



RAG for Schools

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Core Motivation



Educational Accessibility and Engagement: Our primary drive is to make education more accessible and engaging, particularly for students following diverse academic programs like O and A levels, Edexcel, and other local and foreign examination boards.

Adaptability in Education: We recognize the importance of educational resources adapting to the individual needs of each student, which aligns with the belief that education is a fundamental right.

Inclusion and Diversity in Learning: Our project emphasizes inclusivity, aiming to cater to students with different learning preferences and abilities, including those with visual and auditory impairments.

Conversion of Knowledge to Urdu: We aim to convert all knowledge into Urdu for the underprivileged people of Pakistan and ensure that the subject knowledge is accessible to people of all classes.



Project Aims and Features:



Question Answering Chatbot:

Designed to assist students in learning from their specific examination syllabus.

An alternative to generic knowledge platforms, providing syllabus-focused assistance.



Text to Speech Conversion:

A feature to aid visually impaired students, allowing them to learn audibly.

All content will be converted to audio in both English and Urdu, catering to diverse linguistic needs.



Language Translation:

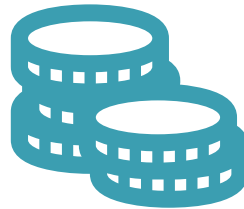
An additional feature to translate all content to Urdu, enabling better understanding for Urdu-speaking students.



Subjects Aimed



History – O and A
Levels



Economics – O and
A Levels



Computer Science –
O and A Levels



User Pipeline

User enters the subject

- Taken to the subject RAG

User enters the level (O or A Level)

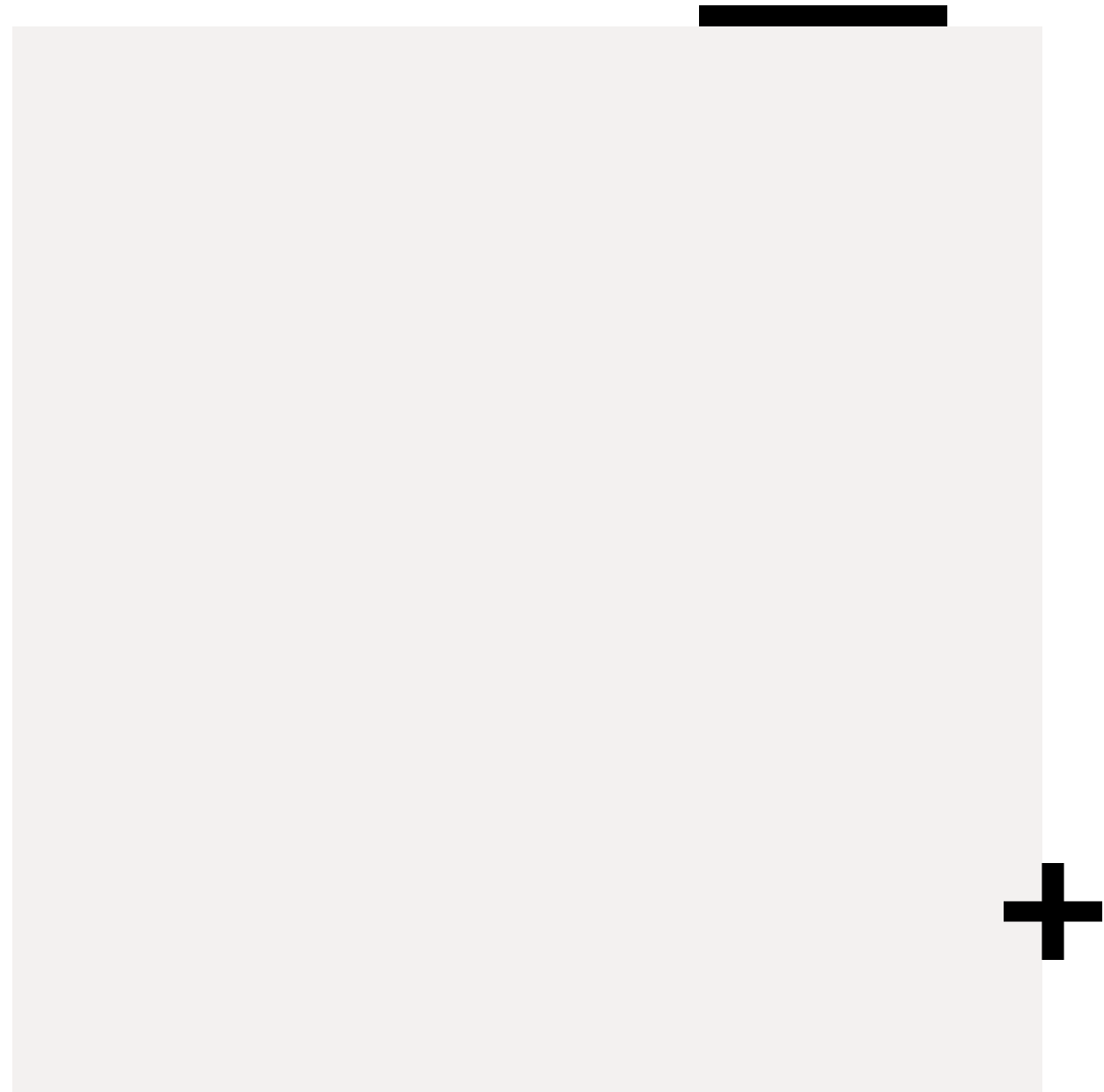
- Taken to the level based RAG (sources different)


User asks a question within the scope of the level chosen

- Answer generation+ evaluation



RAG Architecture



A photograph of a room undergoing renovation. A wooden A-frame ladder stands against a wall where the wallpaper is being removed. The floor is covered with a large pile of torn, yellowed, and crumpled wallpaper. A dark grey semi-transparent banner is overlaid on the upper half of the image, containing the text 'How was the RAG built?'. On the right side of the banner, there is a small white horizontal line above a white plus sign.

How was the RAG
built?

Data Preparation



Data Source: O Level and A Level books on History , Computer Science and Economics.



PDF books have been converted into text files.



Pictures and graphs are currently excluded, with our focus solely on the textual content.

Link for All Subject Sources

: https://drive.google.com/drive/folders/1vwyxMqoXIkV6_-Q6q0OdpFu1dp3nomZ1?usp=sharing

Links for Data Sources



DATA PROCESSING



Text Extraction



Extracted text from a PDF file.



