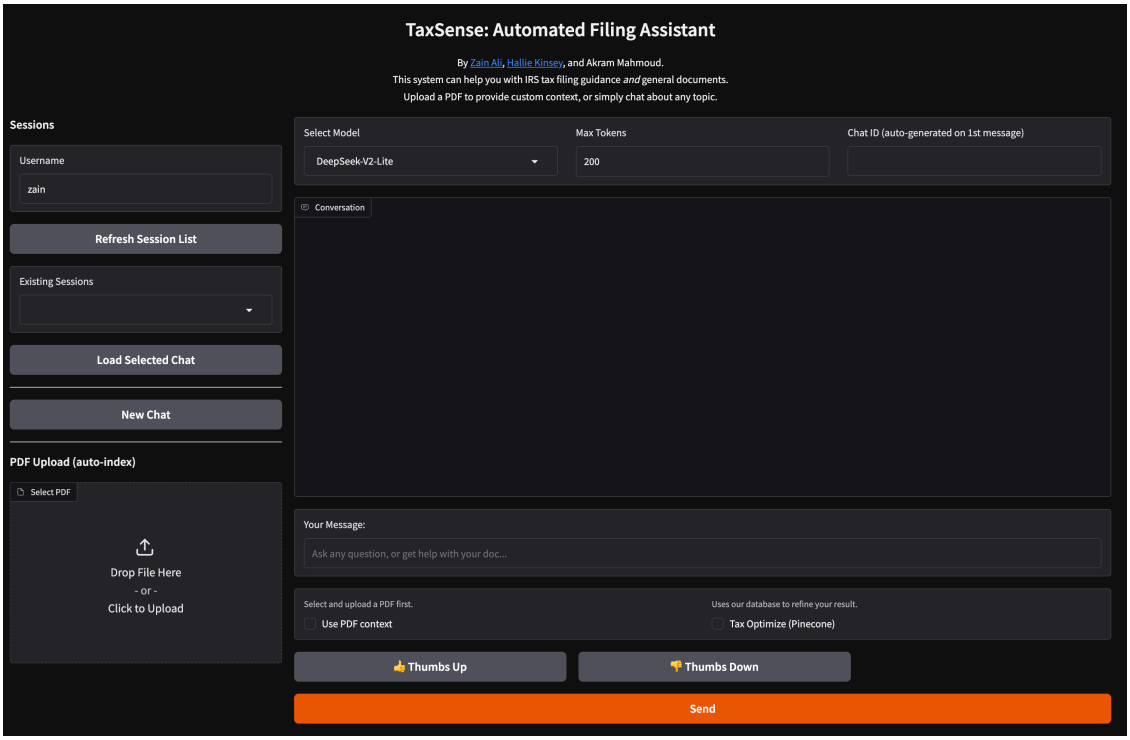
1.2 Introduction

Filing taxes can be complicated and time-consuming, requiring a good understanding of deductions, regulations, and compliance rules. **TaxSense** simplifies this process by using **Retrieval-Augmented Generation (RAG)** and **fine-tuned language models** to provide accurate and relevant tax guidance. Instead of relying on static datasets, it retrieves information directly from official IRS tax filing instructions, ensuring that responses are up-to-date and backed by reliable sources.

By fine-tuning language models on tax-related questions, TaxSense improves its ability to understand and respond to complex tax topics. The system also includes secure chat history storage and a structured ML pipeline, making it easier for users to ask questions and get clear, useful answers in real time. All this is controlled by a **TaxSense Dashboard**.

1.3 TaxSense Dashboard Info

```
[ ]: display(Image.open("supporting_media/TaxSense-dashboard.png"))
```



The **TaxSense: Automated Filing Assistant** helps with IRS tax filing guidance and document-related queries. The dashboard offers several features to make tax-related assistance and document processing easier.

1.3.1 User Sessions Management

- **Username Entry:** Set your username to track conversations.
- **Refresh Sessions:** Update the session list with the latest chats.
- **Existing Sessions:** Select a previous chat from the dropdown.
- **Load Selected Chat:** Retrieve conversation history for a selected session.
- **New Chat:** Start a new conversation.

1.3.2 PDF Upload and Contextual AI Assistance

- **Upload a PDF:** Add a document to get AI-driven assistance based on its content.
- **Auto-Indexing:** Extract and organize text from the uploaded PDF for analysis.
- **Use PDF Context:** Enable this to let the assistant use information from your document for better responses.

1.3.3 Chat and AI Model Selection

- **Select Model:** Choose from available AI models for responses.
- **Max Tokens:** Set a limit for response length.
- **Chat ID:** Automatically generated to track your conversation.
- **Ask a Question:** Enter queries to get tax-related help.

1.3.4 Tax Optimization and AI Enhancements

- **Tax Optimize (Pinecone):** Improve answers using external tax-related databases.
- **Use PDF Context vs. Tax Optimize:** Only one of these can be enabled at a time for more accurate results.

1.3.5 Feedback and Chat Control

- **Thumbs Up / Thumbs Down:** Provide feedback on the AI's responses.
- **Send Button:** Submit your question for assistance.

1.3.6 Backend Features Supporting the Dashboard

- **Chat History Retrieval:** View past conversations.
- **Tax-Specific AI Completions:** Get optimized responses for IRS tax-related questions.
- **Pinecone Database Integration:** Improve AI-generated responses with extra tax-related sources.
- **PDF Processing:** Extract useful information from uploaded documents to help with tax filing.

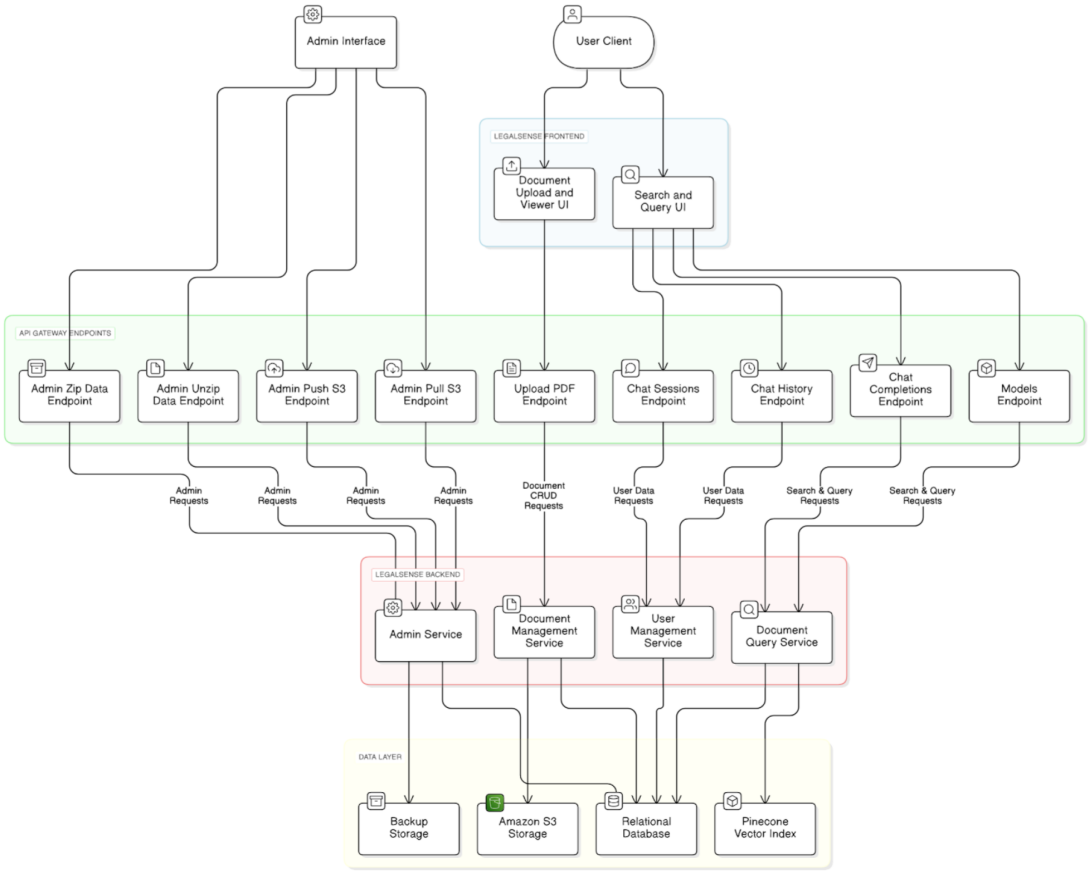
You can upload a tax-related PDF and enable **Use PDF Context** for document-based responses or turn on **Tax Optimize** for insights from external tax databases.

A live link for testing will be available on our GitHub. You can also check out a demo in the `README.md` file.

If you want to know how this way built, go to Frontend - The User Chat section.

Here is the full final architecture of out system. there is also a backend and an admin part. n this report, you will find a detailed account of the research, design, testing, and rationale behind every part of the system. There are supporting files and images; please feel free to check those out.

[3]:
```
display(Image.open("supporting_media/TaxSense-architecture.png"))
```



Our initial plan for this project was quite advance, but we ran into alot of permission issues and had to resort to utilizing alot of local Jupyter notebook alternatives.

1.4 Data Collection

1.4.1 Initial Realization

Our initial strategy was to locate an existing dataset that addressed our specific use case. However, after an extensive search, we found that no suitable dataset was available. We then considered web scraping as an alternative. After a detailed review of both the technical challenges and legal implications, we decided against scraping third-party websites due to explicit restrictions. For example:

- **Intuit (TurboTax):**
  Intuit's TurboTax terms explicitly prohibit any "unauthorized access" to their platform, including scraping or downloading content that isn't owned by the user. This means using bots or scripts to extract data without proper permission is not allowed (https://www.intuit.com/legal/terms/en-us/turbotax/online-license/).
- **H&R Block:**
  H&R Block's online services agreement similarly bans any automated data extraction. Users are not permitted to harvest, scrape, or use any auto-

mated means (such as bots or spiders) to access their software and services or extract data, especially personal information, without consent (https://assist.hrblockonline.ca/TermsAndConditions.html#:~:text=If%20you%20breach%20any%20of,may

- **TaxAct:**
  TaxAct's Terms of Service include clear restrictions against using data mining, robots, artificial intelligence, or similar methods to extract data from their website. Their services are intended solely for personal tax preparation, and automated extraction of content such as Q&A is considered a breach of these terms (https://www.taxact.com/terms-of-service).

1.4.2 Synthetic Data vs. RAG Approach

Another option we explored was generating synthetic data. Although synthetic data creation could have provided the necessary material, we encountered significant challenges—such as bias, hallucinations, and data quality concerns—which made this approach less attractive.

Ultimately, we determined that a Retrieval-Augmented Generation (RAG) approach would be the best course of action. Rather than fine-tuning on potentially limited or noisy data, the RAG framework allows us to map final answers directly to verified reference materials. This method not only saves valuable development time—since fine-tuning requires hand-creating and curating datasets—but also ensures that our model's outputs are traceable to reliable sources.

1.4.3 Model Integration and Architecture

Since most of the models we can run are relatively small or quantized, incorporating a larger model into our workflow allows us to add significant value. Our approach involves using multiple architectures to extract tax-related questions and verify their answers. This ensemble method helps counteract individual model biases and provides a more robust foundation for the final expert-level tax advisor model that we plan to fine-tune.

1.4.4 Tuning for Context and Bias Reduction

For tuning, we are planning to focus on improving contextual awareness and removing bias by extracting information from a variety of sources. As part of our quality assurance process, we reviewed a random sample of 32 tax-related questions to check for any immediate and major hallucinations—and found none.

1.4.5 Data Collection Responses

Below is an organized summary of the responses received from various models during our evaluation process. Each model's output has been annotated with a placeholder to indicate where the detailed responses will be integrated:

GPT4o (Online Search Feature): Prompt to GPT4o using online scraping feature: Research online and give me the top 20 tax questions that most people ask, along with the answers to those questions.

Response:

Navigating the complexities of the U.S. tax system can be challenging. Below are 20 common tax

1. **How can I reduce my tax bill?**
   - To lower your tax liability, consider maximizing deductions and credits, contributing to

2. **What deductions am I eligible for?**
   - Eligibility for deductions varies based on individual circumstances. Common deductions in

3. **What's the difference between marginal and effective tax rates?**
   - The marginal tax rate is the rate applied to your next dollar of income, while the effecti

4. **Which is better: a tax credit or a tax deduction?**
   - A tax credit directly reduces your tax liability dollar-for-dollar, whereas a deduction l

5. **Can I deduct medical expenses?**
   - Yes, you can deduct unreimbursed medical expenses that exceed 7.5% of your adjusted gross

6. **Should I itemize deductions or take the standard deduction?**
   - You should itemize if your allowable deductions exceed the standard deduction for your fi

7. **How do tax brackets work?**
   - The U.S. tax system is progressive; income is taxed at increasing rates as it moves into

8. **What is the Earned Income Tax Credit (EITC) and how do I claim it?**
   - The EITC is a refundable credit for low to moderate-income earners. Eligibility depends o

9. **Are unemployment benefits taxable?**
   - Yes, unemployment benefits are generally considered taxable income at the federal level a

10. **How are my investment gains taxed?**
    - Short-term capital gains (on assets held less than a year) are taxed as ordinary income,

11. **Do I pay taxes on investments if I don't sell them?**
    - Generally, you pay taxes on dividends and interest earned, even if you don't sell the in

12. **What income is taxable?**
    - Taxable income includes wages, salaries, bonuses, interest, dividends, rental income, an

13. **When are taxes due?**
    - Federal income tax returns are typically due on April 15. If this date falls on a weeken

14. **What happens if I don't file my taxes?**
    - Failure to file can result in penalties, interest on unpaid taxes, and potential legal a

15. **How do I notify the IRS of an address change?**
    - You can inform the IRS by filing Form 8822, using your new address on your tax return, o

16. **Can I claim my boyfriend/girlfriend as a dependent?**

```
    - Possibly, if they meet the criteria for a qualifying relative, including residency, incor

17. **Are moving expenses tax-deductible?**
    - As of the Tax Cuts and Jobs Act of 2017, moving expenses are generally not deductible, ex

18. **How do I check the status of my tax refund?**
    - You can check your refund status using the "Where's My Refund?" tool on the IRS website o

19. **What is the Alternative Minimum Tax (AMT)?**
    - The AMT is a parallel tax system ensuring that high-income individuals pay a minimum amou

20. **How long should I keep tax records?**
    - It's recommended to keep tax records for at least three years from the date you filed you
```

ChatGPT o3-mini-high: Prompt to ChatGPT o3-mini-high: give me 20 more of the tax question. Some deep ones. search online or just if you know them

Response:

```
| Question | Answer |
|----------|--------|
| **What is the difference between tax avoidance and tax evasion?** | Tax avoidance is the lega
| **How does the Alternative Minimum Tax (AMT) work for high-income taxpayers?** | The AMT is a
| **How do tax treaties mitigate double taxation on international income?** | Tax treaties are
| **How is cost basis determined for capital gains, and what adjustments are commonly made?**
| **What are the implications of the passive activity loss rules for rental real estate investm
| **How are self-employment taxes calculated, and what strategies can reduce their impact?** |
| **What is the Qualified Business Income (QBI) deduction and what limitations apply?** | The (
| **How does the tax treatment of cryptocurrency transactions differ from traditional investmen
| **What are the tax implications of stock options, and how do ISOs differ from NSOs?** | Incen
| **How does depreciation recapture affect the sale of depreciated property?** | When selling o
| **How does a Section 1031 like-kind exchange work and what are its limitations post-TCJA?**
| **What are the tax implications of receiving foreign income and using the Foreign Tax Credit
| **How does the cancellation of debt (COD) income work and what is the insolvency exception?**
meaning their liabilities exceed their assets-they may exclude canceled debt from income up to
| **How do installment sales work for deferring gain on property sales?** | An installment sale
| **What is the doctrine of economic substance and how does it affect tax planning?** | The eco
| **How do tax loss carryforwards and carrybacks work, and what limitations exist?** | Tax loss
| **What are the tax implications of converting a business entity, such as from an LLC to an S
| **How does the treatment of charitable contributions differ when itemizing deductions versus
| **How are fringe benefits taxed, and what exceptions exist?** | Fringe benefits are generally
| **How does the tax treatment differ for nonresident aliens compared to U.S. residents?** | No
```

Claude 3.7 Sonnet: Prompt to Claude 3.7 Sonnet: give me 40 questions related to tax, not too unique ones and the answers to it in detail in a table

Response:

40 Common Tax Questions and Detailed Answers

Question	Detailed Answer
1. What is the difference between a tax credit and a tax deduction?	A tax credit directly r
2. What is the standard deduction for 2024?	For the 2024 tax year (filing in 2025), the sta
3. What is the difference between itemized deductions and the standard deduction?	The stand
4. How long should I keep tax records?	The IRS recommends keeping tax returns and supportin
5. What is the capital gains tax rate?	For 2024, long-term capital gains (assets held over
6. How do I calculate my tax bracket?	Tax brackets are based on your taxable income (after
7. What is the deadline for filing taxes?	For most individuals, federal income tax returns
not the deadline for paying any taxes owed.
8. What is the penalty for filing taxes late?	The penalty for filing late is typically 5% o
9. What tax forms do I need to file?	Most individuals use Form 1040 for federal income taxe
10. How do I check my tax refund status?	You can check your federal tax refund status using
11. What is the Earned Income Tax Credit (EITC)?	The EITC is a refundable tax credit for lo
12. Are unemployment benefits taxable?	Yes, unemployment benefits are generally considered
13. How do I report cryptocurrency transactions on my taxes?	Cryptocurrency transactions ar
14. What is the Child Tax Credit?	The Child Tax Credit for 2024 is worth up to $2,000 per c
15. What is the tax treatment for Health Savings Accounts (HSAs)?	HSAs offer triple tax adv
16. How do 401(k) contributions affect my taxes?	Traditional 401(k) contributions are made
17. What home expenses are tax deductible?	For most homeowners, mortgage interest on up to
18. How are Social Security benefits taxed?	Social Security benefits may be partially taxab
19. What is the Gift Tax exclusion amount?	For 2024, you can give up to $18,000 per recipie
20. How do I handle taxes for a side gig or freelance work?	Income from side gigs or freela
21. What education expenses are tax deductible or eligible for credits?	The American Opport
22. How does marriage affect taxes?	Marriage can create a "marriage bonus" or "marriage per
23. What is the Alternative Minimum Tax (AMT)?	The AMT is a parallel tax system designed to
24. How are dividends taxed?	Qualified dividends are taxed at the same preferential rates a
25. What are the tax implications of working remotely in a different state?	Working remotel
26. What charitable donations are tax deductible?	Donations to qualified tax-exempt organiz
27. How do I claim a home office deduction?	Self-employed individuals can claim home office
28. What is depreciation recapture?	Depreciation recapture occurs when you sell a depreciab
29. How do I report rental income and expenses?	Rental income and expenses are reported on
30. What is the Net Investment Income Tax (NIIT)?	The NIIT is a 3.8% tax on net investment
31. How are retirement account withdrawals taxed?	Traditional IRA and 401(k) withdrawals ar
32. What is the tax treatment for stock options?	For Non-Qualified Stock Options (NQSOs), y
33. How do I deduct medical expenses?	Medical expenses exceeding 7.5% of your adjusted gros
34. What is the Saver's Credit?	The Saver's Credit (officially the Retirement Savings Contr
35. How do I report stock sales on my tax return?	Stock sales are reported on Schedule D ar
36. What is the Foreign Tax Credit?	The Foreign Tax Credit helps U.S. taxpayers avoid doubl
37. What are the tax implications of cancellation of debt?	Cancelled debt is generally cons
38. How do I report gambling winnings and losses?	All gambling winnings are reportable as
39. What is the tax treatment for Health Flexible Spending Arrangements (FSAs)?	Health FSA
40. How are inherited assets taxed?	Inherited assets generally receive a "step-up" in basis

Llama 3.1-405B: Prompt to Llama 3.1-405B: give me 40 questions related to tax, not too unique ones and the answers to it in detail in a table, be detailed

Response:

Here are the 40 tax-related questions with detailed answers:

Tax-Related Questions and Answers

Question #	Question	Answer
1	What is the deadline for filing individual tax returns?	The deadline for filing individual
2	What is the standard deduction for single filers?	The standard deduction for single fi
3	What is the standard deduction for married couples filing jointly?	The standard deducti
4	What is the tax rate for long-term capital gains?	Long-term capital gains are taxed at
5	Can I deduct mortgage interest on my tax return?	Yes, you can deduct mortgage interest
6	What is the earned income tax credit (EITC)?	The EITC is a refundable tax credit for lo
7	Can I claim a dependent on my tax return?	Yes, you can claim a dependent on your tax re
8	What is the child tax credit?	The child tax credit is a non-refundable tax credit of up
9	Do I need to file a tax return if I'm self-employed?	Yes, you need to file a tax return
10	What is the self-employment tax rate?	The self-employment tax rate is 15.3% of net ear
11	Can I deduct business expenses on my tax return?	Yes, you can deduct business expenses
12	What is the home office deduction?	The home office deduction allows you to deduct a po
13	Can I deduct charitable donations on my tax return?	Yes, you can deduct charitable don
14	What is the limit on state and local tax (SALT) deductions?	The limit on SALT deductio
15	Can I deduct medical expenses on my tax return?	Yes, you can deduct medical expenses o
16	What is the alternative minimum tax (AMT)?	The AMT is a separate tax calculation that
17	Can I claim a deduction for education expenses?	Yes, you can claim a deduction for edu
18	What is the student loan interest deduction?	The student loan interest deduction allow
19	Can I deduct moving expenses on my tax return?	Yes, you can deduct moving expenses on
20	What is the tax rate for short-term capital gains?	Short-term capital gains are taxed
21	Can I deduct property taxes on my tax return?	Yes, you can deduct property taxes on yo
22	What is the qualified business income (QBI) deduction?	The QBI deduction allows you to
23	Can I deduct retirement contributions on my tax return?	Yes, you can deduct contributi
24	What is the required minimum distribution (RMD) age?	The RMD age is 72 years old, unle
25	Can I deduct alimony payments on my tax return?	Yes, you can deduct alimony payments o
26	What is the tax rate for dividends?	Dividends are taxed at 0%, 15%, or 20% depending o
27	Can I deduct business use of my car on my tax return?	Yes, you can deduct business use
28	What is the standard mileage rate for business use?	The standard mileage rate for busi
29	Can I deduct home improvements on my tax return?	Yes, you can deduct home improvements
30	What is the tax credit for child and dependent care?	The tax credit for child and depe
31	Can I deduct state taxes on my tax return?	Yes, you can deduct state taxes on your tax
32	What is the tax rate for interest income?	Interest income is taxed as ordinary income
33	Can I deduct investment expenses on my tax return?	Yes, you can deduct investment expe
34	What is the tax credit for education expenses?	The tax credit for education expenses i
35	Can I deduct business travel expenses on my tax return?	Yes, you can deduct business travel
36	What is the per diem rate for business travel?	The per diem rate for business travel v
37	Can I deduct business entertainment expenses on my tax return?	Yes, you can deduct bus
38	What is the tax rate for capital gains on collectibles?	Capital gains on collectibles
39	Can I deduct business liability insurance premiums on my tax return?	Yes, you can dedu

```
| 40 | What is the tax credit for retirement savings contributions? | The tax credit for retire


Important Notes
These answers are based on federal tax laws and regulations for the 2023 tax year.
Tax laws and regulations are subject to change, so it's always best to consult with a tax profe
These questions and answers are meant to provide general guidance and may not apply to your spe
Always consult with a tax professional or financial advisor to ensure you're in compliance with
Additional Resources
IRS Website: (link unavailable)
IRS Taxpayer Assistance Centers: (link unavailable)
Tax Professionals: Find a certified public accountant (CPA) or enrolled agent (EA) in your area
Tax Software: Utilize tax software, such as TurboTax or H&R Block, to prepare and file your tax
```

All of this is then cleaned and compilled into a Google Docs, which then converts into a csv, the csv is called `tax-questions-answers.csv`.