Saved the extracted text to a file.



Used the pdfminer library for PDF text extraction.



Specified the current directory and PDF filename.



Utilized the os module for file path manipulation.





Text Processing

Processed text files within a specified folder path.

Tokenized text into sentences.

Cleaned each sentence by removing punctuation and irrelevant characters.

Converted cleaned sentences to lowercase and tokenized them.

Removed stopwords from the tokenized sentences.

Returned a nested list containing tokenized sentences for each text file processed.



Word Embeddings

 Attempted to load the "word2vec-google-news-300" model using **gensim.downloader**.

 Saved the loaded model to Google Drive in the specified directory.

 Imported **KeyedVectors** from **gensim.models** to load the model from Google Drive.

 Loaded the saved model from Google Drive using **KeyedVectors.load**.

 Utilized **mmap='r'** parameter to load the model in read-only mode for efficient memory usage.



Pinecone Vector DB

Connection to Pinecone: The script starts by connecting to the Pinecone service using an API key.

Batch Processing: Sentences are divided into batches of 2250, with each batch corresponding to a unique index that is created if it does not already exist.

Index Handling: The script manages index retrieval with retries, introducing delays between attempts if the initial retrieval fails.

Vector Generation and Upserting: Each sentence in the batch is converted into a unique vector associated with a vector ID and metadata. These vectors are then upserted into the Pinecone index in sub-batches of 1000 to manage load efficiently.

Index Name Storage: All index names are saved to a specified file path on Google Drive.

Mapping Vectors to Sentences: A dictionary mapping vector IDs to their corresponding sentences is serialized and stored in a pickle file.

Loading and Querying: The script includes functionality to load existing index names and the vector-sentence map from files, allowing for the querying of relevant sentences based on their vector representation.

Index Specifications: Each index uses a cosine metric, has a dimension of 300, and is hosted on AWS.

Using Pinecone to Store Vectors: Pinecone is utilized to store the vectors, and each index can hold up to 2250 sentence vectors.



Matches from Pinecone

Original Sentence: Turkey: The Treaty of Sevres, 1920
This Treaty was signed in August 1920., Distance: 0.844331682, Metadata: {'index': 618.0}
Original Sentence: Some said the Treaty was unfair!, Distance: 0.828295708, Metadata: {'index': 486.0}
Original Sentence: The Treaty was universally resented., Distance: 0.826934397, Metadata: {'index': 427.0}
Original Sentence: 1 Does he think the Treaty is fair?, Distance: 0.822087, Metadata: {'index': 126.0}
Original Sentence: This was quite legal under the Treaty of Versailles., Distance: 0.814951539, Metadata: {'index': 449.0}
Original Sentence: The new organisation, formed
in April 1949, was known as NATO (North Atlantic Treaty Organization)., Distance: 0.675864279, Metadata: {'index': 2631.0}

Original Sentence: Why do you
think Hungary's membership of the Warsaw Pact was so
important to the Soviet Union?, Distance: 0.661514521, Metadata: {'index': 3799.0}

History

Original Sentence: So when the
resolution was passed, the USSR was not even at the meeting so could not
use its veto., Distance: 0.637894869, Metadata: {'index': 2774.0}
Original Sentence: This has caused much debate as to what Khrushchev was really doing., Distance: 0.614022195, Metadata: {'index': 3105.0}
Original Sentence: The letter
claimed that the missiles on Cuba were purely defensive, but went on: 'If
assurances were given that the USA would not participate in an attack on
Cuba and the blockade was lifted, then the question of the removal or the
destruction of the missile sites would be an entirely different question.' This
was the first time Khrushchev had admitted the presence of the missiles., Distance: 0.610124588, Metadata: {'index': 3082.0}
Original Sentence: For example:

What were Germany's main territorial losses under the Treaty of
Versailles?, Distance: 0.759598851, Metadata: {'index': 5025.0}
Original Sentence: 'The Treaty of Versailles was a fair settlement. How can you
agree with this statement?', Distance: 0.754294813, Metadata: {'index': 5068.0}
Original Sentence: The Treaty was a severe blow to Russia. Distance: 0.728753865, Metadata: {'index': 631.0}
Original Sentence: This paragraph gives reasons why historians or people at
the time might argue the Treaty was unfair., Distance: 0.719790101, Metadata: {'index': 5098.0}
Original Sentence: There are many arguments to support the view that the Treaty of
Versailles was a fair settlement., Distance: 0.712795556, Metadata: {'index': 5080.0}
Original Sentence: • What was the impact of the Treaty of Versailles on the Republic?, Distance: 0.812265158, Metadata: {'index': 7240.0}
Original Sentence: The Treaty of Versailles
The biggest crisis for the new republic came in May 1919 when the terms of
the Treaty of Versailles were announced. Distance: 0.772188485, Metadata: {'index': 7363.0}

query sentence = "What was
the Treaty of Versailles?"

Relevancy

Economics

Filtering out Irrelevant outputs



Filtered out irrelevant responses by selecting matches with scores higher than a predefined **threshold (0.65)**, ensuring that only relevant matches, based on their **similarity scores**, are considered for further processing

```
Original Sentence: 421271_IGCSE_Economics_2e_Sec-04.indd 225 24/01/18 11:19 AM 31 infla Tion and defla Tion 226Policies to control inflation and  
Original Sentence: the inflation rate is negative., Similarity Score: 0.661850631, Metadata: {'index': 3526.0}  
Original Sentence: Economic growth versus stable prices A cut in interest rates or an increase in the money supply in order to stimulate econo  
Original Sentence: » Risk of inflation – if the economy grows due to excessive demand, there is the danger of demand-pull inflation (see Chapt  
Original Sentence: Cost-push inflation can also occur because full employment makes it harder for firms to attract skilled labour, and this can  
Original Sentence: [2] b Using a demand and supply diagram, explain why reduced harvests caused avocado prices to reach a record high in 2017.  
Original Sentence: How many examples of Chapter review questions 1 What is meant by price elasticity of demand (PED) and how is it calculated?  
Original Sentence: Hence, if demand is price inelastic, firms will tend to raise prices to increase sales revenue., Similarity Score: 0.586887  
Original Sentence: 2 Using demand theory, explain why there is such a difference., Similarity Score: 0.578406036, Metadata: {'index': 594.0}  
Original Sentence: there are shortages or surpluses.Excess demand refers to a situation where the market price is below the equilibrium price,
```

```
Original Sentence: 421271_IGCSE_Economics_2e_Sec-04.indd 225 24/01/18 11:19 AM  
31 infla Tion and defla Tion  
226Policies to control inflation and deflation  
Inflation can be controlled by using macroeconomic policies to slow down the  
growth of demand in the economy and/or boost the rate of growth of the economy's overall supply of goods and services., Distance: 0.696607947,  
Original Sentence: the inflation rate is negative., Distance: 0.661850631, Metadata: {'index': 3526.0}  
Original Sentence: Economic growth versus stable prices  
A cut in interest rates or an increase in the money supply in order to stimulate economic growth can conflict with other macroeconomic objecti  
Original Sentence: » Risk of inflation – if the economy grows due to excessive demand, there is the danger of demand-pull inflation (see Chapt
```



Relevancy

Removing Duplicates



It keeps track of **seen sentences** to **avoid duplicate** entries and stores relevant sentences in the `result_sentences` list.

```
Original Sentence: Definition
Opportunity cost is the cost
of the next best opportunity forgone when making a decision.By the end of this chapter, students should be able to:
★ define and provide examples of opportunity cost
★ understand the influence of opportunity cost on decision making., Distance: 0.737483203, Metadata: {'index': 315.0}
Original Sentence: Definition
Opportunity cost is the cost
of the next best opportunity forgone when making a decision.By the end of this chapter, students should be able to:
★ define and provide examples of opportunity cost
★ understand the influence of opportunity cost on decision making., Distance: 0.737483203, Metadata: {'index': 66.0}
Original Sentence: ✓ Opportunity cost is the cost of the next best opportunity forgone when
making a decision., Distance: 0.719081581, Metadata: {'index': 344.0}
Original Sentence: Opportunity cost is the cost of the next best opportunity forgone (given up) when making economic decisions., Distance: 0.7
Original Sentence: Opportunity cost is the cost of the next best opportunity forgone (given up) when making economic decisions., Distance: 0.7
Original Sentence: Shoe leather costs therefore represent an opportunity cost for customers., Distance: 0.643439829, Metadata: {'index': 3626
Original Sentence: Discuss with a
partner the reasons why certain customers would be willing to pay such a high price for one of these goods., Distance: 0.618616104, Metadata:
Original Sentence: the total cost of making one product., Distance: 0.611700773, Metadata: {'index': 2492.0}
```

```
Original Sentence: Definition
Opportunity cost is the cost
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Original Sentence: Discuss with a
partner the reasons why certain customers would be willing to pay such a high price for one of these goods., Distance: 0.618616104, Metadata:
Original Sentence: the total cost of making one product., Distance: 0.611700773, Metadata: {'index': 2492.0}
```



Relevancy

Semantic Matching and Ranking

Match: The law of diminishing marginal utility suggests that as consumption of a good increases, the marginal utility will get smaller. Two important implications of this law are that the marginal utility of a good is zero, and the marginal utility of a good is negative. This is an example of the principle or law of diminishing marginal utility where marginal utility is the additional utility that is derived from the consumption of an additional unit of a good. Match: EXAM-STYLE QUESTIONS: MULTIPLE CHOICE The marginal utility of a good is zero., Cosine Similarity Score: 0.20205290091905262



Preprocessed and transformed sentences and the query into TF-IDF vectors using a scikit-learn pipeline.



Calculated cosine similarity scores to measure the similarity between the query and each sentence.



Sorted the sentences based on their similarity scores for efficient retrieval.



Presented the sorted matches and their similarity scores for easy interpretation.



Relevancy BM25 Ranking

All subjects



Filtering Non-Question Sentences: The script initially includes functionality to filter out non-question sentences from search results, but this part is commented out. This can be useful if focusing specifically on question-type responses.



Tokenization: All sentences from the search results are tokenized to prepare for BM25 ranking.



BM25 Initialization: BM25Okapi, a ranking function from the BM25 family, is initialized with the tokenized sentences. BM25 is effective for ranking documents based on the query terms present in each document.



Scoring with BM25: The script processes a query by tokenizing it and then computes BM25 scores for all the results based on their relevance to the query.



Sorting and Displaying Results: The results along with their BM25 scores are sorted in descending order (highest score first) to prioritize more relevant sentences. Each match is printed alongside its BM25 score, providing a clear view of the relevance of each result to the query.

BM 25 Results

History

Match	BM25 Score
For example: What were Germany's main territorial losses under the Treaty of Versailles?	6.54
• What was the impact of the Treaty of Versailles on the Republic?	4.9
FOCUS TASK 9.3 What was the impact of the Treaty of Versailles on the Republic?	4.66
What was the boom?	3.91
What was the boom?	3.91
This was quite legal under the Treaty of Versailles.	3.17
There are many arguments to support the view that the Treaty of Versailles was a fair settlement.	2.75
Some said the Treaty was unfair!	2.66
The Treaty of Versailles	2.63
The biggest crisis for the new republic came in May 1919 when the terms of the Treaty of Versailles were announced.	
See if you agree that the Treaty of Versailles was responsible for economic problems in Germany.	2.54
Turkey: The Treaty of Sevres, 1920	2.36
This Treaty was signed in August 1920.	
An example of an extended answer question that draws from Key Question A might be:	2.25
How important was the Treaty of Versailles as a reason for instability in the early Weimar Republic?	
Treaty of Brest-Litovsk Treaty between Germany and Russia in 1918 which ended war between the two.	2.18
Why do you think Hungary's membership of the Warsaw Pact was so important to the Soviet Union?	2.13
This paragraph gives reasons why historians or people at the time might argue the Treaty was unfair.	2.13
The letter claimed that the missiles on Cuba were purely defensive, but went on: 'If assurances were given that the USA would not participate in an attack on	2.11

1	For example: What were Germany's main territorial losses under the Treaty of Versailles?	6.54
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S.No	Match	BM25 Score
2	• What was the impact of the Treaty of Versailles on the Republic?	4.9

S.No	Match	BM25 Score
3	FOCUS TASK 9.3 What was the impact of the Treaty of Versailles on the Republic?	4.66

S.No	Match	BM25 Score
4	What was the boom?	3.91

History

Large Language Models

All subjects



Llama 3 – (Meta-llama-3-70b-instruct) (Replicate)



Mistral v2 – (Mistral-7B-Instruct-v0.2) (Hugging Face)



Falcon – (Falcon-40b-instruct) (Replicate)

Generation Using LLMS

Setting Environment Variable: The script sets the Hugging Face API token as an environment variable, which is necessary for authenticated API calls to Hugging Face services.