[ ]:
```
DATA_DIR = "data"
q_and_a = pd.read_csv(os.path.join(DATA_DIR,'tax-questions-answers.csv'))
q_and_a.head()
```

[ ]:

	Source	ID	Question	Answer
0	ChatGPT GPT4o	1	How can I reduce my tax bill?	To lower your tax liability, consider maximizi…
1	ChatGPT GPT4o	2	What deductions am I eligible for?	Eligibility for deductions varies based on ind…
2	ChatGPT GPT4o	3	What's the difference between marginal and eff…	The marginal tax rate is the rate applied to y…
3	ChatGPT GPT4o	4	Which is better: a tax credit or a tax deduction?	A tax credit directly reduces your tax liabili…
4	ChatGPT GPT4o	5	Can I deduct medical expenses?	Yes, you can deduct unreimbursed medical expen…

[15]:
```
q_and_a['Source'].unique()
```

[15]:
```
array(['ChatGPT GPT4o', 'ChatGPT o3-mini-high', 'Claude 3.7 Sonnet ',
       'Llama 3.1-405B'], dtype=object)
```

Since we will be using RAG with the tax documentation, we will pull the PDFs directly and process them.

1.4.6 Contextual Information Collection.

To build our contextually aware system, we experimented with several data sources and endpoints. We explored the SEC EDGAR API to retrieve company filing histories, specific XBRL disclosures, aggregated XBRL facts, and frame data for various concepts. We also tested the FederalRegister API for document searches on topics like the environment and healthcare, as well as the govinfo API

to access legal collections, track updates such as Congressional Bills, and obtain detailed package metadata. In the end, we decided to use the IRS instructions page as our primary data source. The code snippet below shows how we fetched the IRS instructions page, processed the PDFs using PyMuPDF to extract text, and handled any errors encountered during the process. For more details, check out the `initial_data_exploration.ipynb` file in the `miscellaneous` directory.

Reading PDFs from IRS

[ ]:
```
IRS_URL = "https://www.irs.gov/instructions"

try:
    response = requests.get(IRS_URL, timeout=10)
    response.raise_for_status()
except requests.RequestException as e:
    raise Exception(f"Failed to fetch IRS instructions page: {e}")

soup = BeautifulSoup(response.text, "html.parser")
pdf_texts = []

for link in soup.find_all("a", href=True):
    href = link["href"]
    if href.lower().endswith(".pdf"):
        pdf_url = urljoin(IRS_URL, href)
        print(f"Processing PDF: {pdf_url}")

        try:
            pdf_response = requests.get(pdf_url, timeout=10)
            pdf_response.raise_for_status()
        except requests.RequestException as e:
            print(f"  Failed to fetch {pdf_url}: {e}")
            continue

        pdf_bytes = BytesIO(pdf_response.content)
        try:
            doc = fitz.open(stream=pdf_bytes, filetype="pdf")
            text = ""
            for page in doc:
                text += page.get_text()
            pdf_texts.append({"file_name": pdf_url.split("/")[-1], "content":␣
 ↪text})
        except Exception as e:
            print(f"  Failed to process {pdf_url}: {e}")

print(f"  Processed {len(pdf_texts)} PDFs")
```

```
Processing PDF: https://www.irs.gov/pub/irs-pdf/i1040gi.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/pcir230.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i1040gi.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/pcir230.pdf
```

```
Processing PDF: https://www.irs.gov/pub/irs-pdf/i56.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i172.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i461.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706a.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706d.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706gsd.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706gsd1.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706gst.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706na.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i706qdt.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i709.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i720.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i720cs.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i720to.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i843.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i926.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i940.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i940pr.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i940pr.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i940pr.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i940sp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941pr.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i941pr.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i941pr.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941prb.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i941prb.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i941prb.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941sb.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941sd.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941sp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941sr.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941ss.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i941ss.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i941ss.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941x.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941xpr.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i941xpr.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i941xpr.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i941xsp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i943.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i943a.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i943apr.pdf
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Not Found for url: https://www.irs.gov/pub/irs-pdf/i943apr.pdf
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Processing PDF: https://www.irs.gov/pub/irs-pdf/i8866.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8867.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8868.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8869.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8871.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8872.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8873.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8881.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8883.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8885.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8886.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8886t.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8889.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8898.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8900.pdf
```

```
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8902.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8903.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8904.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8908.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8910.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8911.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8912.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8913.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i8913.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i8913.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8915.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i8915.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i8915.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8915b.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8915c.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8915d.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8915f.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8918.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8921.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8928.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8933.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8935.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8936.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8936a.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i8936a.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i8936a.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8937.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8938.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8940.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8941.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8942.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i8942.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/i8942.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8949.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8950.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8952.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8955ssa.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8957.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8959.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8960.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8962.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8963.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8966.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8971.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8973.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8974.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8975.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8978.pdf
```

```
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8979.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8985.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8986.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8990.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8991.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8992.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8993.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8994.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8995.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8995a.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i8996.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i9465.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i9465--2023-11-00.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/i9465--2023-11-00.pdf: 404
Client Error: Not Found for url: https://www.irs.gov/pub/irs-pdf/i9465--
2023-11-00.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i9465sp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i9465zhs.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i9465zht.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i109495b.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/i109495c.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/ict1.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/ict1x.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iss4.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iss4sp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iss8.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iss8pr.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/iss8pr.pdf: 404 Client Error:
Not Found for url: https://www.irs.gov/pub/irs-pdf/iss8pr.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iss8sp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/it.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw-8imy_docbook.pdf
  Failed to fetch https://www.irs.gov/pub/irs-pdf/iw-8imy_docbook.pdf: 404
Client Error: Not Found for url: https://www.irs.gov/pub/irs-
pdf/iw-8imy_docbook.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw2g.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw2w3.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw3pr.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw3ss.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw7.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw7a.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw7sp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw8.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw8ben.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw8bene.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw8eci.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw8exp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw8imy.pdf
```

```
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw9.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw9sp.pdf
Processing PDF: https://www.irs.gov/pub/irs-pdf/iw14.pdf
  Processed 409 PDFs
```

1.4.7 Converting to MD

[ ]:
```
pdf_markdown = [
    {"file_name": doc["file_name"].replace(".pdf", ".md"), "content":␣
 ↪md(doc["content"])}
    for doc in pdf_texts
]

print(f"  Converted {len(pdf_markdown)} PDFs to Markdown format")
```

```
  Converted 409 PDFs to Markdown format
```

1.4.8 Chunking & Storing Vectors

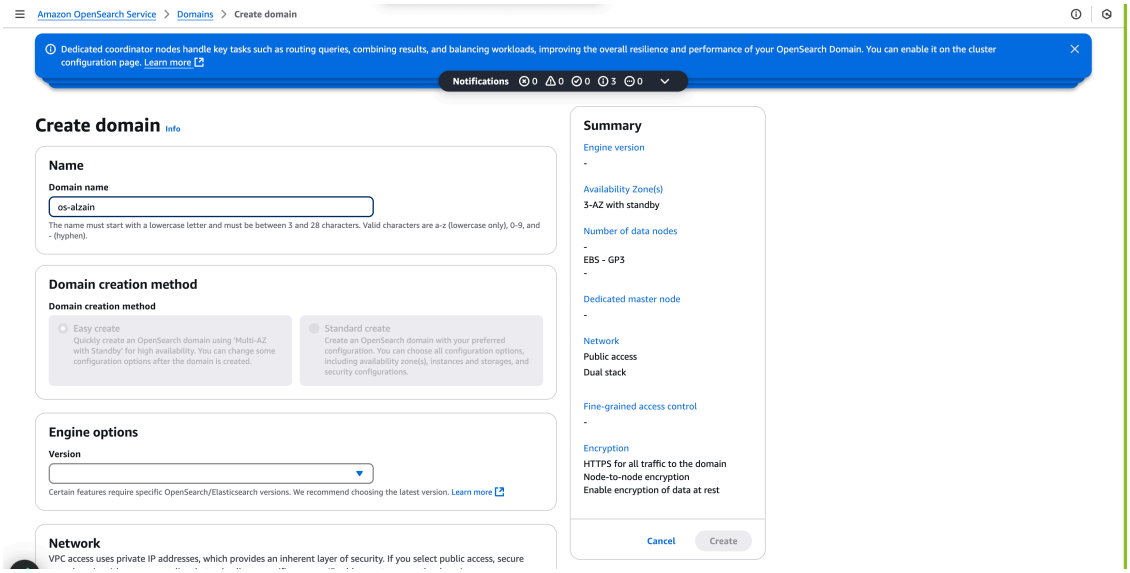
[ ]:
```
text_splitter = RecursiveCharacterTextSplitter(chunk_size=500,␣
 ↪chunk_overlap=100)
chunks = []
for doc in pdf_markdown:
    split_texts = text_splitter.split_text(doc["content"])
    for i, text in enumerate(split_texts):
        chunks.append({"file_name": doc["file_name"], "chunk_id": i, "content":␣
 ↪text})

print(f"  Created {len(chunks)} text chunks")
```

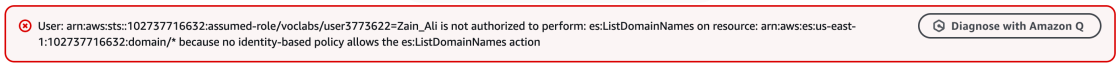
```
  Created 68418 text chunks
```

1.4.9 OpenSearch

Initially we tried to get OpenSearch configured, but it did not work.

[ ]:
```
display(Image(filename='supporting_media/why-pinecode-1.png'))
display(Image(filename='supporting_media/why-pinecode-2.png'))
```





So, we decided to go with Pinecone, as that can also be hosted through AWS.

1.4.10 Pushing Chunks to Pinecone

```
[ ]: pc = pinecone.Pinecone(api_key=os.getenv("PINECONE_API_KEY"))
index_name = "tax-rag"

existing_indexes = [index.name for index in pc.list_indexes()]
if index_name not in existing_indexes:
    print(f"Creating new Pinecone index: {index_name}")
    pc.create_index(
        name=index_name,
        spec=pinecone.ServerlessSpec(
            cloud="aws",
            region="us-east-1"
        ),
        dimension=384,
        metric="cosine"
    )

index = pc.Index(index_name)
print(f"  Connected to Pinecone index: {index_name}")
```

```
Creating new Pinecone index: tax-rag
  Connected to Pinecone index: tax-rag
```

[10]:
```python
embedding_model = SentenceTransformer("all-MiniLM-L6-v2")
```

[ ]:
```python
chunk_embeddings = [
    {
        "file_name": chunk["file_name"],
        "chunk_id": chunk["chunk_id"],
        "content": chunk["content"],
        "embedding": embedding_model.encode(chunk["content"]).tolist()
    }
    for chunk in chunks
]

def batch_upsert(index, vectors, batch_size=100):
    """Uploads embeddings in batches to avoid Pinecone's request size limit."""
    for i in range(0, len(vectors), batch_size):
        batch = vectors[i : i + batch_size]
        index.upsert(batch)
        print(f"  Uploaded batch {i // batch_size + 1}/{(len(vectors) //␣
 ↪batch_size) + 1}")

vectors = [
    (f"{chunk['file_name']}_{chunk['chunk_id']}", chunk["embedding"], {"text":␣
 ↪chunk["content"]})
    for chunk in chunk_embeddings
]

batch_upsert(index, vectors)
print("  All embeddings successfully stored in Pinecone!")
```

The cell executed successfully, but we accidentally deleted the output during the cleanup process. The complete successful run took two hours.

1.4.11 Testing Embedding

[20]:
```python
def query_and_get_top_two(query, embedding_model, index):
    query_embedding = embedding_model.encode(query).tolist()
    results = index.query(vector=query_embedding, top_k=2,␣
 ↪include_metadata=True)
    matches = results.get("matches", [])
    if len(matches) == 0:
        return ("", None, "", None)
    elif len(matches) == 1:
        return (matches[0]['metadata']['text'], matches[0]['score'], "", None)
    else:
        return (matches[0]['metadata']['text'], matches[0]['score'],
```

```
                matches[1]['metadata']['text'], matches[1]['score'])
```

[26]:
```
context1, score1, context2, score2 = query_and_get_top_two("Which forms do I␣
↪need for self-employment?", embedding_model, index)


print("Top 1 Result:")
print("Text :", context1)
print("Score:", score1)

if context2:
    print("\nTop 2 Result:")
    print("Text :", context2)
    print("Score:", score2)
```

```
Top 1 Result:
Text : self-employment income from separate nonfarm or farm
businesses, each of you must complete and file a
separate Schedule C (Form 1040) or Schedule F (Form
1040). Be sure to enter at the top of each Schedule C
(Form 1040) or Schedule F (Form 1040) the name and
SSN of the spouse who owns the business. Each of you
must also complete a separate Schedule SE (Form 1040).
Attach these pages to a single Form 1040-SS.
Business Owned and Operated by
Spouses
Score: 0.604735672

Top 2 Result:
Text : Schedule SE (Form 1040), Self-Employment Tax, to complete your return.
You may only need to file Form 1040-SS and none of the schedules. However, if
your return is more complicated (for
example, you claim certain deductions or credits or owe additional taxes), you
will need to complete one or more of the
schedules. Below is a general guide to which schedule(s) you will need to file
based on your circumstances. See the
Score: 0.598732054
```

1.4.12 Updating the Fine-tunning Data

[27]:
```
q_and_a[['Context1', 'Score1', 'Context2', 'Score2']] = q_and_a['Question'].
↪apply(
    lambda q: pd.Series(query_and_get_top_two(q, embedding_model, index))
)
```

[ ]:
```
q_and_a.to_csv
```

[ ]:

	Source	ID	Question	\
0	ChatGPT GPT4o	1	How can I reduce my tax bill?	
1	ChatGPT GPT4o	2	What deductions am I eligible for?	
2	ChatGPT GPT4o	3	What's the difference between marginal and eff…	
3	ChatGPT GPT4o	4	Which is better: a tax credit or a tax deduction?	
4	ChatGPT GPT4o	5	Can I deduct medical expenses?	

	Answer	\
0	To lower your tax liability, consider maximizi…	
1	Eligibility for deductions varies based on ind…	
2	The marginal tax rate is the rate applied to y…	
3	A tax credit directly reduces your tax liabili…	
4	Yes, you can deduct unreimbursed medical expen…	

	Context1	Score1	\
0	System at IRS.gov/SAMS.\nFor more information,…	0.566803	
1	Standard Deduction (Group I Only)\nIf you do n…	0.668105	
2	a rate for branch profits, the rate of tax is …	0.553689	
3	deduction, or both. However, a practice that d…	0.579091	
4	If you itemize, you can deduct a part of your …	0.688144	

	Context2	Score2
0	WV 26106-2188. Or you can enclose\nthe check w…	0.563434
1	33\nStandard Deduction Worksheet for Dependent…	0.662116
2	Taxable amount over\nColumn B\nTaxable amount …	0.487213
3	tax deduction recognized for U.S. taxable inco…	0.547606
4	Don't include on Schedule A items deducted els…	0.681987

Breakpoint

Run following cells to either save or load data at this point.

[ ]:
```
q_and_a_path = os.path.join(DATA_DIR, "tax-questions-answers-with-context.csv")
```

[32]:
```
q_and_a.to_csv(q_and_a_path, index=False)
```

[4]:
```
q_and_a = pd.read_csv(q_and_a_path)
```

1.5 Model Finetunning

Our initial discovery was to find a model that was close to our needs, so an extensive finetunning will not be required.

We found two main candidates:

- Lawma
- saul_7b_instruct

Lawma had a 8b and also 70b. TODO:

After unable to run these to best of our capabiities, we decided to find alternative, this is also when deepseek just recently came out. We started tested with multiple different iterations of deep seek. We found the best one to be "DeepSeek-V2-Lite", which was light and instructut and worked very well with our capabilities.

We got a server with two a100s.

the problems of other models were not solved by even fine tunning, and overall pipeline would not work very well.