Initializing Text Generation Pipeline: It initializes a text generation pipeline using the 'Mistral-7B-Instruct-v0.2' model from Mistral AI. This model is typically used for generating text that adheres to specific instructions or contexts.

Generating Text: The script uses the highest-ranked sentence from the previous BM25 scoring as a basis for generating a new response. The prompt for the model includes instructions to generate a detailed analysis in paragraph form, specific to the Cambridge IGCSE and O Level History syllabus. The inclusion of a conclusion template helps in structuring the generated response appropriately.

Outputting Generated Text: Finally, the script prints the generated responses. Each response is expected to be a comprehensive answer based on the top sentence derived from your BM25 results, formatted according to your specified instructions.

mistralai/Mistral-7B-Instruct-v0.2

History



Gradio App



Retrieval-Augmented Generation for History

This app uses a retrieval-augmented generation model to generate responses based on historical data.

query

What was the Treaty of Versailles?

Clear Submit

output

The Treaty of Versailles, signed on June 28, 1919, marked the end of World War I and brought significant changes to the political landscape of Europe. The treaty imposed heavy reparations on Germany, which led to economic instability and political unrest. This instability contributed to the rise of the Nazi Party and ultimately the outbreak of World War II.

Regarding the impact of the Treaty of Versailles on the Republic, it is essential to understand that the treaty created a hostile environment towards the German government and people. The harsh terms of the treaty, including the payment of reparations, the loss of territory, and the military restrictions, created widespread resentment and anger among the German population. This resentment fueled the rise of extremist political parties, such as the Nazi Party, who promised to restore German pride and power.

Furthermore, the economic instability caused by the treaty exacerbated the political unrest in the Republic. The reparations payments required by the treaty put a significant strain on the German economy, leading to hyperinflation and economic collapse. This economic instability created an environment in which extremist political parties could thrive, as the population became disillusioned with the governments inability to address their economic and political concerns.

Retrieval-Augmented Generation for History

This app uses a retrieval-augmented generation model to generate responses based on historical data.

query

What was the Spanish Civil War about?

Clear

Submit

output

The League of Nations, established in the aftermath of the First World War, was intended to be a powerful international organization that would prevent future wars and promote peace and cooperation among nations. However, the League's failure to address major crises, such as the Italian invasion of Abyssinia and the Spanish Civil War, undermined its credibility and effectiveness.

The sentence However, all he saw at the League was its lack of action over Abyssinia and the Spanish Civil War highlights the disappointment and frustration felt by many observers towards the League of Nations. The League's inability to prevent or intervene in these conflicts demonstrated its limitations and weaknesses. The Italian invasion of Abyssinia, also known as the Second ItaloAbyssinian War, began in 1935 when Italy, under the leadership of Benito Mussolini, invaded the independent African state of Abyssinia presentday Ethiopia. Despite the League's condemnation of the invasion and the imposition of economic sanctions against Italy, the League was unable to stop the invasion or force Italy to withdraw its troops. The League's failure to protect the sovereignty of Abyssinia was a significant blow to its reputation and credibility.

Similarly, the Spanish Civil War, which began in 1936, was another major crisis that the League of Nations was unable to resolve. The war was fought between the Nationalists, led

Retrieval-Augmented Generation for History Option B (0470/0977/2147)

This app uses a retrieval-augmented generation model to generate responses for the Cambridge IGCSE, IGCSE 9-1 and O Level syllabuses (0470/0977/2147) for examinations from 2020.

Enter your question

What was the Treaty of Versailles?

Response

The Treaty of Versailles, signed on June 28, 1919, marked the end of World War I and brought significant changes to the political landscape of Europe. The treaty imposed heavy reparations on Germany, which led to economic instability and political unrest. This instability contributed to the rise of the Nazi Party and ultimately the outbreak of World War II.

Regarding the impact of the Treaty of Versailles on the Republic, it is essential to understand that the treaty created a hostile environment towards the German government and people. The harsh terms of the treaty, including the payment of reparations, the loss of territory, and the military restrictions, created widespread resentment and anger among the German population. This resentment fueled the rise of extremist political parties, such as the Nazi Party, who promised to restore German pride and power.

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Information Panel

This area can provide additional info or be styled further as needed.



Retrieval-Augmented Generation for History Option B (0470/0977/2147)

This app uses a retrieval-augmented generation model to generate responses for the Cambridge IGCSE, IGCSE 9-1 and O Level syllabuses (0470/0977/2147) for examinations from 2020.

Enter your question

Who was to blame for the Cold War?

Response

The origins of the Cold War are a subject of ongoing debate among historians, and the question of who was to blame for its onset remains a contentious issue. While some argue that the actions of the United States and the Soviet Union were equally responsible, others point to specific instances where one side or the other bears greater culpability.

The Soviet Union, under the leadership of Joseph Stalin, had long harbored suspicions of Western intentions towards the Soviet Union. Stalin's paranoia was fueled by a series of events, including the refusal of the United States and Great Britain to honor their commitments to the Soviet Union during and after World War II. For instance, the Tehran and Yalta conferences, where the Allied leaders made promises to Stalin regarding Soviet influence in Eastern Europe, ultimately failed to materialize. Instead, the United States and Great Britain supported the establishment of capitalist governments in Eastern Europe, which the Soviet Union saw as a direct threat to its security.

However, it is also important to note that the United States, under the leadership of Harry S. Truman, played a role in the escalation of tensions between the two superpowers. The Truman

Information Panel

This area can provide additional info or be styled further as needed.

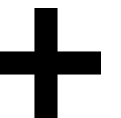




History

Code Links

- Link for History O Level RAG
: <https://colab.research.google.com/drive/11rcsxsT75cUUHMQpHNGnriXlVwvZhck3?usp=sharing>
- Link for the O Level History App
: https://colab.research.google.com/drive/14NsrCVXKhHgQtiS_TfbLoSiRpztJc5jt?usp=sharing



Generated RAG Answer

query sentence = "What was the Treaty of Versailles?"

Response Number	Generated Text
1	<p>The Treaty of Versailles, signed on June 28, 1919, marked the end of World War I and brought significant changes to the political landscape of Europe. Germany, as the main aggressor in the war, faced severe penalties and territorial losses as outlined in the treaty.</p> <p>Germany's main territorial losses under the Treaty of Versailles included the cession of Alsace-Lorraine to France, the loss of Danzig and the Polish Corridor, and the reduction of its military capabilities. The return of Alsace-Lorraine to France was a significant loss for Germany, as it had been part of the German Empire since 1871. The loss of Danzig and the Polish Corridor created a new Polish state, which was a significant threat to Germany's eastern borders. Additionally, the reduction of Germany's military capabilities, including the limitation on the size of its army and navy, weakened its ability to defend itself against potential aggressors.</p> <p>The Treaty of Versailles also imposed heavy financial reparations on Germany, which further weakened its economy and contributed to the rise of the Nazi party in the 1930s. The treaty's harsh terms and the resulting economic instability in Germany set the stage for World War II.</p> <p>In summary, the Treaty of Versailles brought about significant territorial losses and financial burdens for Germany, which contributed to the country's instability and eventual involvement in World War II. The treaty's terms were a response to Germany's aggression during World War I, but they also created new tensions and conflicts in Europe that ultimately led to another devastating war.</p>

Summarization of Generated Answer

query sentence = "Who was to blame for the cold war?"

Response Number	Generated Summarized Text
1	The Cold War was a period of intense political and military tension between the Western Bloc and the Eastern Bloc. The origins of the Cold War are multifaceted and can be attributed to various factors, including ideological differences, territorial disputes, and the actions of key leaders.



Evaluation of Answers

History

	A	B	C	D	E	F	G	H	I	J	
1	S.No	Question	Response #	RAG Answer						Teacher Evaluation (Rate 1 to 10)	
2		O Levels									
3	1	Was the treaty of Versailles fair?	RESPONSE 1	<p>The Treaty of Versailles, signed in 1919, imposed harsh reparations and territorial losses on Germany, which contributed significantly to the rise of Adolf Hitler and the Nazi Party. The following table highlights some of the most significant provisions of the treaty that affected Germany</p> <p>Terms of the Treaty of Versailles Impact on Germany</p> <p>Reparations The reparations imposed on Germany were excessive and burdensome, leading to economic instability and hyperinflation. This, in turn, created a climate of resentment and desperation, making the German population more receptive to the promises of the Nazi Party.</p> <p>Territorial losses The loss of territory, including AlsaceLorraine and Danzig, fueled nationalist sentiment and a desire for revenge. This played into the hands of the Nazi Party, who exploited these feelings to gain support.</p> <p>Demilitarization The demilitarization of Germany limited its ability to defend itself, making it more vulnerable to external threats and creating a sense of humiliation and insecurity. This contributed to the belief that a strong military was necessary to restore German pride and power.</p> <p>League of Nations Germanys exclusion from the League of Nations reinforced its sense of isolation and resentment, making it more likely to seek alliances and expand its territory through military means.</p> <p>Political and military leadership The treaty prohibited the formation of a unified German military and restricted the size of the Reichswehr. This created a power vacuum that the Nazi Party was able to fill by promising to rebuild the military and restore German pride.</p> <p>In summary, the Treaty of Versailles had a profound impact on Germany and contributed to the rise of Adolf Hitler</p>						7	
4	2	What were the consequences of the 1948-49 revolution?	RESPONSE 2	<p>The League of Nations, established in 1919, was an ambitious attempt to maintain peace and prevent another devastating war. However, the Leagues failures in the 1930s had significant consequences that contributed to the outbreak of World War II.</p> <p>First and foremost, the Leagues inability to prevent the Italian invasion of Ethiopia in 1935 demonstrated its impotence in the face of aggressive actions by major powers. The League imposed sanctions on Italy, but these were largely ineffective due to the support of other countries, such as Germany and the Soviet Union, who continued to trade with Italy. This failure to enforce its decisions weakened the Leagues credibility and emboldened other aggressors, such as Japan and Germany.</p> <p>Another significant consequence of the Leagues failures was the rise of appeasement policies in Europe. The Leagues inability to prevent the aggression of Italy, Japan, and Germany led many European leaders to believe that concessions and appeasement were necessary to prevent war. This approach, exemplified by the Munich Agreement of 1938, ultimately failed to prevent the outbreak of war in 1939.</p>						6	





Videos for History Evaluation



1	https://www.loom.com/share/8b9e2f1486e34407b378221852f494aa?sid=836f2f7d-d139-40d9-8ccd-ae471f679d1
2	https://www.loom.com/share/30ff094e98744a58b87f338c90ec4e32?sid=678cee56-a843-4cc9-83a5-e2e75a6e9075
3	https://www.loom.com/share/6500f59a83554b6aa27a01aff6a2425e?sid=448874cc-0575-4cf6-8fe3-a074698251d0
4	https://www.loom.com/share/5805ba152101449eabdecf986d850a13?sid=6bcf4f40-e745-49a4-b6ad-83eaea278661



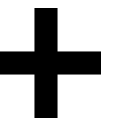
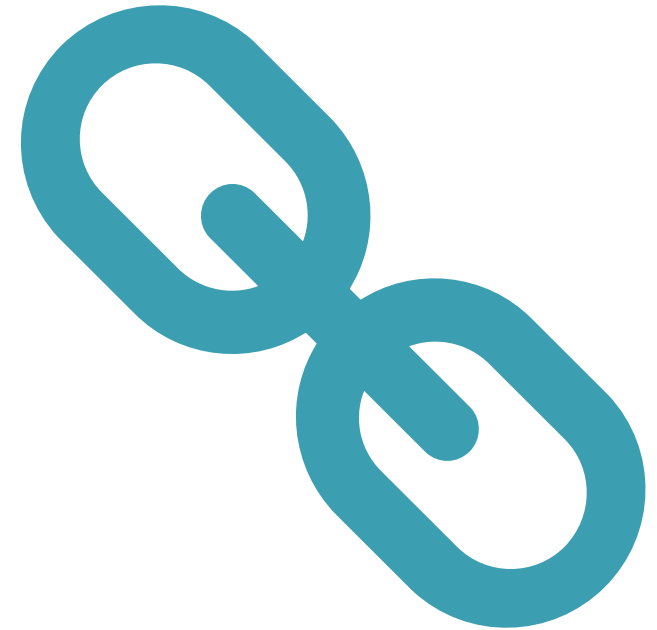


ECONOMICS



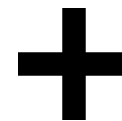
Code Links

- Link for Economics RAG
: <https://colab.research.google.com/drive/17rvrq7iKW64jX-qtZSiQIErLjs8VCxjX?usp=sharing><https://colab.research.google.com/drive/17rvrq7iKW64jX-qtZSiQIErLjs8VCxjX?usp=sharing>



Questions and Answers – Economics O and A Levels

**IT IS TO BE NOTED THAT A
COMBINED RAG FOR O AND A
LEVEL ECONOMICS WAS
MADE**



Economics Rag Pipeline



The program is designed to interact with users interested in Economics Retrieval-Augmented Generation (RAG).