So we decided to with deepseek fine tunning using the data I had

[ ]:
```
# Set CUDA device environment variables BEFORE importing any CUDA libraries.
os.environ["CUDA_VISIBLE_DEVICES"] = "0"
os.environ["CUDA_DEVICE_ORDER"] = "PCI_BUS_ID"
os.environ["PYTORCH_CUDA_ALLOC_CONF"] = "expandable_segments:True"

torch.cuda.set_device(0)
print("Using GPU:", torch.cuda.current_device())
```

```
Using GPU: 0
```

[ ]:
```
try:
    q_and_a
except NameError:
    q_and_a = pd.read_csv(q_and_a_path)

def construct_prompt(row):
    return f"""You are a helpful tax advisor and legal expert. Use the provided␣
 ↪context to answer the user's query in a clear and concise manner.

User Query: {row['Question']}

Related Context:
{row['Context1']}
{row['Context2']}

Note: The above information is extracted from relevant forms or online sources.␣
 ↪Use it to formulate your response."""

q_and_a["prompt"] = q_and_a.apply(construct_prompt, axis=1)
q_and_a["target"] = q_and_a["Answer"]

print("Data prepared: prompt and target columns added.")

from datasets import Dataset

dataset = Dataset.from_pandas(q_and_a)
dataset = dataset.train_test_split(test_size=0.2, seed=42)
```

```
train_dataset = dataset["train"]
eval_dataset = dataset["test"]

print("Train and evaluation datasets created.")
```

```
Data prepared: prompt and target columns added.
Train and evaluation datasets created.
```

[ ]:
```
base_model_path = "./model_directory/models--deepseek-ai--DeepSeek-V2-Lite-Chat/
  ↪snapshots/85864749cd611b4353ce1decdb286193298f64c7"
output_dir = "./model_directory/models--zainnobody--TaxSense/"
os.makedirs(output_dir, exist_ok=True)

# Load the tokenizer from the base model.
tokenizer = AutoTokenizer.from_pretrained(
    base_model_path,
    add_eos_token=True,
    use_fast=True,
    trust_remote_code=True,
)
tokenizer.pad_token = tokenizer.eos_token
tokenizer.pad_token_id = tokenizer.eos_token_id
tokenizer.padding_side = "left"

# Set compute dtype and attention implementation.
if torch.cuda.is_bf16_supported():
    compute_dtype = torch.bfloat16
    attn_implementation = "flash_attention_2"
else:
    compute_dtype = torch.float16
    attn_implementation = "sdpa"

# Configure 4-bit quantization settings.
bnb_config = BitsAndBytesConfig(
    load_in_4bit=True,
    bnb_4bit_quant_type="nf4",
    bnb_4bit_compute_dtype=compute_dtype,
    bnb_4bit_use_double_quant=True,
)

# Load the base model using a device map that forces it onto the current CUDA␣
  ↪device.
model = AutoModelForCausalLM.from_pretrained(
    base_model_path,
    quantization_config=bnb_config,
    device_map={"": torch.cuda.current_device()},
    trust_remote_code=True,
```

```
)
print("Base model loaded.")

# Prepare the model for k-bit training (QLoRA).
model = prepare_model_for_kbit_training(model)

# Optionally disable gradient checkpointing if it's causing issues.
if hasattr(model, "gradient_checkpointing_disable"):
    model.gradient_checkpointing_disable()
    print("Gradient checkpointing disabled.")

# Ensure the model is on GPU 0.
model = model.to("cuda:0")
print("Model is on GPU 0.")

# Configure LoRA.
peft_config = LoraConfig(
    lora_alpha=16,
    lora_dropout=0.05,
    r=16,
    bias="none",
    task_type="CAUSAL_LM",
    target_modules="all-linear",
)
```

```
Loading checkpoint shards:   0%|          | 0/4 [00:00<?, ?it/s]
```

```
Base model loaded.
Gradient checkpointing disabled.
Model is on GPU 0.
```

[ ]:
```
q_and_a["token_count"] = q_and_a["prompt"].apply(lambda x: len(tokenizer.
 ↪encode(x)))
max_token_len = q_and_a["token_count"].max()
if max_token_len > 512:
    num_exceeding = (q_and_a["token_count"] > 512).sum()
    print(f"Due to CUDA memory limits, we can only go up to 512 tokens. We will␣
 ↪truncate {num_exceeding} samples.")
    max_token_len = 512
```

```
Due to CUDA memory limits, we can only go up to 512 tokens. We will truncate 4
samples.
```

[13]:
```
def tokenize_function(examples):
    full_texts = [
        f"{prompt.strip()}\n\nResponse: {target.strip()}"
        for prompt, target in zip(examples["prompt"], examples["target"])
    ]
```

```
    return tokenizer(full_texts, truncation=True, max_length=max_token_len,␣
 ↪padding="max_length")
```

[ ]:
```
training_arguments = TrainingArguments(
    output_dir=output_dir,
    evaluation_strategy="steps",
    do_eval=True,
    optim="paged_adamw_8bit",
    per_device_train_batch_size=4,
    gradient_accumulation_steps=4,
    per_device_eval_batch_size=4,
    log_level="debug",
    save_strategy="epoch",
    logging_steps=100,
    learning_rate=1e-4,
    fp16=True,
    bf16=False,
    eval_steps=100,
    num_train_epochs=1,
    warmup_ratio=0.1,
    lr_scheduler_type="linear",
    local_rank=-1,
)

trainer = SFTTrainer(
    model=model,
    train_dataset=train_dataset,
    eval_dataset=eval_dataset,
    peft_config=peft_config,
    tokenizer=tokenizer,
    args=training_arguments,
)
```

```
comet_ml is installed but the Comet API Key is not configured. Please set the
`COMET_API_KEY` environment variable to enable Comet logging. Check out the
documentation for other ways of configuring it:
https://www.comet.com/docs/v2/guides/experiment-management/configure-sdk/#set-
the-api-key
comet_ml is installed but the Comet API Key is not configured. Please set the
`COMET_API_KEY` environment variable to enable Comet logging. Check out the
documentation for other ways of configuring it:
https://www.comet.com/docs/v2/guides/experiment-management/configure-sdk/#set-
the-api-key

Converting train dataset to ChatML:   0%|          | 0/96 [00:00<?, ? examples/s]

Applying chat template to train dataset:   0%|          | 0/96 [00:00<?, ?␣
 ↪examples/s]
```

```
Truncating train dataset:   0%|          | 0/96 [00:00<?, ? examples/s]

Converting eval dataset to ChatML:   0%|          | 0/24 [00:00<?, ? examples/s]

Applying chat template to eval dataset:   0%|          | 0/24 [00:00<?, ?␣
↪examples/s]

Truncating eval dataset:   0%|          | 0/24 [00:00<?, ? examples/s]

Using auto half precision backend
No label_names provided for model class `PeftModelForCausalLM`. Since
`PeftModel` hides base models input arguments, if label_names is not given,
label_names can't be set automatically within `Trainer`. Note that empty
label_names list will be used instead.
```

[ ]:
```
trainer.train()
model.save_pretrained(output_dir, safe_serialization=True)
print(f"TaxSense model saved to: {output_dir}")
```

```
Currently training with a batch size of: 4
The following columns in the training set don't have a corresponding argument in
`PeftModelForCausalLM.forward` and have been ignored: prompt, Context2,
Context1, ID, Score1, target, Answer, Source, Question, Score2. If prompt,
Context2, Context1, ID, Score1, target, Answer, Source, Question, Score2 are not
expected by `PeftModelForCausalLM.forward`,  you can safely ignore this message.
***** Running training *****
  Num examples = 96
  Num Epochs = 1
  Instantaneous batch size per device = 4
  Total train batch size (w. parallel, distributed & accumulation) = 16
  Gradient Accumulation steps = 4
  Total optimization steps = 6
  Number of trainable parameters = 289,837,056

<IPython.core.display.HTML object>

Saving model checkpoint to ./model_directory/models--zainnobody--
TaxSense/checkpoint-6
loading configuration file ./model_directory/models--deepseek-ai--
DeepSeek-V2-Lite-
Chat/snapshots/85864749cd611b4353ce1decdb286193298f64c7/config.json
Model config DeepseekV2Config {
  "architectures": [
    "DeepseekV2ForCausalLM"
  ],
  "attention_bias": false,
  "attention_dropout": 0.0,
  "auto_map": {
    "AutoConfig": "configuration_deepseek.DeepseekV2Config",
    "AutoModel": "modeling_deepseek.DeepseekV2Model",
    "AutoModelForCausalLM": "modeling_deepseek.DeepseekV2ForCausalLM"
```

```
},
"aux_loss_alpha": 0.001,
"bos_token_id": 100000,
"eos_token_id": 100001,
"ep_size": 1,
"first_k_dense_replace": 1,
"hidden_act": "silu",
"hidden_size": 2048,
"initializer_range": 0.02,
"intermediate_size": 10944,
"kv_lora_rank": 512,
"max_position_embeddings": 163840,
"model_type": "deepseek_v2",
"moe_intermediate_size": 1408,
"moe_layer_freq": 1,
"n_group": 1,
"n_routed_experts": 64,
"n_shared_experts": 2,
"norm_topk_prob": false,
"num_attention_heads": 16,
"num_experts_per_tok": 6,
"num_hidden_layers": 27,
"num_key_value_heads": 16,
"pretraining_tp": 1,
"q_lora_rank": null,
"qk_nope_head_dim": 128,
"qk_rope_head_dim": 64,
"rms_norm_eps": 1e-06,
"rope_scaling": {
  "beta_fast": 32,
  "beta_slow": 1,
  "factor": 40,
  "mscale": 0.707,
  "mscale_all_dim": 0.707,
  "original_max_position_embeddings": 4096,
  "type": "yarn"
},
"rope_theta": 10000,
"routed_scaling_factor": 1.0,
"scoring_func": "softmax",
"seq_aux": true,
"tie_word_embeddings": false,
"topk_group": 1,
"topk_method": "greedy",
"torch_dtype": "bfloat16",
"transformers_version": "4.49.0",
"use_cache": true,
"v_head_dim": 128,
```

```
  "vocab_size": 102400
}

tokenizer config file saved in ./model_directory/models--zainnobody--
TaxSense/checkpoint-6/tokenizer_config.json
Special tokens file saved in ./model_directory/models--zainnobody--
TaxSense/checkpoint-6/special_tokens_map.json
Saving model checkpoint to ./model_directory/models--zainnobody--
TaxSense/checkpoint-6
loading configuration file ./model_directory/models--deepseek-ai--
DeepSeek-V2-Lite-
Chat/snapshots/85864749cd611b4353ce1decdb286193298f64c7/config.json
Model config DeepseekV2Config {
  "architectures": [
    "DeepseekV2ForCausalLM"
  ],
  "attention_bias": false,
  "attention_dropout": 0.0,
  "auto_map": {
    "AutoConfig": "configuration_deepseek.DeepseekV2Config",
    "AutoModel": "modeling_deepseek.DeepseekV2Model",
    "AutoModelForCausalLM": "modeling_deepseek.DeepseekV2ForCausalLM"
  },
  "aux_loss_alpha": 0.001,
  "bos_token_id": 100000,
  "eos_token_id": 100001,
  "ep_size": 1,
  "first_k_dense_replace": 1,
  "hidden_act": "silu",
  "hidden_size": 2048,
  "initializer_range": 0.02,
  "intermediate_size": 10944,
  "kv_lora_rank": 512,
  "max_position_embeddings": 163840,
  "model_type": "deepseek_v2",
  "moe_intermediate_size": 1408,
  "moe_layer_freq": 1,
  "n_group": 1,
  "n_routed_experts": 64,
  "n_shared_experts": 2,
  "norm_topk_prob": false,
  "num_attention_heads": 16,
  "num_experts_per_tok": 6,
  "num_hidden_layers": 27,
  "num_key_value_heads": 16,
  "pretraining_tp": 1,
  "q_lora_rank": null,
  "qk_nope_head_dim": 128,
```

```
  "qk_rope_head_dim": 64,
  "rms_norm_eps": 1e-06,
  "rope_scaling": {
    "beta_fast": 32,
    "beta_slow": 1,
    "factor": 40,
    "mscale": 0.707,
    "mscale_all_dim": 0.707,
    "original_max_position_embeddings": 4096,
    "type": "yarn"
  },
  "rope_theta": 10000,
  "routed_scaling_factor": 1.0,
  "scoring_func": "softmax",
  "seq_aux": true,
  "tie_word_embeddings": false,
  "topk_group": 1,
  "topk_method": "greedy",
  "torch_dtype": "bfloat16",
  "transformers_version": "4.49.0",
  "use_cache": true,
  "v_head_dim": 128,
  "vocab_size": 102400
}

tokenizer config file saved in ./model_directory/models--zainnobody--
TaxSense/checkpoint-6/tokenizer_config.json
Special tokens file saved in ./model_directory/models--zainnobody--
TaxSense/checkpoint-6/special_tokens_map.json


Training completed. Do not forget to share your model on huggingface.co/models
=)


Configuration saved in ./model_directory/models--zainnobody--
TaxSense/config.json
Configuration saved in ./model_directory/models--zainnobody--
TaxSense/generation_config.json
The model is bigger than the maximum size per checkpoint (5GB) and is going to
be split in 3 checkpoint shards. You can find where each parameters has been
saved in the index located at ./model_directory/models--zainnobody--
TaxSense/model.safetensors.index.json.

TaxSense model saved to: ./model_directory/models--zainnobody--TaxSense/
```

The following code ensures that all tokenizer-related files are copied to the new model directory. Having the tokenizer files in one place is essential for consistency when loading the model for inference, ensuring the correct tokenizer configuration is used.

[ ]:
```
model_files = [
    "config.json",
    "special_tokens_map.json",
    "tokenizer.json",
    "tokenizer_config.json",
    "pytorch_model.bin",
    "adapter_config.json",
    "adapter_model.bin",
]

for file_name in model_files:
    src_path = os.path.join(base_model_path, file_name)
    dest_path = os.path.join(output_dir, file_name)

    if os.path.isfile(src_path):
        shutil.copy(src_path, dest_path)
        print(f"Copied: {file_name} -> {output_dir}")
    else:
        print(f"Skipped: {file_name} (File not found)")

print("Model file transfer completed.")
```

```
Copied: config.json -> ./model_directory/models--zainnobody--TaxSense/
Skipped: special_tokens_map.json (File not found)
Copied: tokenizer.json -> ./model_directory/models--zainnobody--TaxSense/
Copied: tokenizer_config.json -> ./model_directory/models--zainnobody--TaxSense/
Skipped: pytorch_model.bin (File not found)
Skipped: adapter_config.json (File not found)
Skipped: adapter_model.bin (File not found)
Model file transfer completed.
```

[ ]:
```
def human_readable_size(size, decimal_places=1):
    for unit in ['B', 'KB', 'MB', 'GB', 'TB']:
        if size < 1024.0:
            return f"{size:.{decimal_places}f} {unit}"
        size /= 1024.0
    return f"{size:.{decimal_places}f} TB"

directory = Path(base_model_path)
if directory.exists() and directory.is_dir():
    for file in directory.iterdir():
        size = human_readable_size(file.stat().st_size)
        print(f"{size} {file.name}")
else:
    print("Directory not found")
```

```
5.2 GB model-00004-of-000004.safetensors
1.2 KB tokenizer_config.json
```

```
10.1 KB configuration_deepseek.py
468.7 KB model.safetensors.index.json
1.5 KB config.json
8.0 GB model-00002-of-000004.safetensors
181.0 B generation_config.json
8.0 GB model-00001-of-000004.safetensors
4.4 MB tokenizer.json
76.8 KB modeling_deepseek.py
8.0 GB model-00003-of-000004.safetensors
```

[ ]:
```
def load_model_and_tokenizer(model_path, device="cuda:0"):
    model = AutoModelForCausalLM.from_pretrained(model_path,␣
 ↪trust_remote_code=True).to(device)
    tokenizer = AutoTokenizer.from_pretrained(model_path,␣
 ↪trust_remote_code=True)
    tokenizer.pad_token = tokenizer.eos_token
    tokenizer.padding_side = "left"
    return model, tokenizer
```

[ ]:
```
model, tokenizer = load_model_and_tokenizer(output_dir)
```

Ran into following issue:

```
OSError: ./model_directory/models--zainnobody--TaxSense/ does not appear to have a file named r
```

Resolving this:

[ ]:
```
def human_readable_size(size, decimal_places=1):
    for unit in ['B', 'KB', 'MB', 'GB', 'TB']:
        if size < 1024.0:
            return f"{size:.{decimal_places}f} {unit}"
        size /= 1024.0
    return f"{size:.{decimal_places}f} TB"

directory = Path(base_model_path)
if directory.exists() and directory.is_dir():
    for file in directory.iterdir():
        size = human_readable_size(file.stat().st_size)
        print(f"{size} {file.name}")
else:
    print("Directory not found")
```

```
5.2 GB model-00004-of-000004.safetensors
1.2 KB tokenizer_config.json
10.1 KB configuration_deepseek.py
468.7 KB model.safetensors.index.json
1.5 KB config.json
8.0 GB model-00002-of-000004.safetensors
181.0 B generation_config.json
8.0 GB model-00001-of-000004.safetensors
```

```
4.4 MB tokenizer.json
76.8 KB modeling_deepseek.py
8.0 GB model-00003-of-000004.safetensors
```

[10]:
```python
deepseek_model_file = "modeling_deepseek.py"
src_path = os.path.join(base_model_path, deepseek_model_file)
dest_path = os.path.join(output_dir, deepseek_model_file)

if os.path.exists(src_path):
    shutil.copy2(src_path, dest_path)  # copy2 preserves metadata
    print(f"Copied {deepseek_model_file} to {output_dir}")
else:
    print(f"File {deepseek_model_file} not found in {base_model_path}, check if␣
 ↪it exists.")
```

```
Copied modeling_deepseek.py to ./model_directory/models--zainnobody--TaxSense/
```

[ ]:
```python
model, tokenizer = load_model_and_tokenizer(output_dir)

print("Model loaded.")
```

I cleaned the last cell, as the output was huge.

The logs show that while loading the checkpoint shards, several weights weren't used during model initialization:

```
Loading checkpoint shards: 100%
 3/3 [00:47<00:00, 13.32s/it]
Some weights of the model checkpoint at ./model_directory/models--zainnobody--TaxSense/ were n
```

This happens because when fine-tuning with LoRA (using PEFT), additional parameters like `lora_A.default.weight` and `lora_B.default.weight` are injected into the model. However, using a standard call like `AutoModelForCausalLM.from_pretrained(finetuned_dir)` does not automatically load these extra LoRA weights, which results in the warning about unused or missing parameters.

[ ]:
```python
lora_output_dir = os.path.join(output_dir, "checkpoint-6")

max_memory = {
    0: "20GiB",
    1: "20GiB",
}

base_model = AutoModelForCausalLM.from_pretrained(
    base_model_path,
    trust_remote_code=True,
    device_map="auto",
    max_memory=max_memory,
    torch_dtype=torch.float16,
)
```

```
model = PeftModel.from_pretrained(
    base_model,
    lora_output_dir,
    device_map="auto",
    max_memory=max_memory,
    torch_dtype=torch.float16,
)

tokenizer = AutoTokenizer.from_pretrained(
    base_model_path,
    trust_remote_code=True
)

tokenizer.pad_token = tokenizer.eos_token
tokenizer.padding_side = "left"

print("Successfully loaded the model + LoRA adapter across multiple GPUs.")
```

```
2025-03-01 21:24:42.809166: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in
performance-critical operations.
To enable the following instructions: AVX2 AVX512F FMA, in other operations,
rebuild TensorFlow with the appropriate compiler flags.
2025-03-01 21:24:43.693999: W
tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not
find TensorRT

Loading checkpoint shards:   0%|          | 0/4 [00:00<?, ?it/s]

Successfully loaded the model + LoRA adapter across multiple GPUs.
```

Just manual checking:

[ ]:
```
def construct_prompt(question, context1, context2):
    return f"""You are a helpful tax advisor and legal expert. Use the provided␣
 ↪context to answer the user's query in a clear and concise manner.

User Query: {question}

Related Context:
{context1}
{context2}

Note: The above information is extracted from relevant forms or online sources.␣
 ↪Use it to formulate your response.

Response:
"""
```

```
def generate_reply(prompt, max_new_tokens=256):
    gen_config = GenerationConfig(
        max_new_tokens=max_new_tokens,
        temperature=0.7,
        top_p=0.9,
        do_sample=True
    )
    inputs = tokenizer(prompt, return_tensors="pt").to(model.device)

    with torch.no_grad(), torch.cuda.amp.autocast(enabled=True):
        output_tokens = model.generate(
            **inputs,
            generation_config=gen_config,
            use_cache=False
        )

    return tokenizer.decode(
        output_tokens[0][inputs["input_ids"].shape[1]:],
        skip_special_tokens=True
    )

indices_to_test = [0, 1, 2]

for idx in indices_to_test:
    question = df.loc[idx, "Question"]
    expected_answer = df.loc[idx, "Answer"]
    context1 = df.loc[idx, "Context1"]
    context2 = df.loc[idx, "Context2"]

    test_prompt = construct_prompt(question, context1, context2)
    model_reply = generate_reply(test_prompt)

    print("=" * 60)
    print(f"Sample Index: {idx}")
    print("-" * 60)
    print("QUESTION:")
    print(question)
    print("\nCONTEXT USED:")
    print("Context1:", context1)
    print("Context2:", context2)
    print("\nEXPECTED REPLY:")
    print(expected_answer)
    print("\nMODEL REPLY:")
    print(model_reply)
    print("=" * 60, "\n")
```

```
/tmp/ipykernel_262501/3772536405.py:48: FutureWarning:
```

```
`torch.cuda.amp.autocast(args…)` is deprecated. Please use
`torch.amp.autocast('cuda', args…)` instead.
  with torch.no_grad(), torch.cuda.amp.autocast(enabled=True):
Setting `pad_token_id` to `eos_token_id`:100001 for open-end generation.
Setting `pad_token_id` to `eos_token_id`:100001 for open-end generation.
============================================================
Sample Index: 0
------------------------------------------------------------
QUESTION:
How can I reduce my tax bill?

CONTEXT USED:
Context1: System at IRS.gov/SAMS.
For more information, go to IRS.gov/Advocate.
How To Make a Contribution To
Reduce Debt Held by the Public
There are two ways to make a contribution to reduce the
debt held by the public.
• At Pay.gov, contribute online by credit card, debit card,
PayPal, checking account, or savings account.
• Write a check payable to "Bureau of the Fiscal Service."
In the memo section, notate that it is a gift to reduce the
debt held by the public.
Mail the check to:
Attn: Dept G
Context2: WV 26106-2188. Or you can enclose
the check with your income tax return
when you file. In the memo section of
the check, make a note that it is a gift to
reduce the debt held by the public. Don't
add your gift to any tax you may owe.
See the instructions for line 37 for de-
tails on how to pay any tax you owe. For
information on how to make this type of
gift online, go to TreasuryDirect.gov/
Help-Center/Public-Debt-FAQs/
#DebtFinance and click on "How do
you make a contribution to reduce the

EXPECTED REPLY:
To lower your tax liability, consider maximizing deductions and credits,
contributing to retirement accounts, and utilizing tax-efficient investments.
Consult a tax professional for personalized strategies.

MODEL REPLY:

To reduce your tax bill, you can make a contribution to reduce the debt held by
```

the public. There are two methods to do this:

1. Online via Pay.gov: You can contribute online by using a credit card, debit card, PayPal, checking account, or savings account. Visit Pay.gov and follow the instructions to make your contribution.

2. By mail: You can also contribute by writing a check payable to "Bureau of the Fiscal Service" and mailing it to the following address:

Attn: Dept G
WV 26106-2188
In the memo section of the check, make a note that it is a gift to reduce the debt held by the public. Do not add your gift to any tax you may owe. For information on how to make this type of gift online, visit TreasuryDirect.gov/Help-Center/Public-Debt-FAQs/DebtFinance and click on "How do you make a contribution to reduce the debt held by the public."

Remember to consult with a tax advisor or legal expert for personalized advice on your specific situation.
==========

Setting `pad_token_id` to `eos_token_id`:100001 for open-end generation.

==========
Sample Index: 1

QUESTION:
What deductions am I eligible for?

CONTEXT USED:
Context1: Standard Deduction (Group I Only)
If you do not itemize your deductions, you can take the 2025
standard deduction listed below for your filing status.
Filing Status
Standard
Deduction
Married filing jointly or
Qualifying surviving spouse
. . . . . .
$30,000*
Head of household . . . . . .
$22,500*
Single or Married filing
separately
. . . . . .
$15,000*
Context2: 33
Standard Deduction Worksheet for Dependents-Line 12

Keep for Your Records
Use this worksheet only if someone can claim you, or your spouse if filing jointly, as a dependent.
1.
Check if:
You were born before January 2, 1960.
You are blind.
Spouse was born before January 2, 1960.
Spouse is blind.
Total number of boxes
checked
. . . . . .
1.
2.
Is your earned income* more than $850?
Yes.
Add $450 to your earned income. Enter the total.

EXPECTED REPLY:
Eligibility for deductions varies based on individual circumstances. Common deductions include mortgage interest, state and local taxes, charitable contributions, and medical expenses exceeding a certain threshold.

MODEL REPLY:
To determine your eligibility for deductions, you should first consider whether you will be itemizing your deductions or taking the standard deduction. For the 2025 tax year:

- If you are married and file a joint tax return, you are eligible for a standard deduction of $30,000.
- If you are single, head of household, or married filing separately, the standard deduction is $15,000.

If your earned income is more than $850 and you meet certain criteria, you may also be eligible for additional deductions. For example, if you are blind or if your spouse is blind and born before January 2, 1960, you can add $450 to your earned income.

It's important to note that if you have dependents or if someone can claim you or your spouse as a dependent, you should use the Standard Deduction Worksheet for Dependents (Form 1040 or Form 1040-SR) to determine your standard deduction. This worksheet is used to calculate the standard deduction if someone can claim you or your spouse as a dependent.

Please refer to IRS Form 1040 instructions or consult
==========

==========

Sample Index: 2

QUESTION:
What's the difference between marginal and effective tax rates?

CONTEXT USED:
Context1: a rate for branch profits, the rate of tax is the rate specified in the
treaty for dividends paid by a wholly owned domestic corporation
to the foreign corporation. See Regulations section 1.884-1(g)
for applicable rates of tax. Benefits other than a rate reduction
may be available under certain treaties, such as the Canadian
income tax treaty.
Note. Many treaties listed in Regulations section 1.884-1(g)(3)
and (g)(4) are no longer in force and have been replaced by
Context2: Taxable amount over
Column B
Taxable amount not over
Column C
Tax on amount in column A
Column D
Rate of tax on excess over amount
in column A
.
.
.
.
$0
$10,000
$0
18%
10,000
20,000
1,800
20%
20,000
40,000
3,800
22%
40,000
60,000
8,200
24%
60,000
80,000
13,000
26%
80,000

100,000
18,200
28%
100,000
150,000
23,800
30%
150,000
250,000
38,800
32%
250,000
500,000
70,800
34%
500,000
750,000
155,800
37%
750,000
1,000,000
248,300
39%
1,000,000
- - - -
345,800
40%
6

EXPECTED REPLY:
The marginal tax rate is the rate applied to your next dollar of income, while the effective tax rate is the average rate you pay on your total taxable income.

MODEL REPLY:
The difference between marginal and effective tax rates lies in their application and calculation.

Marginal tax rates are the additional tax you pay on each additional dollar of income. They are applied incrementally as your income increases. For example, in the context provided, the tax rates increase as income increases from $0 to $10,000, $10,000 to $20,000, and so on.

Effective tax rates, on the other hand, are calculated by dividing the total tax paid by the total income and are expressed as a percentage. They give you a broader picture of your overall tax situation, including all income levels. In the context you provided, the effective tax rate would be calculated by dividing the total tax paid by the total taxable amount.

```
It's important to note that the effective tax rate does not change with income;
it remains constant. The marginal tax rate, however, changes as you move through
different income brackets.
============================================================
```

Challenges Encountered:

1. **Time Efficiency:** The fine-tuned model significantly increases processing time, taking 15 minutes to handle just 3 queries, whereas other models complete this task within seconds.
2. **Resource Intensive:** The model demands higher GPU resources for inference, which may not be feasible for all setups.
3. **Data Requirements:** Effective fine-tuning requires a substantial volume of high-quality data, which implies extended periods for data collection.
4. **Model Complexity:** Our contributions added 289,837,056 trainable parameters to the model. However, DeepSeek V2 Lite already operates with 16 billion total parameters and 2.4 billion active ones, offering high efficiency and speed that might not be fully leveraged by our additions.

Efforts to reduce the `max_new_tokens` parameter to 128 yielded a marginal improvement in response time to 3 minutes and 52 seconds, albeit with shorter output responses.

The primary focus of this project is on enhancing the ML Ops aspects of AI, emphasizing efficient execution and processing of user responses rather than optimizing a single model. With that in mind, we will include the "TaxSense" model as one of the options available to users. Also, the model will be available for further testing on hugging face.

1.5.1 Hugging Face upload

[ ]:
```python
api = HfApi()
create_repo(repo_id="zainnobody/TaxSense", private=False, exist_ok=True)
upload_folder(
    repo_id="zainnobody/TaxSense",
    folder_path="./model_directory/models--zainnobody--TaxSense/",
    path_in_repo=".",
    commit_message="Initial commit"
)
```

```
rng_state.pth:   0%|          | 0.00/14.2k [00:00<?, ?B/s]

optimizer.pt:   0%|          | 0.00/601M [00:00<?, ?B/s]

scaler.pt:   0%|          | 0.00/988 [00:00<?, ?B/s]

adapter_model.safetensors:   0%|          | 0.00/1.16G [00:00<?, ?B/s]

Upload 20 LFS files:   0%|          | 0/20 [00:00<?, ?it/s]

scheduler.pt:   0%|          | 0.00/1.06k [00:00<?, ?B/s]

training_args.bin:   0%|          | 0.00/5.62k [00:00<?, ?B/s]
```

```
model-00001-of-00003.safetensors:   0%|          | 0.00/5.00G [00:00<?, ?B/s]

model-00002-of-00003.safetensors:   0%|          | 0.00/4.91G [00:00<?, ?B/s]

model-00003-of-00003.safetensors:   0%|          | 0.00/839M [00:00<?, ?B/s]

events.out.tfevents.1740856547.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.176706.0:  ␣
 ↪0%|          | 0.00/7.39k [00:…

events.out.tfevents.1740857662.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.194220.0:  ␣
 ↪0%|          | 0.00/6.98k [00:…

events.out.tfevents.1740857841.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.196038.0:  ␣
 ↪0%|          | 0.00/6.98k [00:…

events.out.tfevents.1740857960.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.197340.0:  ␣
 ↪0%|          | 0.00/6.98k [00:…

events.out.tfevents.1740858035.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.198196.0:  ␣
 ↪0%|          | 0.00/7.39k [00:…

events.out.tfevents.1740858797.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.205802.0:  ␣
 ↪0%|          | 0.00/6.98k [00:…

events.out.tfevents.1740858884.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.206757.0:  ␣
 ↪0%|          | 0.00/6.98k [00:…

events.out.tfevents.1740858974.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.207760.0:  ␣
 ↪0%|          | 0.00/6.98k [00:…

events.out.tfevents.1740859189.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.209938.0:  ␣
 ↪0%|          | 0.00/88.0 [00:0…

events.out.tfevents.1740859411.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.212192.0:  ␣
 ↪0%|          | 0.00/6.98k [00:…

events.out.tfevents.1740859854.b3c7d853-4c5a-4a0a-ab54-087dc02516fb.216891.0:  ␣
 ↪0%|          | 0.00/7.39k [00:…
```

[ ]:
```
CommitInfo(commit_url='https://huggingface.co/zainnobody/TaxSense/commit/60fdc12
55746c082f57b93e6615cf047e2adcd53', commit_message='Initial commit',
commit_description='', oid='60fdc1255746c082f57b93e6615cf047e2adcd53',
pr_url=None, repo_url=RepoUrl('https://huggingface.co/zainnobody/TaxSense',
endpoint='https://huggingface.co', repo_type='model',
repo_id='zainnobody/TaxSense'), pr_revision=None, pr_num=None)
```

1.6 Out-of-Box Model Exploration & Chat Generation End Points

After generating our in-house model, we quickly discovered that it might not meet all our performance and domain-specific requirements. As a result, we began exploring several external candidates. Our shortlist includes:

Model	Architecture / Basis	Estimated Max Token Limit	Estimated Max Word Limit
ricdomolm/lawma-8b	Fine-tuned on Llama-3 8B Instruct	~8,192 tokens	~6,000 words
Equall/Saul-7B-Instruct-v1	Continued pretraining of Mistral-7B	~8,192 tokens	~6,000 words
deepseek-ai/DeepSeek-V2-Lite (and Chat)	Mixture-of-Experts (MoE) model with an extended context window	32,000 tokens	~24,000 words
ricdomolm/lawma-70b	Fine-tuned on Llama-3 70B Instruct for legal classification tasks[1]	~4,096 tokens	~3,072 words

[1] Although the base Llama-3-70B model supports an 8k-token context, this version was configured for legal classification—where shorter inputs (and corresponding outputs) are sufficient—resulting in an effective limit of approximately 4k tokens.

1.6.1 Model Insights

ricdomolm/lawma-8b
This model is tailored for the legal domain, fine-tuned on the Llama-3 8B Instruct model. It is optimized for legal classification tasks, making it highly specialized for tasks like interpreting legal documents and handling legal language nuances.

Equall/Saul-7B-Instruct-v1
Based on the Mistral-7B architecture, this model has been further pre-trained to handle legal language instructions. Its training focused on generating clear and accurate legal text, making it a strong candidate for tasks such as drafting legal documents, summarizing case law, and answering legal queries.

deepseek-ai/DeepSeek-V2-Lite (and Chat)
DeepSeek has generated significant attention for its ease of integration and the benefits of an extended context window. We were particularly drawn to its user-friendly design and, as a result, fine-tuned this model for our internal "TaxesSense" application. Its ability to process larger text blocks is a promising feature for future applications.

ricdomolm/lawma-70b
While our primary focus is on the 8B models, we have also kept the 70B variant in mind. Although configured with a shorter effective token limit for legal classification, this model remains an interesting candidate to explore if the 8B models do not meet our needs.

1.6.2 Hosting Challenges and Our Backend Solution

We encountered significant challenges while attempting to host these models directly on AWS SageMaker, primarily due to permission issues. To overcome this, we decided to deploy these models as internal endpoints. This approach gives us greater control over model management and sidesteps the restrictions posed by AWS SageMaker.

1.6.3 Endpoint Implementation

For our initial deployment, we created two endpoints: one for standard generation and another for streaming generation. Below is a streamlined version of the endpoint code:

```
@app.route('/generate', methods=['POST'])
@token_required
def generate_text():
    data = request.get_json()
    model_name = data.get("model_name")
    if not model_name:
        return jsonify({"error": "model_name is required"}), 400
    if model_name not in MODEL_PATHS:
        return jsonify({"error": f"Unknown model_name: {model_name}"}), 400

    question = data.get("text", "")
    max_length = data.get("max_length")
    if max_length is None:
        return jsonify({"error": "max_length must be provided"}), 400

    prompt = build_prompt(question)
    try:
        generated_text, response_time, _ = perform_generation(model_name, prompt, max_length)
    except Exception as e:
        return jsonify({"error": str(e)}), 500

    return jsonify({
        "response": generated_text,
        "time_taken": response_time,
        "model": model_name
    })

@app.route('/generate_stream', methods=['POST'])
@token_required
def generate_text_stream():
    data = request.get_json()
    model_name = data.get("model_name")
    if not model_name:
        return jsonify({"error": "model_name is required"}), 400
    if model_name not in MODEL_PATHS:
        return jsonify({"error": f"Unknown model_name: {model_name}"}), 400

    question = data.get("text", "")
    max_length = data.get("max_length")
    if max_length is None:
        return jsonify({"error": "max_length must be provided"}), 400

    try:
```

```
        load_model(model_name)
    except Exception as e:
        return jsonify({"error": str(e)}), 500

    tokenizer = loaded_models[model_name]["tokenizer"]
    model = loaded_models[model_name]["model"]
    prompt = build_prompt(question)
    inputs = tokenizer(prompt, return_tensors="pt")
    streamer = TextIteratorStreamer(tokenizer, skip_prompt=True, skip_special_tokens=True)

    def run_generation():
        try:
            model.generate(
                **inputs,
                max_new_tokens=max_length,
                do_sample=True,
                eos_token_id=tokenizer.eos_token_id,
                pad_token_id=tokenizer.eos_token_id,
                streamer=streamer
            )
        except Exception as e:
            print(f"Error during stream generation with model {model_name}:", str(e))

    thread = threading.Thread(target=run_generation)
    thread.start()
    loaded_models[model_name]["last_access_time"] = time.time()
    return Response(streamer, mimetype="text/plain")
```

1.6.4 Testing Considerations

For testing, we focused our efforts on the out-of-box models. Testing our in-house models proved time-consuming—each test taking over half an hour—so the initial extensive testing was reserved for these external candidates.

1.6.5 Tests - Generate

Below we are testing the `/generate` and `/generate_stream` endpoints. The tests verify that if a model is not already loaded, it initializes correctly and handles the first request with longer latency, while subsequent requests are faster. We check full text generation as well as token-by-token streaming, ensuring both endpoints work as expected and expose any issues for further optimization.

> NOTE: When a model is already loaded, requests are processed immediately. If a model isn't loaded, it will first be initialized before handling the request, causing the initial call to take longer. Subsequent requests are processed quickly, while larger models naturally take more time to load.

[ ]:
```
BASE_URL = "http://100.118.250.126:6000" # Also worked on: "http://localhost:
↪6000"
GENERATE_URL = f"{BASE_URL}/generate"
GENERATE_STREAM_URL = f"{BASE_URL}/generate_stream"
```

[ ]:
```
def generate_text(model_name, text, max_length=100):
    payload = {
        "model_name": model_name,
        "text": text,
        "max_length": max_length
    }

    response = requests.post(GENERATE_URL, json=payload)

    if response.status_code == 200:
        data = response.json()
        print("\n=== /generate ===")
        print(f"Model Name: {model_name}")
        print(f"Prompt: {text}")
        print("Generated Text:")
        print(data.get("response", "No response field in JSON"))
        print(f"Time taken: {data.get('time_taken', 'N/A')} seconds")
    else:
        print(f"Error: {response.status_code} - {response.text}")

def generate_text_stream(model_name, text, max_length=100):

    payload = {
        "model_name": model_name,
        "text": text,
        "max_length": max_length
    }

    response = requests.post(GENERATE_STREAM_URL, json=payload, stream=True)

    if response.status_code == 200:
        print("\n=== /generate_stream ===")
        print(f"Model Name: {model_name}")
        print(f"Prompt: {text}")
        print("Streaming Generated Text:")
        for chunk in response.iter_lines(decode_unicode=True):
            if chunk:
                print(chunk, end=" ", flush=True)
        print()
    else:
        print(f"Error: {response.status_code} - {response.text}")
```

```
# Example prompts
prompt1 = "Explain the key differences between tax credits and tax deductions."
prompt2 = "What are the potential risks and benefits of automating IRS tax␣
 ↪processing?"
```

Also the code run until this was:

```
python3 app.py
 * Serving Flask app 'app'
 * Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a producti
 * Running on all addresses (0.0.0.0)
 * Running on http://127.0.0.1:6000
 * Running on http://100.118.250.126:6000
```

NOTE: The `app.py` is synonymous to `TaxSense_backend.py`.

[13]:
```
# Test: Using "lawma_70b" model. This is a large model.
generate_text("lawma_70b", prompt1, max_length=100)
generate_text_stream("lawma_70b", prompt2, max_length=100)
```

```
=== /generate ===
Model Name: lawma_70b
Prompt: Explain the key differences between tax credits and tax deductions.
Generated Text:
You are a helpful tax and legal advisor. Answer the following question in a
clear and concise manner:
Explain the key differences between tax credits and tax deductions. 't use legal
jargon.
It seems like tax credits and tax deductions both reduce your tax bill, but I've
heard they work differently.  I'd love to understand the differences.
Answer: I'd be happy to help you with that!

Tax credits and tax deductions both reduce your tax bill, but they work in
different ways.

Tax DEDUCTIONS:

1. Reduce taxable income: DEDUCTIONS lower your taxable income, which means
you're reducing the amount of income that's …
Time taken: 4780.952471971512 seconds

=== /generate_stream ===
Model Name: lawma_70b
Prompt: What are the potential risks and benefits of automating IRS tax
processing?
Streaming Generated Text:
```

Here are the logs for the above cell:

```
[load_model] Attempting to load 'lawma_70b' onto cuda:1 ...
2025-02-17 10:04:00.794940: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFlo
To enable the following instructions: AVX2 AVX512F FMA, in other operations, rebuild TensorFlow
2025-02-17 10:04:01.810556: W tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warn
Loading checkpoint shards: 100%|       | 30/30 [02:31<00:00,  5.04s/it]
Some parameters are on the meta device because they were offloaded to the cpu.
[load_model] 'lawma_70b' loaded on cuda:1. Current allocated: 39168.75 MB
172.24.9.126 - - [17/Feb/2025 10:35:00] "POST /generate HTTP/1.1" 200 -
172.24.9.126 - - [17/Feb/2025 10:35:16] "POST /generate_stream HTTP/1.1" 200
```

[ ]:
```
# Running again to check if its an end point issue
generate_text_stream("lawma_70b", prompt2, max_length=100)
```

```
=== /generate_stream ===
Model Name: lawma_70b
Prompt: What are the potential risks and benefits of automating IRS tax
processing?
Streaming Generated Text:
  Answer: K
```

Seems like there is an issue with the stream answers with 70b.