Users are prompted to choose between O Level and A Level.

Based on the user's choice, the program directs them to specific functions: **display_o_level_rag()** for O Level (1) and **display_a_level_rag()** for A Level (2).

If the user enters an invalid choice, the program provides an error message prompting them to select either option 1 or 2.

Economics Rag Initial Prompt

Welcome to the Economics Retrieval-Augmented Generation (RAG)!

Please select your level:

1. O Level

2. A Level

Enter your choice (1 or 2): 2

Enter your query sentence: explain cross elasticity of demand

Original Sentence: 8.4 Cross elasticity of demand Cross elasticity of demand (XED) measures the responsiveness of the quantity demanded for one good to a change in the price of another good.

Original Sentence: 8.2 Price elasticity of demand Price elasticity of demand (PED) measures the responsiveness of the quantity demanded for a good to a change in its own price.

Original Sentence: SELF-EVALUATION CHECKLIST After studying this chapter, complete a table like this: You should be able to: Needs more work Already mastered



Economics – O level Rag and A level Rag

The `display_o_level_rag()` / `display_a_level_rag()` function is defined to process O Level Economics study material.

It utilizes the PyPDF2 library to extract text data from a PDF file.

Extracted text is saved to a text file for further processing.

The text is preprocessed and loaded into memory for vectorization and similarity calculations.

Sentence vectors are generated using a pre-trained Word2Vec model.

Pinecone, a vector database service, is utilized to index and query sentence vectors efficiently.

Relevant matches are retrieved based on user queries using cosine similarity and BM25 scoring methods.

The top matching sentences are then used as prompts for generating detailed answers using a generative model via the Replicate API.

The generated responses are streamed and displayed to the user.



Results of Experiments on Economics RAG

S.No.	Question	Cosine Similarity	BM25 Ranking	Llama 3 70b	Mistral 7b	Falcon 40b
0 levels				10	10	10
1	Explain demand-pull inflation.	0.312	1.809	8	6	7
2	Explain opportunity cost with an example.	0.592	1.622	7	5	8
3	Analyse the advantages that a country may gain from specialising in a product.	0.117	4.524		3	
4	Explain the difference between direct and indirect taxes.	0.772	-0.373		9	
5	Distinguish between floating and fixed foreign exchange rate systems.	0.431	1.336		6	
A levels				10	10	10
1	Explain cross elasticity of demand.	0.361	1.149	6	8	6
2	Explain the marginal utility theory.	0.375	0.432	8	7	5
3	How is wage determined in labour market?	0.321	2.032		4	
4	What is liquidity preference theory?	0.591	-0.178		6	
5	What are policy objectives conflicts?	0.287	2.058		5	





Question 1:

Explain demand-pull inflation.

Llama 3 – 70b

8/10

Definition,
causes,
overall, it is
good

"Demand-pull inflation is a type of inflation that occurs when aggregate demand exceeds the available supply of goods and services in an economy. This happens when the economy is growing rapidly, fueled by excessive demand, which leads to an increase in the overall price level. The excessive demand can be caused by various factors such as an increase in consumer confidence, a rise in disposable income, or a decrease in interest rates, making borrowing cheaper. As a result, households and businesses are more likely to spend and invest, leading to an increase in aggregate demand. However, if the economy is already operating at or near full capacity, businesses may not be able to meet the increased demand, leading to a shortage of goods and services. In order to capture the excess demand, businesses respond by increasing prices, resulting in inflation. The demand-pull inflation is often depicted as a movement up the aggregate demand curve, where the increase in demand leads to an increase in the price level. The upward pressure on prices is further exacerbated by the fact that businesses may also increase their prices in anticipation of future demand, leading to a self-reinforcing cycle of inflation. Moreover, if the economy is experiencing a prolonged period of demand-pull inflation, it can lead to a wage-price spiral, where workers demand higher wages to keep up with the rising cost of living, and businesses respond by increasing prices further, leading to even higher inflation.

In conclusion, the analysis discussed above illustrates the complexities and impacts of demand-pull inflation. It highlights the importance of managing aggregate demand and supply in an economy to prevent excessive demand from leading to inflation. Central banks and governments must be vigilant in monitoring the economy's growth rate and take measures to curb excessive demand, such as increasing interest rates or reducing government spending, to prevent demand-pull inflation from taking hold."



Question 1:

Explain demand-pull inflation.

Mistral v2 – 7b

6/10

"Demand-pull inflation occurs when the aggregate demand for goods and services in an economy exceeds the available supply, leading to an upward pressure on prices. Contrary to the given statement that the inflation rate is negative, demand-pull inflation implies a positive inflation rate. To understand this concept, let us first examine the components of aggregate demand (AD) and aggregate supply (AS) in an economy. Aggregate demand is the total demand for goods and services in an economy, while aggregate supply represents the total quantity of goods and services that producers are willing and able to supply at various price levels. In a normal market situation, the equilibrium price and quantity are determined where the aggregate demand and aggregate supply curves intersect. At this point, the quantity demanded equals the quantity supplied, and there is no inflation or deflation. However, when aggregate demand exceeds aggregate supply, demand-pull inflation occurs. This situation can be caused by various factors, such as an increase in consumer spending due to higher disposable income, an expansionary fiscal policy, or an increase in investment spending. The result of demand-pull inflation is a leftward shift in the aggregate demand curve, leading to a higher equilibrium price level and a lower equilibrium real GDP. Producers, sensing the opportunity to increase prices, may also respond by increasing production to meet the higher demand, leading to a rightward shift in the aggregate supply curve. However, the initial response of producers is often to raise prices before increasing production, leading to a temporary shortage of goods and further upward pressure on prices. In conclusion, the statement that the inflation rate is negative but the economy is experiencing demand-pull inflation is contradictory. Demand-pull inflation implies a positive inflation rate, as the economy experiences upward pressure on prices due to excess aggregate demand."





Question 1:

Explain demand-pull inflation.

Falcon – 40b

7/10

"Demand-pull inflation is a type of inflation that occurs when the demand for goods and services in an economy exceeds the capacity of producers to meet this demand. This causes an increase in the prices of goods and services, as producers are able to raise prices without losing customers due to high demand. Demand-pull inflation is usually caused by an increase in aggregate demand, which is the total demand for goods and services in an economy. Factors that can increase aggregate demand include increases in consumer spending, business investment, government spending, or exports. One example of demand-pull inflation is the current inflation in the United States. During the Covid-19 pandemic, the U.S. government has implemented various stimulus policies, such as direct payments to individuals and small businesses, increased unemployment benefits, and other support programs. These policies have increased the demand for goods and services and the prices of these goods and services have risen as a result of these policies. While some argue that this inflation is largely temporary and will subside once the economy fully recovers, others are concerned that the government's stimulus policies may continue to cause inflation in the future. To prevent demand-pull inflation, governments can implement policies that reduce the demand for goods and services in the economy, such as increasing interest rates or reducing government spending. These policies may have negative effects on economic growth in the short-term, but they can help prevent excessive demand in the economy and prevent inflation in the long-term. However, it is important for governments to strike a balance between implementing policies to prevent inflation and policies that support economic growth, as too much restraint can also harm the economy."



Question 2:

What is opportunity cost? Explain with an example.

7/10

Llama 3 – 70b

Opportunity cost is a fundamental concept in economics that refers to the value of the next best alternative that is given up when a choice is made. In other words, it is the cost of choosing one option over another. This concept is essential in decision-making as it helps individuals and businesses evaluate the trade-offs involved in their choices. For instance, let's consider a simple example to illustrate opportunity cost. Suppose a farmer has a plot of land that can be used to grow either wheat or corn. If the farmer decides to grow wheat, the opportunity cost would be the revenue that could have been earned from growing corn on that same plot of land. In this case, the farmer has forgone the opportunity to grow corn, and the value of that forgone opportunity is the opportunity cost.

In this example, the opportunity cost is not just the monetary value of the corn that could have been grown, but also the potential benefits that come with growing corn, such as the job opportunities created, the contribution to food security, and the potential for export earnings. By choosing to grow wheat, the farmer has implicitly valued the benefits of growing wheat over those of growing corn. This decision is influenced by the opportunity cost, as the farmer has weighed the benefits of growing wheat against the benefits of growing corn and chosen the option that is perceived to be more valuable. Therefore, opportunity cost plays a crucial role in decision-making, as it forces individuals and businesses to consider the trade-offs involved in their choices and make informed decisions that maximize their benefits.



5/10

Question 2:

What is opportunity cost? Explain with an example.

Mistral v2 – 7b

Definition is good but the example is too complicated for O level.



Opportunity cost is the cost of the next best opportunity forgone when making a decision. It is an inherent concept in economics that arises due to the limited resources available to individuals, firms, and societies. In simpler terms, opportunity cost represents the sacrifice of one alternative when choosing another.

Let's consider an example to illustrate the concept of opportunity cost. Suppose John, a farmer, has 10 acres of land to cultivate. He can either grow wheat or rice on this land. The market price for wheat is \$300 per acre, and the market price for rice is \$200 per acre. If John decides to grow wheat on all 10 acres, his total revenue will be \$3,000 (10 acres * \$300/acre).

However, if John decides to grow rice instead, he can produce 10 acres * \$200/acre = \$2,000 in revenue. The difference between the revenue he could have earned by growing wheat and the revenue he actually earned by growing rice is the opportunity cost of his decision.

In this case, the opportunity cost of growing rice instead of wheat is \$1,000 (the revenue he gave up by not growing wheat). This \$1,000 represents the cost of the next best alternative forgone. It is essential to note that opportunity cost is not a monetary cost but rather an opportunity that was lost.

In conclusion, opportunity cost is a crucial concept in economics that represents the sacrifice of one alternative when choosing another. It is an inherent aspect of decision-making due to the limited resources available to individuals, firms, and societies. The example of John, the farmer, illustrates how opportunity cost arises when making a decision between two alternatives, each with its unique benefits and costs.



Question 2:

What is opportunity cost? Explain with an example.

8/10

Falcon – 40b

In the real world, the opportunity cost refers to the benefits that an individual or business entity loses when taking one option over another. The next best opportunity forgone is the second-best alternative that the decision maker chooses not to pursue. Opportunity cost refers to the trade-offs individuals and businesses face when choosing between options.

For instance, consider a person who has to choose between going to college to study their preferred subject, computer science or going to work to earn money to fund their education. If they were to choose to work, they would forego studying, but by earning money while working, they can fund their college education. Going to college to study the preferred subject would mean foregoing the opportunity to earn money while working. The opportunity cost of studying computer science in college, therefore, is the forgoing of earning a salaried income.

When calculating opportunity cost, you need to consider the costs of the decision and the returns associated with the second-best alternative. In addition to tangible monetary costs, opportunity cost includes intangible benefits like the satisfaction or fulfillment associated with the opportunity forgone. Opportunity cost may also involve sacrificing time, personal relationships, or experiences in support of pursuing economic goals. In some cases, opportunity costs are easy to understand, while in other cases, they are more abstract and difficult to quantify.

Therefore, individuals and businesses have to weigh the costs associated with their choices and evaluate whether the returns are adequate compensation for the forgone opportunity. They need to consider their goals, priorities, and values carefully when making such choices.

In summary, opportunity cost refers to the benefits that an individual loses because they choose one option over another. It refers to the trade-offs individuals and businesses face when making decisions. A proper analysis of opportunity cost involves considering the costs associated with the decision, as well as the benefits associated with the forgone opportunity. Overall, opportunity cost is a critical





6/10

May be a more detailed explanation of XED would have worked better before implementation. Additionally, a graph would be helpful.



Question 1:

Explain cross elasticity of demand.