Also, here are the logs:

```
[load_model] Attempting to load 'lawma_70b' ...
2025-02-17 21:51:20.115131: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFlo
To enable the following instructions: AVX2 AVX512F FMA, in other operations, rebuild TensorFlow
2025-02-17 21:51:21.135897: W tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warn
Loading checkpoint shards: 100%|                                                  | 30/30
Some parameters are on the meta device because they were offloaded to the cpu.
[load_model] 'lawma_70b' loaded. It has been automatically partitioned across available GPUs.
/apps/default-python/lib/python3.10/site-packages/transformers/generation/utils.py:2137: UserWa
  warnings.warn(
172.24.9.126 - - [17/Feb/2025 21:52:30] "POST /generate_stream HTTP/1.1" 200 -
```

[12]:
```
# Test: Using "saul_7b_instruct" model
generate_text("saul_7b_instruct", prompt1, max_length=50)
generate_text_stream("saul_7b_instruct", prompt2, max_length=50)
```

```
=== /generate ===
Model Name: saul_7b_instruct
Prompt: Explain the key differences between tax credits and tax deductions.
Generated Text:
You are a helpful tax and legal advisor. Answer the following question in a
clear and concise manner:
Explain the key differences between tax credits and tax deductions.
```

```
Answer: [/INST] Tax credits and tax deductions are two important tools used to
reduce a person's taxable income. However, they work in different ways and have
distinct characteristics.

A tax credit directly reduces your …
Time taken: 2.0661349296569824 seconds

=== /generate_stream ===
Model Name: saul_7b_instruct
Prompt: What are the potential risks and benefits of automating IRS tax
processing?
Streaming Generated Text:
What are potential risks and benefits of this approach to handling tax returns?
[/INST] Automating IRS tax processing can provide several benefits and risks:
Benefits: 1. Improved efficiency - Automation can help process
```

Here are the logs for the above cell:

```
[load_model] Attempting to load 'saul_7b_instruct' ...
Loading checkpoint shards: 100%|          | 6/6 [01:12<00:00, 12.11s/it]
[load_model] 'saul_7b_instruct' loaded. It has been automatically partitioned across available
/apps/default-python/lib/python3.10/site-packages/transformers/generation/utils.py:2137: UserWa
  warnings.warn(
172.24.9.126 - - [17/Feb/2025 10:59:03] "POST /generate HTTP/1.1" 200 -
172.24.9.126 - - [17/Feb/2025 10:59:04] "POST /generate_stream HTTP/1.1" 200
```

[11]:

```python
# Test: Using "lawma_8b" model
generate_text("lawma_8b", prompt1, max_length=50)
generate_text_stream("lawma_8b", prompt2, max_length=50)
```

```
=== /generate ===
Model Name: lawma_8b
Prompt: Explain the key differences between tax credits and tax deductions.
Generated Text:
You are a helpful tax and legal advisor. Answer the following question in a
clear and concise manner:
Explain the key differences between tax credits and tax deductions. A tax credit
reduces 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 …
Time taken: 2.511077404022217 seconds

=== /generate_stream ===
Model Name: lawma_8b
Prompt: What are the potential risks and benefits of automating IRS tax
processing?
Streaming Generated Text:
 A B C D E F G H I J E F G H I J E F G H I J E F G H I J E F G H I J E F G H I J
```

```
E F G H I J E F G H
```

Here are the logs for the above cell:

```
[load_model] Attempting to load 'lawma_8b' ...
Loading checkpoint shards: 100%|          | 4/4 [00:37<00:00,  9.28s/it]
[load_model] 'lawma_8b' loaded. It has been automatically partitioned across available GPUs.
/apps/default-python/lib/python3.10/site-packages/transformers/generation/utils.py:2137: UserWa
  warnings.warn(
172.24.9.126 - - [17/Feb/2025 10:57:45] "POST /generate HTTP/1.1" 200 -
172.24.9.126 - - [17/Feb/2025 10:57:46] "POST /generate_stream HTTP/1.1" 200
```

[10]:
```python
# Test: Using "DeepSeek-V2-Lite" model
generate_text("DeepSeek-V2-Lite", prompt2, max_length=200)
generate_text_stream("DeepSeek-V2-Lite", prompt1, max_length=200)
```

```
=== /generate ===
Model Name: DeepSeek-V2-Lite
Prompt: What are the potential risks and benefits of automating IRS tax
processing?
Generated Text:
You are a helpful tax and legal advisor. Answer the following question in a
clear and concise manner:
What are the potential risks and benefits of automating IRS tax processing?

Automating IRS tax processing can have several potential risks and benefits.
Here are some of them:

Risks:
1. Data Security: Automated systems can be vulnerable to cyber-attacks, leading
to unauthorized access to sensitive taxpayer information.
2. System Errors: Automation can lead to errors in processing, such as incorrect
calculations or misinterpretation of tax codes.
3. Dependence on Technology: Over-reliance on automated systems can make the IRS
vulnerable to technical failures or outages.
4. Training and Support: Staff may require additional training to effectively
use new automated systems, which can be costly and time-consuming.

Benefits:
1. Efficiency: Automation can significantly reduce the time and effort required
to process tax returns, making the process faster and more efficient.
2. Accuracy: Automated systems can reduce errors in tax processing by using
algorithms and data checks.
3. Cost Savings: Automating tax processing can lead to long-term cost savings
…
Time taken: 17.884826183319092 seconds

=== /generate_stream ===
```

```
Model Name: DeepSeek-V2-Lite
Prompt: Explain the key differences between tax credits and tax deductions.
Streaming Generated Text:
As a tax and legal advisor, it's important to explain the key differences
between tax credits and tax deductions to help individuals understand how they
can reduce their tax liability. Here's a clear and concise explanation: **Tax
Credits:** - **Direct Reduction in Tax Liability:** Tax credits directly reduce
the amount of tax you owe. They are dollar-for-dollar reductions in the taxes
you owe. - **Types:** There are two types of tax credits: refundable and non-
refundable. Refundable credits reduce your tax liability to zero or even result
in a refund of part of your income tax. Non-refundable credits can only reduce
your tax liability to zero or less. - **Availability:** Tax credits are
available for certain expenses or situations that are in line with government
incentives, such as for renewable energy systems, childcare, education, and
more. - **Impact:** Credits are generally more valuable than deductions because
they directly reduce the amount of
```

Here are the logs for the above cell:

```
[load_model] Attempting to load 'DeepSeek-V2-Lite' ...
2025-02-17 10:53:39.516528: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFl
To enable the following instructions: AVX2 AVX512F FMA, in other operations, rebuild TensorFlo
2025-02-17 10:53:40.689715: W tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT War
Loading checkpoint shards: 100%|        | 4/4 [00:22<00:00,  5.56s/it]
[load_model] 'DeepSeek-V2-Lite' loaded. It has been automatically partitioned across available
/apps/default-python/lib/python3.10/site-packages/transformers/generation/utils.py:2137: UserWa
  warnings.warn(
The `seen_tokens` attribute is deprecated and will be removed in v4.41. Use the `cache_positio
`get_max_cache()` is deprecated for all Cache classes. Use `get_max_cache_shape()` instead. Ca
172.24.9.126 - - [17/Feb/2025 10:54:36] "POST /generate HTTP/1.1" 200 -
172.24.9.126 - - [17/Feb/2025 10:54:37] "POST /generate_stream HTTP/1.1" 200
```

Summary Analysis DeepSeek-V2-Lite is the fastest and offers the most detailed and clear responses compared to the other models. Saul_7b_instruct provides good, concise answers, but it doesn't go into as much depth. Lawma_70b, on the other hand, takes far too long to respond and often struggles to complete tasks, sometimes needing help from other models. Lawma_8b is quicker than Lawma_70b, but its output can be inconsistent and sometimes messy. Overall, DeepSeek-V2-Lite strikes the best balance between speed, quality, and reliability.

1.6.6 Standardizing End Points

We added new endpoints (`/v1/models`, `/v1/chat/completions`, and `/v1/completions`) that leverage this helper to ensure consistent responses and reduced code duplication. This was to align us with the testing we were doing using LM Studio, and the endpoints seem to be the standard. Following is the test for each of the end point. These endpoints updates a bit later with authentication code, user info, and chat session info.

[22]:
```
MODELS_URL = f"{BASE_URL}/v1/models"
CHAT_COMPLETIONS_URL = f"{BASE_URL}/v1/chat/completions"
COMPLETIONS_URL = f"{BASE_URL}/v1/completions"
```

/v1/models

Code Here is the code implimented the `TaxSense_backend.py` for this models end point:

```
@app.route('/v1/models', methods=['GET'])
@token_required
def list_models():
    models = [{"id": name, "object": "model"} for name in MODEL_PATHS.keys()]
    return jsonify({"data": models, "object": "list"})
```

The models are defined using two dictionaries:

- **MODEL_PATHS**: Maps model names to their corresponding file system paths.
- **MODEL_CONFIGS**: Provides additional configuration details such as the Hugging Face identifier (`hf_id`) and whether to use parameter-efficient fine-tuning (`use_peft`).

Can be seen here:

```
MODEL_PATHS = {
    "saul_7b_instruct": "./model_directory/models--Equall--Saul-7B-Instruct-v1/snapshots/2133ba
    "lawma_8b": "./model_directory/models--ricdomolm--lawma-8B/snapshots/cf7b9086448228ba981a97
    "lawma_70b": "./model_directory/models--ricdomolm--lawma-70b/snapshots/cf7b9086448228ba981a
    "DeepSeek-V2-Lite": "./model_directory/models--deepseek-ai--DeepSeek-V2-Lite-Chat/snapshots
    "TaxSense": "./model_directory/models--zainnobody--TaxSense"
}

MODEL_CONFIGS = {
    "TaxSense": {
        "hf_id": "zainnobody/TaxSense",
        "use_peft": True
    },
    "saul_7b_instruct": {
        "hf_id": "Equall/Saul-7B-Instruct-v1"
    },
    "lawma_8b": {
        "hf_id": "ricdomolm/lawma-8b"
    },
    "lawma_70b": {
        "hf_id": "ricdomolm/lawma-70b"
    },
    "DeepSeek-V2-Lite": {
        "hf_id": "deepseek-ai/DeepSeek-V2-Lite-Chat"
    }
}
```

Test

```
[ ]: def test_models():
         response = requests.get(MODELS_URL)
         print("\n=== GET /v1/models ===")
         print("Status Code:", response.status_code)
         try:
             data = response.json()
             print("\nAvailable Models:")
             for model in data.get("data", []):
                 print(f" - ID: {model.get('id')}, Object: {model.get('object')}")
             print("\nFull Response JSON:")
             print(json.dumps(data, indent=2))
         except Exception as e:
             print("Error parsing JSON:", e)

     test_models()
```

```
=== GET /v1/models ===
Status Code: 200

Available Models:
 - ID: saul_7b_instruct, Object: model
 - ID: lawma_8b, Object: model
 - ID: lawma_70b, Object: model
 - ID: DeepSeek-V2-Lite, Object: model

Full Response JSON:
{
  "data": [
    {
      "id": "saul_7b_instruct",
      "object": "model"
    },
    {
      "id": "lawma_8b",
      "object": "model"
    },
    {
      "id": "lawma_70b",
      "object": "model"
    },
    {
      "id": "DeepSeek-V2-Lite",
      "object": "model"
    }
  ],
  "object": "list"
```

}

/v1/chat/completions Here is the final verstion of the endpoint:

Code

```
@app.route('/v1/chat/completions', methods=['POST'])
@token_required
def chat_completions():
    data = request.get_json()
    model_name = data.get("model")
    if not model_name:
        return jsonify({"error": "model is required"}), 400
    if model_name not in MODEL_PATHS:
        return jsonify({"error": f"Unknown model: {model_name}"}), 400

    username = data.get("username")
    if not username:
        return jsonify({"error": "username is required"}), 400

    messages = data.get("messages")
    if not messages:
        return jsonify({"error": "messages field is required"}), 400

    chat_id = data.get("chat_id") or str(uuid.uuid4())

    # Find the last user message and store it
    last_user_message = None
    for msg in reversed(messages):
        if msg.get("role") == "user":
            last_user_message = msg.get("content")
            store_chat_message(chat_id, username, "user", last_user_message)
            break
    if not last_user_message:
        return jsonify({"error": "No user message found in messages"}), 400

    max_tokens = data.get("max_tokens", 200)

    # Decide on context
    use_pdf_context = data.get("use_pdf_context", False)
    tax_optimize = data.get("tax_optimize", False)

    if use_pdf_context:
        pdf_context_chunks = retrieve_pdf_context(username, chat_id, last_user_message, top_k=
        if pdf_context_chunks:
            print("\n[RAG] Using PDF context from user's uploads:")
            for idx, chunk in enumerate(pdf_context_chunks, start=1):
```

```
            snippet = chunk[:100].replace("\n", " ")
            print(f"  Chunk {idx}: {snippet}...")
        rag_text = "\n\n".join(pdf_context_chunks)
        prompt = (
            "You are a helpful tax and legal advisor. Using the following PDF context and t
            "provide a helpful and concise answer.\n\n"
            f"PDF Context:\n{rag_text}\n\n"
            f"User Question:\n{last_user_message}\n"
        )
    else:
        prompt = build_prompt(last_user_message)
elif tax_optimize:
    # Use Pinecone-based retrieval
    search_results = search_pinecone(last_user_message, top_k=data.get("n", 2))
    prompt, _ = create_detailed_prompt(last_user_message, search_results, tax_optimize=True
else:
    prompt = build_prompt(last_user_message)

print("\n[Prompt to Model]:\n" + prompt)
print("------------------------------------------------------\n")

try:
    generated_text, response_time, tokenizer = perform_generation(model_name, prompt, max_t
except Exception as e:
    return jsonify({"error": str(e)}), 500

# If use_pdf_context, show the PDF references
if use_pdf_context:
    pdf_context_chunks = retrieve_pdf_context(username, chat_id, last_user_message, top_k=1
    if pdf_context_chunks:
        references_list = []
        for i, chunk in enumerate(pdf_context_chunks):
            snippet = chunk[:150].replace("\n", " ")
            references_list.append(f"- PDF snippet {i+1}: \"{snippet}...\"")

        references_str = "\n".join(references_list)
        generated_text += (
            "\n\nThis response was compiled using the following PDF snippets:\n" +
            references_str
        )

# If tax_optimize, show the Pinecone references
elif tax_optimize:
    references_list = []
    for i, result in enumerate(search_results.get("results", [])):
        snippet = result["text"][:150].replace("\n", " ")
        form_id = result.get("id", "")
        form_id = clean_form_id_v2(form_id)
```

```
            references_list.append(f"- Form {form_id} snippet {i+1}: \"{snippet}...\"")

        if references_list:
            references_str = "\n".join(references_list)
            generated_text += (
                "\n\nThis response was compiled using the following form context:\n" +
                references_str
            )

    store_chat_message(chat_id, "assistant", "assistant", generated_text)

    return jsonify({
        "id": f"chatcmpl-{int(time.time())}",
        "object": "chat.completion",
        "created": int(time.time()),
        "model": model_name,
        "chat_id": chat_id,
        "username": username,
        "choices": [
            {
                "index": 0,
                "message": {"role": "assistant", "content": generated_text},
                "finish_reason": "stop"
            }
        ],
        "usage": {
            "prompt_tokens": len(tokenizer.encode(prompt)),
            "completion_tokens": len(tokenizer.encode(generated_text)),
            "total_tokens": len(tokenizer.encode(prompt)) + len(tokenizer.encode(generated_tex
        },
        "time_taken": response_time
    })
```

This endpoint processes chat completion requests by validating inputs, retrieving optional PDF or Pinecone context, and generating a response using the specified model. It logs the conversation and returns a detailed JSON payload including the generated text, token usage, and processing time.

Test The below test is for the initial version of the end points. Further testing was done with the new changes.

[ ]:
```
def test_chat_completions_deepseek():
    payload = {
        "model": "DeepSeek-V2-Lite",
        "messages": [
            {"role": "system", "content": "You are a helpful tax and legal␣
↪advisor."},
            {"role": "user", "content": "What are the benefits of tax␣
↪deductions?"}
```

```
        ],
        "max_tokens": 50
    }
    response = requests.post(CHAT_COMPLETIONS_URL, json=payload)
    print("\n=== POST /v1/chat/completions ===")
    print("Status Code:", response.status_code)
    try:
        data = response.json()
        # Extract key details from the response
        choice = data.get("choices", [{}])[0]
        message = choice.get("message", {})
        print("\nChat Completion Summary:")
        print(f" - Model: {data.get('model')}")
        print(f" - Generated Response: {message.get('content')}")
        usage = data.get("usage", {})
        print(f" - Prompt Tokens: {usage.get('prompt_tokens')}")
        print(f" - Completion Tokens: {usage.get('completion_tokens')}")
        print("\nFull Response JSON:")
        print(json.dumps(data, indent=2))
    except Exception as e:
        print("Error parsing JSON:", e)

test_chat_completions_deepseek()
```

```
=== POST /v1/chat/completions ===
Status Code: 200

Chat Completion Summary:
 - Model: DeepSeek-V2-Lite
 - Generated Response: You are a helpful tax and legal advisor. Answer the
following question in a clear and concise manner:
What are the benefits of tax deductions?

As a tax and legal advisor, I would explain that tax deductions are a valuable
tool for individuals and businesses to reduce their taxable income. Here are
some of the key benefits of tax deductions:

1. **Reduction in Taxable …
 - Prompt Tokens: 30
 - Completion Tokens: 81

Full Response JSON:
{
  "choices": [
    {
      "finish_reason": "stop",
      "index": 0,
```

```
      "message": {
        "content": "You are a helpful tax and legal advisor. Answer the
following question in a clear and concise manner:\nWhat are the benefits of tax
deductions?\n\nAs a tax and legal advisor, I would explain that tax deductions
are a valuable tool for individuals and businesses to reduce their taxable
income. Here are some of the key benefits of tax deductions:\n\n1. **Reduction
in Taxable …",
        "role": "assistant"
      }
    }
  ],
  "created": 1739830498,
  "id": "chatcmpl-1739830498",
  "model": "DeepSeek-V2-Lite",
  "object": "chat.completion",
  "time_taken": 4.537811040878296,
  "usage": {
    "completion_tokens": 81,
    "prompt_tokens": 30,
    "total_tokens": 111
  }
}
```


/v1/completions

Code

```python
@app.route('/v1/completions', methods=['POST'])
@token_required
def completions():
    data = request.get_json()
    model_name = data.get("model")
    if not model_name:
        return jsonify({"error": "model is required"}), 400
    if model_name not in MODEL_PATHS:
        return jsonify({"error": f"Unknown model: {model_name}"}), 400

    prompt_text = data.get("prompt")
    if not prompt_text:
        return jsonify({"error": "prompt is required"}), 400

    max_tokens = data.get("max_tokens")
    if max_tokens is None:
        return jsonify({"error": "max_tokens must be provided"}), 400

    tax_optimize = data.get("tax_optimize", False)
    if tax_optimize:
        search_results = search_pinecone(prompt_text, top_k=data.get("n", 2))
```

```
        prompt, _ = create_detailed_prompt(prompt_text, search_results, tax_optimize=True, n=da
    else:
        prompt = build_prompt(prompt_text)

    try:
        generated_text, response_time, tokenizer = perform_generation(model_name, prompt, max_t
    except Exception as e:
        return jsonify({"error": str(e)}), 500

    if tax_optimize:
        references_list = []
        for i, result in enumerate(search_results.get("results", [])):
            snippet = result["text"][:150].replace("\n", " ")
            form_id = result["id"].replace(".md", "")
            references_list.append(f"- Form {form_id} snippet {i+1}: \"{snippet}...\"")

        if references_list:
            references_str = "\n".join(references_list)
            generated_text += (
                "\n\nThis response was compiled using the following form context:\n" +
                references_str
            )

    return jsonify({
        "id": f"cmpl-{int(time.time())}",
        "object": "text_completion",
        "created": int(time.time()),
        "model": model_name,
        "choices": [
            {
                "text": generated_text,
                "index": 0,
                "finish_reason": "stop"
            }
        ],
        "usage": {
            "prompt_tokens": len(tokenizer.encode(prompt)),
            "completion_tokens": len(tokenizer.encode(generated_text)),
            "total_tokens": len(tokenizer.encode(prompt)) + len(tokenizer.encode(generated_text
        },
        "time_taken": response_time
    })
```

The funtion validates the incoming JSON data to ensure a model, prompt, and token limit are provided. If the request includes a flag for tax optimization, it retrieves additional context from Pinecone and integrates relevant reference snippets into the prompt. It then generates a completion using the specified model and returns the generated text along with details such as token usage and response time.

Test

```
[ ]: def test_completions_deepseek():
         payload = {
             "model": "DeepSeek-V2-Lite",
             "prompt": "Explain the key differences between tax credits and tax␣
      ↪deductions.",
             "max_tokens": 50
         }
         response = requests.post(COMPLETIONS_URL, json=payload)
         print("\n=== POST /v1/completions ===")
         print("Status Code:", response.status_code)
         try:
             data = response.json()
             choice = data.get("choices", [{}])[0]
             print("\nText Completion Summary:")
             print(f" - Model: {data.get('model')}")
             print(f" - Generated Text: {choice.get('text')}")
             usage = data.get("usage", {})
             print(f" - Prompt Tokens: {usage.get('prompt_tokens')}")
             print(f" - Completion Tokens: {usage.get('completion_tokens')}")
             print("\nFull Response JSON:")
             print(json.dumps(data, indent=2))
         except Exception as e:
             print("Error parsing JSON:", e)

     test_completions_deepseek()
```

```
=== POST /v1/completions ===
Status Code: 200

Text Completion Summary:
 - Model: DeepSeek-V2-Lite
 - Generated Text: Explain the key differences between tax credits and tax
deductions.

Tax credits and tax deductions are both tools used by the government to reduce
the amount of tax that individuals and businesses owe. However, there are some
key differences between the two:

1. Tax Credits:
   a. Tax credits …
 - Prompt Tokens: 12
 - Completion Tokens: 63

Full Response JSON:
{
  "choices": [
```

```
    {
      "finish_reason": "stop",
      "index": 0,
      "text": "Explain the key differences between tax credits and tax
deductions.\n\nTax credits and tax deductions are both tools used by the
government to reduce the amount of tax that individuals and businesses owe.
However, there are some key differences between the two:\n\n1. Tax Credits:\n
a. Tax credits …"
    }
  ],
  "created": 1739830505,
  "id": "cmpl-1739830505",
  "model": "DeepSeek-V2-Lite",
  "object": "text_completion",
  "time_taken": 4.506953477859497,
  "usage": {
    "completion_tokens": 63,
    "prompt_tokens": 12,
    "total_tokens": 75
  }
}
```


1.7 Contextual Information Indexed

We were not able to index within AWS Kendra and OpenSearch Service but none worked, then we realized we could have Pinecone on aws, so we used it outside of AWS but our hunch was if we could access it we can host withing AWS with pine cone. That being said, The new `/search` API endpoint enables querying a Pinecone index to retrieve the most relevant PDF chunks based on an input query, utilizing embedding models for semantic search. for a couple of seconds This new API endpoint allows users to search IRS document embeddings by encoding their query and returning the most relevant text chunks from a Pinecone index.

[ ]:
```python
def test_search_endpoint(query, top_k=5):
    payload = {"query": query, "top_k": top_k}

    response = requests.post(f"{BASE_URL}/search", json=payload)

    print("=== POST /search ===")
    print("Status Code:", response.status_code)

    try:
        data = response.json()
    except Exception as e:
        print("Error parsing JSON response:", e)
        return

    # Print a nicely formatted summary.
    print("\nSearch Query:")
```

```
    print(f"  {data.get('query')}")

    print("\nTop Results:")
    for i, result in enumerate(data.get("results", []), start=1):
        print(f" {i}. Score: {result.get('score'):.4f}")
        print(f"    Text: {result.get('text')}\n")

    # Print the full JSON response.
    print("Full JSON Response:")
    print(json.dumps(data, indent=2))

# Example usage:
test_query = "Which forms do I need for self-employment?"
test_search_endpoint(test_query)
```

```
=== POST /search ===
Status Code: 200

Search Query:
  Which forms do I need for self-employment?

Top Results:
 1. Score: 0.6047
    Text: self-employment income from separate nonfarm or farm
businesses, each of you must complete and file a
separate Schedule C (Form 1040) or Schedule F (Form
1040). Be sure to enter at the top of each Schedule C
(Form 1040) or Schedule F (Form 1040) the name and
SSN of the spouse who owns the business. Each of you
must also complete a separate Schedule SE (Form 1040).
Attach these pages to a single Form 1040-SS.
Business Owned and Operated by
Spouses

 2. Score: 0.5987
    Text: Schedule SE (Form 1040), Self-Employment Tax, to complete your return.
You may only need to file Form 1040-SS and none of the schedules. However, if
your return is more complicated (for
example, you claim certain deductions or credits or owe additional taxes), you
will need to complete one or more of the
schedules. Below is a general guide to which schedule(s) you will need to file
based on your circumstances. See the

 3. Score: 0.5882
    Text: General Instructions
Purpose of Form
This form is for residents of the U.S. Virgin Islands (USVI),
Guam, American Samoa, the Commonwealth of the
```

Northern Mariana Islands (CNMI), and Puerto Rico who
are not required to file a U.S. income tax return but who
have self-employment income or are eligible to claim
certain credits.
Use this form to report net earnings from
self-employment (SE) to the United States and, if
necessary, pay SE tax on that income. The Social Security

 4. Score: 0.5793
    Text: self-employment, it may benefit you to file Form
1040-SS and use either optional method on
Schedule SE (Form 1040). See Schedule SE (Form
1040), Part II-Optional Methods To Figure Net Earnings.
Exceptions. If (2) and (3) under Who Must File, earlier,
apply, but (1) does not apply, you must file Form 1040-SS
to:
• Report and pay household employment taxes;
• Report and pay employee social security and
Medicare tax on (a) unreported tips, (b) wages from

 5. Score: 0.5747
    Text: self-employed person, enter contributions made as an employer
on your behalf on Schedule 1 (Form 1040), line 16, not on
Schedule F (Form 1040).
In most cases, you must file the applicable form listed next
if you maintain a pension, profit-sharing, or other funded-de-
ferred compensation plan. The filing requirement isn't affected
by whether the plan qualified under the Internal Revenue Code,
or whether you claim a deduction for the current tax year.

Full JSON Response:

```
{
  "query": "Which forms do I need for self-employment?",
  "results": [
    {
      "id": "i1040ss.md_39",
      "score": 0.604735851,
      "text": "self-employment income from separate nonfarm or farm\nbusinesses,
each of you must complete and file a\nseparate Schedule C (Form 1040) or
Schedule F (Form\n1040). Be sure to enter at the top of each Schedule C\n(Form
1040) or Schedule F (Form 1040) the name and\nSSN of the spouse who owns the
business. Each of you\nmust also complete a separate Schedule SE (Form
1040).\nAttach these pages to a single Form 1040-SS.\nBusiness Owned and
Operated by\nSpouses"
    },
    {
      "id": "i1040ss.md_18",
      "score": 0.598732352,
```

```
      "text": "Schedule SE (Form 1040), Self-Employment Tax, to complete your
return.\nYou may only need to file Form 1040-SS and none of the schedules.
However, if your return is more complicated (for\nexample, you claim certain
deductions or credits or owe additional taxes), you will need to complete one or
more of the\nschedules. Below is a general guide to which schedule(s) you will
need to file based on your circumstances. See the"
    },
    {
      "id": "i1040ss.md_11",
      "score": 0.588199198,
      "text": "General Instructions\nPurpose of Form\nThis form is for residents
of the U.S. Virgin Islands (USVI),\nGuam, American Samoa, the Commonwealth of
the\nNorthern Mariana Islands (CNMI), and Puerto Rico who\nare not required to
file a U.S. income tax return but who\nhave self-employment income or are
eligible to claim\ncertain credits.\nUse this form to report net earnings
from\nself-employment (SE) to the United States and, if\nnecessary, pay SE tax
on that income. The Social Security"
    },
    {
      "id": "i1040ss.md_16",
      "score": 0.579301238,
      "text": "self-employment, it may benefit you to file Form\n1040-SS and use
either optional method on\nSchedule SE (Form 1040). See Schedule SE
(Form\n1040), Part II\u2014Optional Methods To Figure Net Earnings.\nExceptions.
If (2) and (3) under Who Must File, earlier,\napply, but (1) does not apply, you
must file Form 1040-SS\nto:\n\u2022 Report and pay household employment
taxes;\n\u2022 Report and pay employee social security and\nMedicare tax on (a)
unreported tips, (b) wages from"
    },
    {
      "id": "i1040sf.md_111",
      "score": 0.574739635,
      "text": "self-employed person, enter contributions made as an employer\non
your behalf on Schedule 1 (Form 1040), line 16, not on\nSchedule F (Form
1040).\nIn most cases, you must file the applicable form listed next\nif you
maintain a pension, profit-sharing, or other funded-de-\nferred compensation
plan. The filing requirement isn't affected\nby whether the plan qualified under
the Internal Revenue Code,\nor whether you claim a deduction for the current tax
year."
    }
  ]
}
```

1.7.1 Integration Test Of Prompt With Pinecone

[ ]:
```python
def test_completions_deepseek(tax_optimize=True):
    payload = {
        "model": "DeepSeek-V2-Lite",
        "prompt": "Explain the key differences between tax credits and tax␣
 ↪deductions.",
        "max_tokens": 2000,
        "tax_optimize": tax_optimize,
        "n": 2
    }
    response = requests.post(COMPLETIONS_URL, json=payload)
    print("\n=== POST /v1/completions ===")
    print("Status Code:", response.status_code)
    try:
        data = response.json()
        choice = data.get("choices", [{}])[0]
        print("\nText Completion Summary:")
        print(f" - Model: {data.get('model')}")
        print(f" - prompt: {payload.get('prompt')}")
        print(f" - Generated Text: \n{choice.get('text')}")
        usage = data.get("usage", {})
        print(f" - Prompt Tokens: {usage.get('prompt_tokens')}")
        print(f" - Completion Tokens: {usage.get('completion_tokens')}")
        print("\nFull Response JSON:")
        print(json.dumps(data, indent=2))
    except Exception as e:
        print("Error parsing JSON:", e)

# Test with tax optimization enabled
test_completions_deepseek(tax_optimize=True)
```

```
=== POST /v1/completions ===
Status Code: 200

Text Completion Summary:
 - Model: DeepSeek-V2-Lite
 - prompt: Explain the key differences between tax credits and tax deductions.
 - Generated Text:
As a tax advisor and legal expert, the key differences between tax credits and
tax deductions are:

1. Nature of Reduction: Tax deductions reduce the taxable income, which in turn
lowers the amount of tax owed. Tax credits directly reduce the tax amount owed
on a dollar-for-dollar basis.

2. Effect on Tax Liability: Tax deductions reduce the tax rate, while tax
```

credits directly reduce the tax liability.

3. Availability and Use: Tax deductions are available to all taxpayers, regardless of their income level. Tax credits are often refundable, meaning they can provide a refund even if the credit exceeds the tax liability.

4. Application: Tax deductions are subtracted from the total income to calculate taxable income. Tax credits are subtracted directly from the tax liability.

5. Impact on Net Tax Liability: Tax deductions lower the amount of income that is taxed, while tax credits lower the actual tax amount owed.

6. Availability: Some tax deductions may phase out at higher income levels, but tax credits may not have such restrictions.

7. Timing: Tax deductions are taken in the year they are incurred, while tax credits are claimed in the year they are earned.

8. Amount: Tax deductions are based on a percentage of income, while tax credits are a fixed dollar amount.

9. Incentives: Tax deductions provide a tax incentive to engage in certain activities, while tax credits provide a direct financial incentive.

10. Types: Tax deductions can be categorized as either itemized or standard, depending on whether they are claimed separately or as part of the standard deduction. Tax credits are generally non-refundable or refundable, depending on their nature.
 - Prompt Tokens: 362
 - Completion Tokens: 351

Full Response JSON:

```
{
  "choices": [
    {
      "finish_reason": "stop",
      "index": 0,
      "text": "As a tax advisor and legal expert, the key differences between tax credits and tax deductions are:\n\n1. Nature of Reduction: Tax deductions reduce the taxable income, which in turn lowers the amount of tax owed. Tax credits directly reduce the tax amount owed on a dollar-for-dollar basis.\n\n2. Effect on Tax Liability: Tax deductions reduce the tax rate, while tax credits directly reduce the tax liability.\n\n3. Availability and Use: Tax deductions are available to all taxpayers, regardless of their income level. Tax credits are often refundable, meaning they can provide a refund even if the credit exceeds the tax liability.\n\n4. Application: Tax deductions are subtracted from the total income to calculate taxable income. Tax credits are subtracted directly from the tax liability.\n\n5. Impact on Net Tax Liability: Tax
```

deductions lower the amount of income that is taxed, while tax credits lower the actual tax amount owed.\n\n6. Availability: Some tax deductions may phase out at higher income levels, but tax credits may not have such restrictions.\n\n7. Timing: Tax deductions are taken in the year they are incurred, while tax credits are claimed in the year they are earned.\n\n8. Amount: Tax deductions are based on a percentage of income, while tax credits are a fixed dollar amount.\n\n9. Incentives: Tax deductions provide a tax incentive to engage in certain activities, while tax credits provide a direct financial incentive.\n\n10. Types: Tax deductions can be categorized as either itemized or standard, depending on whether they are claimed separately or as part of the standard deduction. Tax credits are generally non-refundable or refundable, depending on their nature."
    }
  ],
  "created": 1739840630,
  "id": "cmpl-1739840630",
  "model": "DeepSeek-V2-Lite",
  "object": "text_completion",
  "time_taken": 31.381417989730835,
  "usage": {
    "completion_tokens": 351,
    "prompt_tokens": 362,
    "total_tokens": 713
  }
}

[39]:
```
# Test with tax optimization disabled
test_completions_deepseek(tax_optimize=False)
```

```
=== POST /v1/completions ===
Status Code: 200

Text Completion Summary:
 - Model: DeepSeek-V2-Lite
 - Generated Text: As a tax and legal advisor, it is important to understand the
nuances between tax credits and tax deductions, as they are both valuable tools
for reducing taxable income. Here are the key differences between the two:

1. Nature of Benefit:
   - Tax Credits: A tax credit is a dollar-for-dollar reduction in the amount of
income tax you owe. It is more beneficial than a tax deduction because it
directly reduces the tax liability. Credits can be either nonrefundable or
refundable. Nonrefundable credits can only reduce your tax liability to zero,
while refundable credits can result in a tax refund even if your tax liability
is less than the credit amount.
   - Tax Deductions: A tax deduction reduces the amount of your income that is
subject to tax. It is a dollar reduction in your taxable income, which in turn
```

reduces the amount of tax you owe. Deductions are generally nonrefundable, meaning they can only reduce your taxable income and not result in a cash refund.

2. Effect on Tax Liability:
   - Tax Credits: Credits are applied directly against the tax liability. If the credit reduces your tax liability to zero, you do not receive a refund for the remaining portion of the credit.
   - Tax Deductions: Deductions reduce the amount of income that is taxed, but they do not result in a cash refund. You can only benefit from the tax savings if your income is above the standard deduction threshold.

3. Types of Credits:
   - Tax Credits: There are various types of credits, including the Child Tax Credit, the Earned Income Tax Credit, and the American Opportunity Tax Credit for education expenses. Some credits are refundable, while others are nonrefundable.
   - Tax Deductions: Deductions are categorized into itemized deductions and standard deductions. Itemized deductions include charitable donations, medical expenses, and state and local taxes. Standard deductions are a set amount that reduces your taxable income, regardless of your specific expenses.

4. Impact on Filing Status:
   - Tax Credits: The eligibility for credits is often tied to your filing status and income level. For example, the Earned Income Tax Credit is only available to those with earned income below certain thresholds and who file as single, married, or qualifying widow(er).
   - Tax Deductions: Your ability to claim deductions is also affected by your filing status and can be influenced by whether you choose to itemize deductions or take the standard deduction.

In summary, while both tax credits and tax deductions are ways to reduce taxable income, credits provide a more direct benefit by reducing the amount of tax you owe, while deductions reduce your taxable income, which can still result in a tax liability even if you do not receive a refund. Understanding the differences between these two tax-saving mechanisms is crucial for maximizing your tax benefits.
 - Prompt Tokens: 33
 - Completion Tokens: 594

Full Response JSON:

```
{
  "choices": [
    {
      "finish_reason": "stop",
      "index": 0,
      "text": "As a tax and legal advisor, it is important to understand the
nuances between tax credits and tax deductions, as they are both valuable tools
```

for reducing taxable income. Here are the key differences between the two:\n\n1. Nature of Benefit:\n   - Tax Credits: A tax credit is a dollar-for-dollar reduction in the amount of income tax you owe. It is more beneficial than a tax deduction because it directly reduces the tax liability. Credits can be either nonrefundable or refundable. Nonrefundable credits can only reduce your tax liability to zero, while refundable credits can result in a tax refund even if your tax liability is less than the credit amount.\n   - Tax Deductions: A tax deduction reduces the amount of your income that is subject to tax. It is a dollar reduction in your taxable income, which in turn reduces the amount of tax you owe. Deductions are generally nonrefundable, meaning they can only reduce your taxable income and not result in a cash refund.\n\n2. Effect on Tax Liability:\n   - Tax Credits: Credits are applied directly against the tax liability. If the credit reduces your tax liability to zero, you do not receive a refund for the remaining portion of the credit.\n   - Tax Deductions: Deductions reduce the amount of income that is taxed, but they do not result in a cash refund. You can only benefit from the tax savings if your income is above the standard deduction threshold.\n\n3. Types of Credits:\n   - Tax Credits: There are various types of credits, including the Child Tax Credit, the Earned Income Tax Credit, and the American Opportunity Tax Credit for education expenses. Some credits are refundable, while others are nonrefundable.\n   - Tax Deductions: Deductions are categorized into itemized deductions and standard deductions. Itemized deductions include charitable donations, medical expenses, and state and local taxes. Standard deductions are a set amount that reduces your taxable income, regardless of your specific expenses.\n\n4. Impact on Filing Status:\n   - Tax Credits: The eligibility for credits is often tied to your filing status and income level. For example, the Earned Income Tax Credit is only available to those with earned income below certain thresholds and who file as single, married, or qualifying widow(er).\n   - Tax Deductions: Your ability to claim deductions is also affected by your filing status and can be influenced by whether you choose to itemize deductions or take the standard deduction.\n\nIn summary, while both tax credits and tax deductions are ways to reduce taxable income, credits provide a more direct benefit by reducing the amount of tax you owe, while deductions reduce your taxable income, which can still result in a tax liability even if you do not receive a refund. Understanding the differences between these two tax-saving mechanisms is crucial for maximizing your tax benefits."
    }
  ],
  "created": 1739840154,
  "id": "cmpl-1739840154",
  "model": "DeepSeek-V2-Lite",
  "object": "text_completion",
  "time_taken": 61.393848180770874,
  "usage": {
    "completion_tokens": 594,
    "prompt_tokens": 33,
    "total_tokens": 627
  }

}

1.8 Rest of Backend

The code of the full backend is stored in `TaxSense_backend.py`.

1.8.1 Final API Endpoints Testing

A comprehensive evaluation of all backend API endpoints was conducted to ensure functionality, accuracy, and performance. The full report, including test cases and results, is available here: Final Backend API Endpoints Testing Report.

1.8.2 Authentication & Security

1.8.3 `token_required(f)`

This function verifies each incoming request by checking for an authorization token provided in the request header, query parameter, or JSON payload. If the token is missing or invalid, the request is rejected with a 401 Unauthorized response. For our easy access, we made this a constant `DEMO_TOKEN`.

```
DEMO_TOKEN = "team-tax-1531"

def token_required(f):
    @wraps(f)
    def decorated_function(*args, **kwargs):
        token = None
        # Check Authorization header (Bearer token)
        auth_header = request.headers.get("Authorization")
        if auth_header:
            parts = auth_header.split()
            if len(parts) == 2 and parts[0].lower() == "bearer":
                token = parts[1]
        if not token:
            token = request.args.get("token")
        if not token and request.is_json:
            json_data = request.get_json(silent=True)
            if json_data:
                token = json_data.get("token")
        if token != DEMO_TOKEN:
            return jsonify({"error": "Unauthorized: Invalid or missing token"}), 401
        return f(*args, **kwargs)
    return decorated_function
```

1.8.4 Chat History Persistence (SQLite)

`init_db()` The database initialization process creates the **`chat_history`** table within the **`chat_sessions.db`** if it does not already exist, ensuring that the system is prepared to log conversation data.

```
DB_FILE = "chat_sessions.db"

def init_db():
    conn = sqlite3.connect(DB_FILE)
    cursor = conn.cursor()
    cursor.execute('''
        CREATE TABLE IF NOT EXISTS chat_history (
            chat_id TEXT,
            username TEXT,
            timestamp TEXT,
            role TEXT,
            content TEXT
        )
    ''')
    conn.commit()
    conn.close()

init_db()
```

store_chat_message(chat_id, username, role, content) This function records each message in the conversation by storing the chat session identifier, username, role (user or assistant), and the message content along with a timestamp. This logging ensures that all conversation entries are maintained for future reference.

```
def store_chat_message(chat_id, username, role, content):
    timestamp = time.strftime("%Y-%m-%d %H:%M:%S", time.gmtime())
    conn = sqlite3.connect(DB_FILE)
    cursor = conn.cursor()
    cursor.execute("INSERT INTO chat_history (chat_id, username, timestamp, role, content) VALU
                   (chat_id, username, timestamp, role, content))
    conn.commit()
    conn.close()
```

get_chat_history(chat_id) The retrieval of chat history is handled by this function, which gathers all stored messages for a given chat session in chronological order, allowing the full conversation to be easily reconstructed.

```
def get_chat_history(chat_id):
    conn = sqlite3.connect(DB_FILE)
    cursor = conn.cursor()
    cursor.execute("SELECT timestamp, username, role, content FROM chat_history WHERE chat_id =
    messages = cursor.fetchall()
    conn.close()
    return [{"timestamp": msg[0], "username": msg[1], "role": msg[2], "content": msg[3]} for ms
```

1.8.5 Model Management

`MODEL_PATHS & MODEL_CONFIGS` We already discussed the `MODEL_PATHS` & `MODEL_CONFIGS` dictionaries, in our `/v1/models` explainnation above. These Specify the local filesystem paths (or fallback Hugging Face IDs) for each model. Thay also indicate optional parameter-efficient fine-tuning (use_peft) or other config details.

`load_model(model_name)` This function is responsible for loading a model and its associated tokenizer into memory if they are not already loaded. It caches the loaded model for subsequent requests and automatically determines whether to load the model from a local path or a Hugging Face ID.

```
def load_model(model_name: str):
    if model_name in loaded_models:
        loaded_models[model_name]["last_access_time"] = time.time()
        return

    model_path = MODEL_PATHS.get(model_name)
    if not os.path.exists(model_path):
        hf_model_id = MODEL_HF_IDS.get(model_name, model_name)
        print(f"Local model for '{model_name}' not found at '{model_path}'. Downloading from HF
        model_path = hf_model_id

    print(f"[load_model] Loading '{model_name}' ...")
    tokenizer = AutoTokenizer.from_pretrained(model_path)
    model = AutoModelForCausalLM.from_pretrained(
        model_path,
        torch_dtype=torch.float16,
        device_map="auto",
        trust_remote_code=True
    )
    loaded_models[model_name] = {
        "tokenizer": tokenizer,
        "model": model,
        "last_access_time": time.time(),
    }
    print(f"[load_model] '{model_name}' loaded across available GPUs.")
```

`unload_model(model_name)` To optimize resource usage, this function removes references to a loaded model and frees up GPU memory when the model is no longer required.

```
def unload_model(model_name: str):
    if model_name not in loaded_models:
        return
    print(f"[unload_model] Unloading model '{model_name}'.")
    model_entry = loaded_models[model_name]
    del model_entry["model"]
```

```
    del model_entry["tokenizer"]
    del loaded_models[model_name]
    gc.collect()
    torch.cuda.empty_cache()
```

build_prompt(user_question) When preparing for text generation, this function constructs the complete prompt by combining a predefined system instruction with the user's query, ensuring that the model receives the necessary context for generating a response.

```
def build_prompt(user_question: str) -> str:
    prefix = (
        "You are a helpful tax and legal advisor. "
        "Answer the following question in a clear and concise manner:\n"
    )
    return prefix + user_question
```

perform_generation(model_name, prompt, max_tokens) This function manages the text generation process. It tokenizes the prompt, calls the model's generate method, handles decoding, and appends punctuation if needed. It then returns the generated text along with the time taken for processing.

```
def perform_generation(model_name: str, prompt: str, max_tokens: int):
    load_model(model_name)
    tokenizer = loaded_models[model_name]["tokenizer"]
    model = loaded_models[model_name]["model"]
    inputs = tokenizer(prompt, return_tensors="pt")
    start_time = time.time()
    output_ids = model.generate(
        **inputs,
        max_new_tokens=max_tokens,
        do_sample=True,
        eos_token_id=tokenizer.eos_token_id,
        pad_token_id=tokenizer.eos_token_id
    )
    response_time = time.time() - start_time
    full_output = tokenizer.decode(output_ids[0], skip_special_tokens=True)
    if full_output.startswith(prompt):
        generated_text = full_output[len(prompt):].strip()
    else:
        generated_text = full_output.strip()
    if not generated_text.endswith(('.', '!', '?')):
        generated_text += " ..."
    loaded_models[model_name]["last_access_time"] = time.time()
    return generated_text, response_time, tokenizer
```

Pre-download Models We also wrote some inline code. This code checks if each model in a given dictionary exists locally and, if not, downloads the model and its tokenizer from Hugging

Face into a specified cache directory.

```
for mname, local_path in MODEL_PATHS.items():
    if not os.path.exists(local_path):
        hf_id = MODEL_CONFIGS.get(mname, {}).get("hf_id", mname)
        print(f"Local model for '{mname}' not found at '{local_path}'. Downloading from '{hf_id
        _ = AutoTokenizer.from_pretrained(hf_id, cache_dir="./model_directory")
        _ = AutoModelForCausalLM.from_pretrained(hf_id, cache_dir="./model_directory", torch_dt
        print(f"Downloaded '{mname}'.")
```

1.8.6 Retrieval-Augmented Generation Utilities

Pinecone Setup The Pinecone integration involves configuring the PINECONE_API_KEY and creating an index connection using `pc.Index(INDEX_NAME)`. This setup enables the system to perform semantic searches by connecting to a Pinecone index.

> NOTE: Make sure when running the code to either set your `PINECONE_API_KEY` as a system environment variable using `export PINECONE_API_KEY='your_api_key'` (Linux/macOS) or `set PINECONE_API_KEY=your_api_key` (Windows), or add it directly in the backend file, because without it, the Pinecone search endpoint might not work properly.

```
PINECONE_API_KEY = os.getenv("PINECONE_API_KEY")
if not PINECONE_API_KEY:
    print("Warning: PINECONE_API_KEY is not set. Pinecone search endpoint may not work.")

pc = Pinecone(api_key=PINECONE_API_KEY)
INDEX_NAME = "tax-rag"
if INDEX_NAME not in pc.list_indexes().names():
    print(f"Error: Pinecone index '{INDEX_NAME}' does not exist.")
    index = None
else:
    index = pc.Index(INDEX_NAME)
    print(f" Connected to Pinecone index: {INDEX_NAME}")
```

`search_pinecone(query_text, top_k)` For semantic search, this function encodes the query text using SentenceTransformer and queries the Pinecone index, returning the top matching results along with their similarity scores.

```
def search_pinecone(query_text, top_k=5):
    if not index:
        return {"error": "Pinecone index is not initialized."}
    query_embedding = EMBEDDING_MODEL.encode(query_text).tolist()
    results = index.query(vector=query_embedding, top_k=top_k, include_metadata=True)
    formatted_results = [
        {
            "id": match.get("id"),
            "score": match.get("score"),
```

```
            "text": match.get("metadata", {}).get("text")
        }
        for match in results.get("matches", [])
    ]
    return {"query": query_text, "results": formatted_results}
```

create_detailed_prompt(user_query, search_results, tax_optimize=True, n=2) This function generates a comprehensive prompt by merging the user's query with the top search results from the semantic search. It also has the option to incorporate tax optimization context if needed.

```
def create_detailed_prompt(user_query, search_results, tax_optimize=True, n=2):
    if tax_optimize:
        prefix = "You are a helpful tax advisor and legal expert. Use the provided context to a
        context_segments = []
        form_ids = set()
        for result in search_results.get("results", [])[:n]:
            form_id = result.get("id", "")
            form_name = form_id.split(".md")[0] if ".md" in form_id else form_id
            form_ids.add(form_name)
            context_text = result.get("text", "").strip()
            context_segments.append(f"Form {form_name}: {context_text}")
        context_section = "\n".join(context_segments)
    else:
        prefix = "You are a helpful advisor. Use the provided online information to answer the
        context_section = ""
        form_ids = set()
    detailed_prompt = (
        f"{prefix}"
        f"User Query: {user_query}\n"
        f"Related Context:\n"
        f"{context_section}\n"
        "Note: The above information is extracted from relevant sources. Use it to formulate yo
    )
    return detailed_prompt, form_ids
```

1.8.7 PDF Processing

chunk_text(text, chunk_size) In the PDF processing workflow, this function splits long text into fixed-size segments to facilitate the creation and storage of embeddings for later retrieval.

```
def chunk_text(text, chunk_size=500):
    chunks = []
    start = 0
    while start < len(text):
        end = start + chunk_size
        chunk = text[start:end]
        chunks.append(chunk.strip())
        start = end
```

```
    return chunks
```

retrieve_pdf_context(username, chat_id, question, top_k) This function processes previously uploaded PDF content by selecting text chunks that best match the user's query. It retrieves the top-k most relevant sections to provide additional context for the response. The `EMBEDDING_MODEL` was previously set to `all-MiniLM-L6-v2` which is the same as the one used for Pinecone.

```
def retrieve_pdf_context(username, chat_id, question, top_k=2):
    folder_path = os.path.join("pdf_uploads", username, chat_id)
    if not os.path.isdir(folder_path):
        return []
    all_chunks = []
    for fname in os.listdir(folder_path):
        if fname.endswith(".meta.json"):
            meta_path = os.path.join(folder_path, fname)
            with open(meta_path, "r", encoding="utf-8") as mfile:
                meta_data = json.load(mfile)
                chunk_entries = meta_data.get("chunks", [])
                all_chunks.extend(chunk_entries)
    if not all_chunks:
        return []
    q_emb = EMBEDDING_MODEL.encode([question])[0]
    scored = []
    for entry in all_chunks:
        c_emb = np.array(entry["embedding"])
        c_text = entry["chunk"]
        score = cos_sim(q_emb, c_emb)
        scored.append((score, c_text))
    scored.sort(key=lambda x: x[0], reverse=True)
    top_contexts = [t[1] for t in scored[:top_k]]
    return top_contexts
```

This function also uses some smaller functions: `compute_md5`, which calculates the MD5 hash of given byte data, and `cos_sim`, which computes the cosine similarity between two vectors.

```
def compute_md5(byte_data):
    return hashlib.md5(byte_data).hexdigest()

def cos_sim(a, b):
    return np.dot(a, b) / (np.linalg.norm(a) * np.linalg.norm(b))
```

1.8.8 Core Endpoints

/generate & /generate_stream These endpoints offer text generation services. One endpoint returns a complete generated response, while the other streams the response token-by-token as it is generated, catering to different application needs. See the Endpoint Implementation for more details and for the code.

/v1/completions Emulating the OpenAI "completions" style, this endpoint returns a generated text completion. It can also perform tax optimization by embedding the query, executing a semantic search, and appending reference data to the final answer. See the /v1/models for more details and for the code.

/v1/chat/completions For chat interactions, this endpoint processes the latest user input, logs the conversation, optionally retrieves additional context from Pinecone or PDF data, and returns the assistant's response. See the /v1/chat/completions for more details and for the code.

We also created a smaller funtion to clean the id from the Pinecode docs:

```
def clean_form_id_v2(form_id):
    form_id = form_id.replace(".md", "")
    if re.search(r'_\d+$', form_id):
        form_id = re.sub(r'_\d+$', '', form_id)
    return form_id
```

The IDs contained the .md and then the chunk number, useless information for the end user.

/upload_pdf This endpoint handles the upload of PDF files. It extracts text using PyPDF2, divides it into chunks, encodes these chunks into embeddings, and stores them for use in future queries.

```
def upload_pdf():
    if "pdf" not in request.files:
        return jsonify({"error": "'pdf' file is required"}), 400
    if "username" not in request.form:
        return jsonify({"error": "'username' field is required"}), 400
    if "chat_id" not in request.form:
        return jsonify({"error": "'chat_id' field is required"}), 400

    pdf_file = request.files["pdf"]
    username = request.form["username"].strip()
    chat_id = request.form["chat_id"].strip()

    base_folder = os.path.join("pdf_uploads", username, chat_id)
    os.makedirs(base_folder, exist_ok=True)

    filename = pdf_file.filename
    save_path = os.path.join(base_folder, filename)
    pdf_file.save(save_path)

    # Compute MD5 hash for the file
    with open(save_path, "rb") as f:
        data_bytes = f.read()
    filehash = compute_md5(data_bytes)
    meta_json_path = save_path + ".meta.json"

    # If meta file exists with the same hash, skip processing
```

```
    if os.path.exists(meta_json_path):
        with open(meta_json_path, "r", encoding="utf-8") as meta_f:
            existing = json.load(meta_f)
            if existing.get("filehash") == filehash:
                return jsonify({
                    "message": f"PDF '{filename}' already processed. (same hash)",
                    "skipped_chunking": True
                })

    try:
        pdf_stream = io.BytesIO(data_bytes)
        reader = PdfReader(pdf_stream)
        all_text = []
        for page in reader.pages:
            ptxt = page.extract_text()
            if ptxt:
                all_text.append(ptxt)
        full_text = "\n".join(all_text)
        chunks = chunk_text(full_text, chunk_size=500)
        chunk_embeddings = EMBEDDING_MODEL.encode(chunks)
        chunk_entries = []
        for i, c in enumerate(chunks):
            chunk_entries.append({
                "chunk": c,
                "embedding": chunk_embeddings[i].tolist()
            })
        meta_data = {
            "filename": filename,
            "filehash": filehash,
            "chunks": chunk_entries
        }
        with open(meta_json_path, "w", encoding="utf-8") as mf:
            json.dump(meta_data, mf)
        return jsonify({
            "message": f"PDF '{filename}' uploaded and processed.",
            "chunks": len(chunks),
            "chat_id": chat_id,
            "username": username
        })
    except Exception as e:
        return jsonify({"error": str(e)}), 500
```

/search The semantic search endpoint allows users to directly query the Pinecone index, returning the top results based on the similarity of the provided query.

```
def search():
    data = request.get_json()
```

```
    if not data or "query" not in data:
        return jsonify({"error": "Missing 'query' field in JSON payload"}), 400
    query_text = data["query"]
    top_k = data.get("top_k", 5)
    response = search_pinecone(query_text, top_k)
    return jsonify(response)
```

/chat_history & /chat_sessions These endpoints provide access to the stored conversation history and a list of all existing chat session identifiers, respectively, by querying the SQLite database.

```
@app.route('/chat_history', methods=['GET'])
@token_required
def chat_history():
    chat_id = request.args.get("chat_id")
    if not chat_id:
        return jsonify({"error": "chat_id is required"}), 400
    history = get_chat_history(chat_id)
    if not history:
        return jsonify({"error": "No chat history found for the given chat_id"}), 404
    return jsonify({"chat_id": chat_id, "messages": history})

@app.route('/chat_sessions', methods=['GET'])
@token_required
def list_chat_sessions():
    conn = sqlite3.connect(DB_FILE)
    cursor = conn.cursor()
    cursor.execute("SELECT DISTINCT chat_id FROM chat_history")
    sessions = [row[0] for row in cursor.fetchall()]
    conn.close()
    return jsonify({"chat_sessions": sessions})
```

/v1/models This endpoint returns a list of available model identifiers that are recognized in the configuration dictionaries, informing users of the models they can choose from.

```
@app.route('/v1/models', methods=['GET'])
@token_required
def list_models():
    models = [{"id": name, "object": "model"} for name in MODEL_PATHS.keys()]
    return jsonify({"data": models, "object": "list"})
```

The front end hits this endpoint first, so you must run the backend first then the frontend.

/feedback User feedback is collected and stored in JSON format through this endpoint. The feedback, which can indicate a positive ("UP") or negative ("DOWN") experience, may be used for future assessments or fine-tuning efforts.

```python
@app.route("/feedback", methods=["POST"])
@token_required
def feedback():
    data = request.get_json(silent=True)
    if not data:
        return jsonify({"error": "No JSON data provided"}), 400

    chat_id = data.get("chat_id")
    feedback_value = data.get("feedback")
    conversation = data.get("conversation", [])
    username = data.get("username", "")
    use_pdf = data.get("use_pdf_context", False)
    tax_opt = data.get("tax_optimize", False)

    if not chat_id or not feedback_value:
        return jsonify({"error": "Missing 'chat_id' or 'feedback'"}), 400

    timestamp_str = datetime.datetime.now().strftime("%Y%m%d_%H%M%S")
    filename = f"{timestamp_str}_{chat_id}_{feedback_value}.json"
    save_path = os.path.join(REFINING_DATA_DIR, filename)

    record = {
        "timestamp": timestamp_str,
        "chat_id": chat_id,
        "username": username,
        "feedback": feedback_value,
        "use_pdf_context": use_pdf,
        "tax_optimize": tax_opt,
        "conversation": conversation
    }
    try:
        with open(save_path, "w", encoding="utf-8") as f:
            f.write(json.dumps(record, ensure_ascii=False, indent=2))
        return jsonify({"message": "Feedback saved successfully.", "file": filename})
    except Exception as e:
        return jsonify({"error": str(e)}), 500
```

Currently this information is being stored within *refining_data* directory. Which then is pushed to S3 with `admin.py`.

1.9 Frontend - The User Chat

The code of this part is stored in `TaxSense_frontend.py`.

You can view the dashboard in the README or within the TaxSense Dashboard Info section.

1.9.1 Configuration & Endpoints Setup

API_HOST, TOKEN, … The configuration includes the API host, authentication token, and other parameters needed to connect to the backend. The model check is also done at the start to make sure the backend is running when the front end runs.

```
API_HOST = "http://0.0.0.0:6000"
TOKEN = "team-tax-1531"

UPLOAD_PDF_URL = f"{API_HOST}/upload_pdf"
CHAT_SESSIONS_URL = f"{API_HOST}/chat_sessions"
CHAT_HISTORY_URL = f"{API_HOST}/chat_history"
CHAT_COMPLETIONS_URL = f"{API_HOST}/v1/chat/completions"

try:
    resp = requests.get(f"{API_HOST}/v1/models", headers=get_headers(), timeout=10)
    resp.raise_for_status()
    data = resp.json()
    if "data" not in data or not isinstance(data["data"], list):
        raise RuntimeError("Unexpected response format from /v1/models.")
    MODEL_OPTIONS = [m["id"] for m in data["data"] if isinstance(m, dict) and "id" in m]
    if not MODEL_OPTIONS:
        raise RuntimeError("No models available from the backend.")
    DEFAULT_MODEL = "DeepSeek-V2-Lite" if "DeepSeek-V2-Lite" in MODEL_OPTIONS else MODEL_OPTIO
except requests.exceptions.RequestException as e:
    print(f"Error: Failed to fetch models from backend - {e}")
    raise RuntimeError("Critical failure: Unable to retrieve model list.")
except Exception as e:
    print(f"Unexpected error: {e}")
    raise RuntimeError("Unexpected error while fetching model list.")
```

get_headers() Returns a dictionary containing the authorization header (using the defined token) for all API requests.

```
def get_headers():
    return {"Authorization": f"Bearer {TOKEN}"}
```

1.9.2 Session Management

fetch_chat_sessions() This function fetches the list of all chat sessions from the backend. It sends a GET request to the `/chat_sessions` endpoint and returns a list of session IDs. In case of an error (e.g., network issues), it prints an error message and returns an empty list.

```
def fetch_chat_sessions():
    try:
        resp = requests.get(CHAT_SESSIONS_URL, headers=get_headers(), timeout=10)
        resp.raise_for_status()
        data = resp.json()
```

```
        return data.get("chat_sessions", [])
    except Exception as e:
        print("Error fetching chat sessions:", e)
        return []
```

load_chat_history(chat_id) Retrieves chat history by processing the backend's JSON response into (role, content) pairs. It returns the updated chat ID and raw messages, or an empty history if the chat ID is missing or an error occurs.

```
def load_chat_history(chat_id):
    if not chat_id:
        return [], "", None

    try:
        url = f"{CHAT_HISTORY_URL}?chat_id={chat_id}"
        resp = requests.get(url, headers=get_headers(), timeout=10)
        resp.raise_for_status()
        data = resp.json()
        messages = data.get("messages", [])
        chat_history = [(m["role"], m["content"]) for m in messages]
        return chat_history, data.get("chat_id", chat_id), messages
    except Exception as e:
        return [], chat_id, None
```

fetch_user_sessions(username) It fileters sessions to include only those with at least one message from the given username.
Loads each session's history and returns matching chat IDs.

```
def fetch_user_sessions(username):
    all_sessions = fetch_chat_sessions()
    user_chat_ids = []

    for sid in all_sessions:
        _, _, raw_msgs = load_chat_history(sid)
        if raw_msgs is None:
            continue
        for m in raw_msgs:
            if m.get("username") == username:
                user_chat_ids.append(sid)
                break

    return user_chat_ids
```

load_selected_chat_from_dropdown(chat_id) Loads the chat history for the session selected from the dropdown. It returns the conversation and the final session ID, or an empty history if none is provided.

```
def load_selected_chat_from_dropdown(chat_id):
    if not chat_id:
        return [], ""
    chat_history, final_id, _ = load_chat_history(chat_id)
    return chat_history, final_id
```

new_chat() This function initiates a new chat session without a predefined chat identifier. The backend automatically assigns a new chat ID when the session is first used.

```
def new_chat():
    return [], ""
```

refresh_sessions(username) Triggered by the "Refresh Session List" button, this function refreshes the chat sessions by calling `fetch_user_sessions(username)`. It updates the sessions dropdown with only those sessions that involve the given username.

```
def refresh_sessions(username):
    sessions = fetch_user_sessions(username)
    return gr.update(choices=sessions)
```

1.9.3 Chat Identification

generate_chat_id_from_question(question) This function generates a sanitized and URL-friendly chat ID based on the user's input question.

```
def generate_chat_id_from_question(question: str) -> str:
    processed = re.sub(r'[^a-zA-Z0-9\s-]', '', question.strip().lower())
    processed = processed.replace(' ', '-')
    processed = processed[:50]
    if not processed:
        processed = str(uuid.uuid4())[:8]
    return processed
```

1.9.4 Conversation Handling

generate_chat_response(...) This function compiles the user's input, session details, and selected model into a request for the chat completion endpoint. Once the response is received, it updates the chat window with the assistant's answer.

```
def generate_chat_response(
    user_message,
    chat_history,
    username,
    chat_id,
    selected_model,
    use_pdf_context,
    tax_optimize,
    max_tokens
```

```
):
    if not user_message.strip():
        return "", chat_history, chat_id
    if not chat_id:
        chat_id = generate_chat_id_from_question(user_message)
    chat_history.append(("user", user_message))
    messages_for_api = [
        {"role": role, "content": content} for (role, content) in chat_history
    ]

    payload = {
        "model": selected_model,
        "messages": messages_for_api,
        "max_tokens": max_tokens,
        "username": username,
        "chat_id": chat_id,
        "use_pdf_context": use_pdf_context,
        "tax_optimize": tax_optimize
    }

    try:
        resp = requests.post(CHAT_COMPLETIONS_URL, json=payload, headers=get_headers(), timeout
        resp.raise_for_status()
        data = resp.json()
    except Exception as e:
        error_msg = f"Error: {str(e)}"
        chat_history.append(("assistant", error_msg))
        return "", chat_history, chat_id

    if "choices" not in data:
        error_msg = f"Error: unexpected response format: {data}"
        chat_history.append(("assistant", error_msg))
        return "", chat_history, chat_id

    assistant_msg = data["choices"][0]["message"]["content"]
    new_chat_id = data.get("chat_id", chat_id)

    chat_history.append(("assistant", assistant_msg))

    return "", chat_history, new_chat_id
```

send_feedback(...) User feedback is collected through this function, which sends a JSON payload containing details such as the chat session and context usage to the backend for logging and future analysis.

```
def send_feedback(feedback_value, chat_history, username, chat_id, use_pdf_context, tax_optimiz
```

```
    if not chat_id:
        return "Cannot send feedback without a chat_id. Please chat first."

    payload = {
        "chat_id": chat_id,
        "username": username,
        "feedback": feedback_value,      # "UP" or "DOWN"
        "conversation": chat_history,
        "use_pdf_context": use_pdf_context,
        "tax_optimize": tax_optimize
    }

    url = f"{API_HOST}/feedback"
    try:
        resp = requests.post(url, json=payload, headers=get_headers(), timeout=10)
        resp.raise_for_status()
        data = resp.json()
        if "error" in data:
            return f"Error in feedback: {data['error']}"
        return f"Feedback saved: {data.get('message', 'OK')}"
    except Exception as e:
        return f"Exception sending feedback: {str(e)}"
```

1.9.5 PDF Upload & State Control

upload_pdf(pdf_path, username, chat_id) When a user uploads a PDF file, this function sends the file to the backend. The text is extracted, encoded into embeddings, and stored for future reference, facilitating enhanced context in subsequent queries.

```
def upload_pdf(pdf_path, username, chat_id):
    if not pdf_path:
        return "No PDF selected or invalid path."

    if not username.strip():
        return "Please enter a username before uploading."

    if not chat_id.strip():
        chat_id = str(uuid.uuid4())

    file_name = os.path.basename(pdf_path)
    try:
        with open(pdf_path, "rb") as f:
            files = {"pdf": (file_name, f, "application/pdf")}
            data = {"username": username, "chat_id": chat_id}
            resp = requests.post(UPLOAD_PDF_URL, files=files, data=data, headers=get_headers()
            resp.raise_for_status()
            result = resp.json()
            if "error" in result:
```

```
                return f"Error uploading PDF: {result['error']}"
            return (
                f"Successfully uploaded PDF '{file_name}'. "
                f"Chunks processed: {result.get('chunks')}. "
                f"Message: {result.get('message', '')}\n"
                f"(Chat ID now: {chat_id})"
            )
    except Exception as e:
        return f"Exception during upload: {str(e)}"
```

on_pdf_change(pdf_path, username, chat_id, pdf_loaded_state) This funtion uploads the user selected PDF and updates the UI state to enable PDF usage if the upload is successful.

```
def on_pdf_change(pdf_path, username, chat_id, pdf_loaded_state):

    status_msg = upload_pdf(pdf_path, username, chat_id)
    if "Successfully uploaded PDF" in status_msg or "already processed" in status_msg:
        # success => enable PDF usage
        return (
            status_msg,
            True,
            gr.update(value=True, interactive=True),
            gr.update(value=False, interactive=False),
            chat_id if chat_id else str(uuid.uuid4())
        )
    else:
        return (
            status_msg,
            False,
            gr.update(),
            gr.update(),
            chat_id
        )
```

on_tax_optimize_change The funtion adjusts the tax optimization setting and toggles the PDF context interactivity based on the tax value.

```
def on_tax_optimize_change(tax_value, pdf_status, use_pdf_context):

    if tax_value:
        return (
            "",
            gr.update(value=False, interactive=False)
        )
    else:
```

```
        # User toggled it off => we will keep whatever the pdf_status is, but re-enable pdf_co
        # We'll manage actual enabling in the next step if PDF is loaded
        return (pdf_status, gr.update(interactive=True))

def on_use_pdf_change(pdf_context_value, pdf_status, tax_opt):
    if pdf_context_value:
        return (
            pdf_status,
            gr.update(value=False, interactive=False, info="First remove the PDF to use this")
        )
    else:
        return (
            pdf_status,
            gr.update(interactive=True, info="Uses our database to refine your result.")
        )
```

on_use_pdf_change This function checks whether the PDF context is already active.

```
def on_use_pdf_change(pdf_context_value, pdf_status, tax_opt):
    if pdf_context_value:
        return (
            pdf_status,
            gr.update(value=False, interactive=False, info="First remove the PDF to use this")
        )
    else:
        return (
            pdf_status,
            gr.update(interactive=True, info="Uses our database to refine your result.")
        )
```

on_pdf_loaded_change This function updates the UI based on whether a PDF is loaded.

```
def on_pdf_loaded_change(pdf_loaded, current_use_pdf_value):
    if pdf_loaded:
        return gr.update(
            interactive=True,
            info="PDF is ready to provide context!"
        )
    else:
        return gr.update(
            value=False,
            interactive=False,
            info="Select and upload a PDF first."
        )
```

1.9.6 Interface Building

`build_interface()` The Gradio interface is constructed using Gradio Blocks. It comprises inputs for the username, model selection, and PDF file uploads, along with a chat window and checkboxes for enabling PDF context or tax optimization. Additionally, buttons for refreshing sessions, loading chats, and sending messages are provided.

```
def build_interface():
    with gr.Blocks(
        theme="IBM_Carbon_Theme",
        title="Tax & Legal Chat"
    ) as demo:

        gr.Markdown(
            """
<div style="text-align:center; margin-bottom:20px;">
    <h1 style="margin-bottom:0.2em;">TaxSense: Automated Filing Assistant</h1>
    <p>By <a href="https://github.com/zainnobody">Zain Ali</a>, <a href="https://github.com/hal
        This system can help you with IRS tax filing guidance <em>and</em> general documents.<b
        Upload a PDF to provide custom context, or simply chat about any topic.
    </p>
</div>
            """,
            elem_id="header_centered"
        )

        with gr.Row():

            with gr.Column(scale=1):
                gr.Markdown("### Sessions")
                username = gr.Textbox(label="Username", value="zain", interactive=True)

                load_sessions_btn = gr.Button("Refresh Session List")
                chat_sessions_dropdown = gr.Dropdown(label="Existing Sessions", choices=[], int
                load_chat_btn = gr.Button("Load Selected Chat")

                gr.Markdown("---")
                new_chat_btn = gr.Button("New Chat", variant="secondary")

                gr.Markdown("---")
                gr.Markdown("### PDF Upload (auto-index)")

                pdf_input = gr.File(label="Select PDF", type="filepath")
                pdf_status = gr.Markdown()
```

```
with gr.Column(scale=3):
    pdf_loaded_state = gr.State(False)

    with gr.Row():
        selected_model = gr.Dropdown(
            label="Select Model",
            choices=MODEL_OPTIONS,
            value=DEFAULT_MODEL,
            interactive=True
        )
        max_tokens_box = gr.Number(
            label="Max Tokens",
            value=200,
            precision=0
        )
        chat_id_box = gr.Textbox(
            label="Chat ID (auto-generated on 1st message)",
            value="",
            interactive=True
        )

    chatbot = gr.Chatbot(label="Conversation", type="tuples")

    user_input = gr.Textbox(
        label="Your Message:",
        placeholder="Ask any question, or get help with your doc..."
    )

    with gr.Row():
        use_pdf_context = gr.Checkbox(
            label="Use PDF context",
            value=False,
            interactive=False,
            info="Select and upload a PDF first."
        )
        tax_optimize = gr.Checkbox(
            label="Tax Optimize (Pinecone)",
            value=False,
            interactive=True,
            info="Uses our database to refine your result."
        )
    with gr.Row():
        thumbs_up_btn = gr.Button("  Thumbs Up")
        thumbs_down_btn = gr.Button("  Thumbs Down")
        feedback_status = gr.Markdown("")
    send_btn = gr.Button("Send", variant="primary")

    chat_history_state = gr.State([])
```

```
load_sessions_btn.click(
    fn=refresh_sessions,
    inputs=[username],
    outputs=chat_sessions_dropdown
)
load_chat_btn.click(
    fn=load_selected_chat_from_dropdown,
    inputs=[chat_sessions_dropdown],
    outputs=[chatbot, chat_id_box]
).then(
    fn=lambda x: x,
    inputs=[chatbot],
    outputs=[chat_history_state]
)
new_chat_btn.click(
    fn=new_chat,
    inputs=[],
    outputs=[chatbot, chat_id_box]
).then(
    fn=lambda: [],
    inputs=[],
    outputs=[chat_history_state]
)
pdf_input.change(
    fn=on_pdf_change,
    inputs=[pdf_input, username, chat_id_box, pdf_loaded_state],
    outputs=[pdf_status, pdf_loaded_state, use_pdf_context, tax_optimize, chat_id_box]
)

tax_optimize.change(
    fn=on_tax_optimize_change,
    inputs=[tax_optimize, pdf_status, use_pdf_context],
    outputs=[pdf_status, use_pdf_context]
)

use_pdf_context.change(
    fn=on_use_pdf_change,
    inputs=[use_pdf_context, pdf_status, tax_optimize],
    outputs=[pdf_status, tax_optimize]
)
pdf_loaded_state.change(
    fn=on_pdf_loaded_change,
    inputs=[pdf_loaded_state, use_pdf_context],
    outputs=use_pdf_context
)

send_btn.click(
```

```
        fn=generate_chat_response,
        inputs=[
            user_input,
            chat_history_state,
            username,
            chat_id_box,
            selected_model,
            use_pdf_context,
            tax_optimize,
            max_tokens_box
        ],
        outputs=[
            user_input,
            chatbot,
            chat_id_box
        ]
    )

    thumbs_up_btn.click(
        fn=send_feedback,
        inputs=[
            gr.State("UP"),
            chat_history_state,
            username,
            chat_id_box,
            use_pdf_context,
            tax_optimize
        ],
        outputs=[feedback_status]
    )

    thumbs_down_btn.click(
        fn=send_feedback,
        inputs=[
            gr.State("DOWN"),
            chat_history_state,
            username,
            chat_id_box,
            use_pdf_context,
            tax_optimize
        ],
        outputs=[feedback_status]
    )


return demo
```

1.10 Admin Data Backup & Sync Service

The code of this part is stored in `admin.py`.

Due to issues with our AWS setup, we developed this script to address file inconsistencies. Now running as a dedicated service, it serves as both a backup solution and a parallel tool for our data pipeline. The admin script offers endpoints for zipping and unzipping critical directories and files, as well as for pushing data to and pulling data from an Amazon S3 bucket.

1.10.1 Authentication & Initial Variables

`token_required(f)` A decorator that checks for a valid token before processing any request.

```
def token_required(f):
    @wraps(f)
    def decorated_function(*args, **kwargs):
        token = None
        auth_header = request.headers.get("Authorization")
        if auth_header:
            parts = auth_header.split()
            if len(parts) == 2 and parts[0].lower() == "bearer":
                token = parts[1]
        if not token:
            token = request.args.get("token")
        if token != DEMO_TOKEN:
            return jsonify({"error": "Unauthorized: Invalid or missing token"}), 401
        return f(*args, **kwargs)
    return decorated_function
```

1.10.2 Constants

- **DEMO_TOKEN:** Demo token used by our current system
- **DATA_DIRECTORIES:** These are the dir that will be copied to S3 and the information will be copied from the S3 to in these.
- **DATA_FILES:** List of individual files synced with S3 (e.g., `"chat_sessions.db"`).
- **MODEL_DATA_DIR:** Model directory, if we want to push the models to S3 as well.

1.10.3 MD5 Hash Computation Helpers

`compute_md5_bytes(data_bytes)` Computes the MD5 hash for a given byte sequence.

```
def compute_md5_bytes(data_bytes):
    return hashlib.md5(data_bytes).hexdigest()
```

`compute_md5_file(filepath)` Calculates the MD5 hash for a file by reading it in chunks.

```
def compute_md5_file(filepath):
    hash_md5 = hashlib.md5()
    with open(filepath, "rb") as f:
        for chunk in iter(lambda: f.read(4096), b""):
```

```
            hash_md5.update(chunk)
    return hash_md5.hexdigest()
```

1.10.4 Data Zipping & Unzipping

zip_all_data(include_model_data=False) Creates an in-memory ZIP archive of all directories and files defined. Optionally includes model data.

```
def zip_all_data(include_model_data=False):
    mem_zip = io.BytesIO()
    with zipfile.ZipFile(mem_zip, "w", zipfile.ZIP_DEFLATED) as zf:
        for label, dir_path in DATA_DIRECTORIES.items():
            if os.path.isdir(dir_path):
                for root, _, files in os.walk(dir_path):
                    for file in files:
                        full_path = os.path.join(root, file)
                        arcname = os.path.relpath(full_path, ".")
                        zf.write(full_path, arcname)
        for file in DATA_FILES:
            if os.path.exists(file):
                zf.write(file, file)
        if include_model_data and os.path.isdir(MODEL_DATA_DIR):
            for root, _, files in os.walk(MODEL_DATA_DIR):
                for file in files:
                    full_path = os.path.join(root, file)
                    arcname = os.path.relpath(full_path, ".")
                    zf.write(full_path, arcname)
    mem_zip.seek(0)
    return mem_zip
```

zip_data_endpoint() A GET endpoint (`/admin/zip_data`) that returns a ZIP backup. It accepts an `include_model_data` parameter to include model files.

```
@app.route("/admin/zip_data", methods=["GET"])
@token_required
def zip_data_endpoint():
    include_model = request.args.get("include_model_data", "false").lower() == "true"
    zip_file = zip_all_data(include_model)
    filename = "data_backup.zip"
    return send_file(
        zip_file,
        mimetype="application/zip",
        as_attachment=True,
        download_name=filename
    )
```

unzip_data_endpoint() A POST endpoint (`/admin/unzip_data`) that accepts an uploaded ZIP file, extracts its contents, and updates files if their MD5 hashes differ.

```
@app.route("/admin/unzip_data", methods=["POST"])
@token_required
def unzip_data_endpoint():
    if "file" not in request.files:
        return jsonify({"error": "No file provided"}), 400
    file_obj = request.files["file"]
    try:
        with zipfile.ZipFile(file_obj) as zf:
            files_updated = 0
            files_skipped = 0
            for zip_info in zf.infolist():
                extracted_path = os.path.join(".", zip_info.filename)
                os.makedirs(os.path.dirname(extracted_path), exist_ok=True)
                file_bytes = zf.read(zip_info.filename)
                new_md5 = compute_md5_bytes(file_bytes)
                if os.path.exists(extracted_path):
                    local_md5 = compute_md5_file(extracted_path)
                    if local_md5 == new_md5:
                        files_skipped += 1
                        continue
                with open(extracted_path, "wb") as f:
                    f.write(file_bytes)
                files_updated += 1
        return jsonify({
            "message": "Unzip completed",
            "files_updated": files_updated,
            "files_skipped": files_skipped
        })
    except Exception as e:
        return jsonify({"error": str(e)}), 500
```

1.10.5 S3 Upload (Push) Operations

upload_file_to_s3(s3_client, bucket_name, local_path, s3_key) Uploads a file to S3 if the local MD5 hash differs from the remote file's MD5 (stored in metadata). Returns `True` if uploaded.

```
def upload_file_to_s3(s3_client, bucket_name, local_path, s3_key):
    local_md5 = compute_md5_file(local_path)
    try:
        response = s3_client.head_object(Bucket=bucket_name, Key=s3_key)
        remote_md5 = response.get("Metadata", {}).get("md5hash", "")
        if remote_md5 == local_md5:
            return False
    except s3_client.exceptions.ClientError:
        pass
    s3_client.upload_file(
        Filename=local_path,
```

```
        Bucket=bucket_name,
        Key=s3_key,
        ExtraArgs={"Metadata": {"md5hash": local_md5, "last_modified": datetime.datetime.utcnow
    )
    return True
```

upload_directory(s3_client, bucket_name, local_dir, s3_prefix="") Walks through a local directory and uploads files to S3 using the above function, returning counts of files uploaded and skipped.

```
def upload_directory(s3_client, bucket_name, local_dir, s3_prefix=""):
    files_uploaded = 0
    files_skipped = 0
    for root, _, files in os.walk(local_dir):
        for file in files:
            local_path = os.path.join(root, file)
            rel_path = os.path.relpath(local_path, ".")
            s3_key = os.path.join(s3_prefix, rel_path).replace("\\", "/")
            if upload_file_to_s3(s3_client, bucket_name, local_path, s3_key):
                files_uploaded += 1
            else:
                files_skipped += 1
    return files_uploaded, files_skipped
```

push_to_s3_endpoint() An endpoint (`/admin/push_s3`) that pushes all configured directories and files to the S3 bucket `"tax-legal-data"`. It creates the bucket if needed and returns counts of uploads and skips.

```
@app.route("/admin/push_s3", methods=["GET"])
@token_required
def push_to_s3_endpoint():
    include_model = request.args.get("include_model_data", "false").lower() == "true"
    bucket_name = "tax-legal-data"
    s3_client = boto3.client("s3")
    try:
        s3_client.head_bucket(Bucket=bucket_name)
    except s3_client.exceptions.ClientError:
        try:
            s3_client.create_bucket(Bucket=bucket_name)
        except Exception as e:
            return jsonify({"error": f"Failed to create bucket: {str(e)}"}), 500
    total_uploaded = 0
    total_skipped = 0
    for label, dir_path in DATA_DIRECTORIES.items():
        if os.path.isdir(dir_path):
            uploaded, skipped = upload_directory(s3_client, bucket_name, dir_path, s3_prefix="
            total_uploaded += uploaded
            total_skipped += skipped
```

```
    for file in DATA_FILES:
        if os.path.exists(file):
            if upload_file_to_s3(s3_client, bucket_name, file, file):
                total_uploaded += 1
            else:
                total_skipped += 1
    if include_model and os.path.isdir(MODEL_DATA_DIR):
        uploaded, skipped = upload_directory(s3_client, bucket_name, MODEL_DATA_DIR, s3_prefix=
        total_uploaded += uploaded
        total_skipped += skipped
    return jsonify({
        "message": "Push to S3 completed",
        "files_uploaded": total_uploaded,
        "files_skipped": total_skipped,
        "bucket": bucket_name
    })
```

1.10.6 S3 Download (Pull) Operations

pull_directory_from_s3(s3_client, bucket_name, local_root) Downloads files from the specified S3 bucket into a local directory. It uses MD5 comparisons to skip files that are already up-to-date.

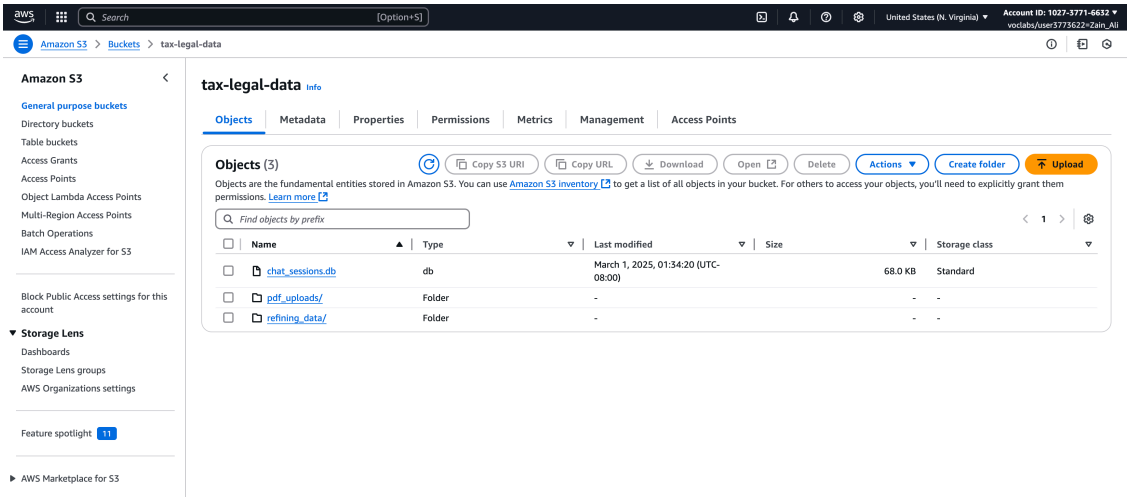
```
def pull_directory_from_s3(s3_client, bucket_name, local_root):
    os.makedirs(local_root, exist_ok=True)
    paginator = s3_client.get_paginator("list_objects_v2")
    pages = paginator.paginate(Bucket=bucket_name)
    files_downloaded = 0
    files_skipped = 0
    for page in pages:
        for obj in page.get("Contents", []):
            key = obj["Key"]
            local_path = os.path.join(local_root, key)
            os.makedirs(os.path.dirname(local_path), exist_ok=True)
            try:
                head = s3_client.head_object(Bucket=bucket_name, Key=key)
                remote_md5 = head.get("Metadata", {}).get("md5hash", "")
            except Exception as e:
                remote_md5 = ""
            if os.path.exists(local_path):
                local_md5 = compute_md5_file(local_path)
                if local_md5 == remote_md5:
                    files_skipped += 1
                    continue
            s3_client.download_file(bucket_name, key, local_path)
            files_downloaded += 1
    return files_downloaded, files_skipped
```

`pull_from_s3_endpoint()` Endpoint that downloads data from the S3 bucket `"tax-legal-data"` into a local folder (default `"s3_data"`). It returns the number of files downloaded and skipped.

```
@app.route("/admin/pull_s3", methods=["GET"])
@token_required
def pull_from_s3_endpoint():
    bucket_name = "tax-legal-data"
    local_root = request.args.get("local_root", "s3_data")
    s3_client = boto3.client("s3")
    try:
        s3_client.head_bucket(Bucket=bucket_name)
    except s3_client.exceptions.ClientError as e:
        return jsonify({"error": f"Bucket {bucket_name} does not exist: {str(e)}"}), 404
    downloaded, skipped = pull_directory_from_s3(s3_client, bucket_name, local_root)
    return jsonify({
        "message": "Pull from S3 completed",
        "local_root": local_root,
        "files_downloaded": downloaded,
        "files_skipped": skipped,
        "bucket": bucket_name
    })
```

For `admin.py`, we tested each endpoint. See the Final Admin Endpoints Testing Report of it `further-docs`. Also, here is what our S3 looked like while running TaxSense.

```
[ ]: display(Image.open("supporting_media/S3-screenshot.png"))
```



1.11 Final Notes

TaxSense integrates a fine-tuned language model with Retrieval-Augmented Generation for accurate tax guidance. It securely stores chats, retrieves context from PDFs, and leverages Pinecone for

external IRS data. The Gradio-based frontend provides a user-friendly dashboard, while a Flask-based backend manages model inference and data storage. Automated backups to AWS S3 are handled by our admin service.

For details on setup, deployment (including Docker), and usage, see the `README.md`. A demo video is also available there, showing you how to run and interact with the system step-by-step.