Llama 3 – 70b

Cross elasticity of demand (XED) measures the responsiveness of the quantity demanded for one product following a change in the price of another product. Based on the cross elasticity of demand (XED) values, the producer should spend most on promoting product D. This is because product D has the highest XED value of +2.4, indicating that it is highly complementary with other products. Promoting product D is likely to have a significant impact on sales. Estimates of PED, XED, and YED provide valuable information for businesses when making decisions about pricing, production, and marketing strategies.





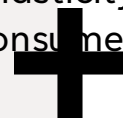
Question 1:

Explain cross elasticity of demand.

Mistral v2 – 7b

8/10

"Cross elasticity of demand Cross elasticity of demand (XED) measures the responsiveness of the quantity demanded for one product following a change in the price of another product. It is calculated as the percentage change in the quantity demanded for product A following a percentage change in the price of product B, holding all other factors constant. Mathematically, XED can be expressed as: $XED = (\% \text{ change in } Q_{dA} / \% \text{ change in } P_B)$ Where: Q_{dA} = Quantity demanded for product A P_B = Price of product B The concept of cross elasticity of demand is important in understanding how changes in the price of one product can affect the demand for another product. It is particularly relevant in industries where there are substitutes for each other's products. For example, if the price of Coca-Cola increases, the demand for Pepsi may also increase as consumers switch to the cheaper alternative. Cross elasticity of demand can be positive or negative. A positive cross elasticity indicates that the two products are substitutes, meaning that an increase in the price of one product leads to an increase in the demand for the other product. A negative cross elasticity indicates that the two products are complements, meaning that an increase in the price of one product leads to a decrease in the demand for the other product. For example, if the price of bread increases, the demand for butter may also increase as consumers use more butter to spread on their bread. In this case, the cross elasticity of demand between bread and butter would be positive. On the other hand, if the price of gasoline increases, the demand for public transportation may also increase as consumers switch to using public transportation to save on fuel costs. In this case, the cross elasticity of demand between gasoline and public transportation would be positive. However, it is important to note that cross elasticity of demand is not always constant. It can change depending on the price elasticity of demand for each product and the availability of substitutes. Therefore, it is essential to analyze the specific market conditions and consumer behavior to accurately determine the cross elasticity of"





Question 1:

Explain cross elasticity of demand.

Falcon – 40b

6/10

The cross elasticity of demand (XED) measures the responsiveness of the quantity demanded for one product (e.g. product A) following a change in the price of another product (e.g. product B). It is often used in econometric models to determine the effect of changes in the price of one product on the demand for a related product. XED helps companies and producers understand how changes in the prices of their own products or related products can impact the demand for their products. This information can be used to help optimize pricing strategies and marketing efforts. For example, if the XED between product A and product B is small, then a transfer of customers from product A to product B may not have a large impact on overall demand for either product. Conversely, if the XED between product A and product B is large, then a change in the price of one product can have a significant impact on the demand for the other product. Overall, XED is a useful measure that helps companies better understand how their own products and associated products interact with each other in the market place.





Question 2:

Explain the marginal utility theory.

Llama 3 – 70b

8/10

"The marginal utility theory, a fundamental concept in microeconomics, explains how the additional utility or satisfaction a consumer derives from consuming one more unit of a good or service changes as the quantity consumed increases. In the context of Table 30.1, which illustrates the utility gained from time spent on revision, we can apply this theory to analyze the relationship between the number of days spent on revision and the resulting utility. To calculate the marginal utility, we need to determine the additional utility gained from each successive day of revision. The marginal utility is calculated as the change in total utility divided by the change in the number of days spent on revision. From the table, we can see that the total utility gained from one day of revision is 120, from two days it is 213, and so on. Therefore, the marginal utility for the second day is 93 ($213 - 120$), for the third day it is 70 ($283 - 213$), and so on. As the number of days increases, the marginal utility decreases, indicating that the law of diminishing marginal utility holds true in this scenario. This means that each additional day of revision yields a smaller increase in utility than the previous day. The total utility curve, which plots the total utility gained against the number of days spent on revision, will be upward-sloping but concave, indicating that the total utility increases at a decreasing rate as the number of days increases. The marginal utility curve, which plots the marginal utility against the number of days spent on revision, will be downward-sloping, illustrating the decreasing marginal utility as the number of days increases. The point at which the marginal utility curve intersects the x-axis represents the point of diminishing returns, where the additional utility gained from one more day of revision becomes zero. This analysis highlights the importance of understanding the marginal utility theory in making informed decisions about resource allocation, in this case, the optimal number of days to spend on revision to maximize utility."



Question 2:

Explain the marginal utility theory.

Mistral v2 – 7b

7/10

Explanation would have been better with more concrete example and graphs



"This is an example of the principle or law of diminishing marginal utility where marginal utility is the additional utility that is derived from the consumption of one more unit of a good. According to the theory of marginal utility, as the quantity of a good consumed increases, the additional utility derived from each additional unit decreases. This is because as we consume more units of a good, our needs and wants become satiated, and the utility we derive from each additional unit becomes less. The theory of marginal utility is based on the assumption that individuals rationally allocate their limited resources to satisfy their unlimited needs and wants. It suggests that individuals make consumption decisions based on the marginal utility they derive from each good, rather than the total utility derived from the entire bundle of goods. In other words, individuals are willing to give up a unit of one good to obtain an additional unit of another good if the marginal utility derived from the latter is greater. The theory of marginal utility is also related to the concept of opportunity cost, which is the value of the next best alternative forgone when making a particular choice. According to the theory, the opportunity cost of consuming an additional unit of a good is the marginal utility that could have been derived from the next best alternative that was given up. This is why the theory of marginal utility is often referred to as the theory of scarcity, as it emphasizes that individuals face trade-offs when making consumption decisions. The theory of marginal utility has important implications for the study of consumer behavior and market equilibrium. For example, it explains why consumers may prefer a bundle of goods that maximizes their total utility, even if the marginal utility derived from each good is not constant. It also explains why demand curves are downward sloping, as the marginal utility derived from each additional unit of a good decreases as the quantity consumed increases. In conclusion, the theory of marginal utility is a fundamental concept in microeconomics that explains how individuals make consumption decisions based on the additional utility derived from each unit of a good. It emphasizes the importance of scarcity and the concept of opportunity cost, and has important implications for the study of consumer behavior and market equilibrium."



Question 2:

Explain the marginal utility theory.

Falcon – 40b

5/10

In simple terms, the law of diminishing marginal utility states that as we consume increasing quantities of a good, the additional utility derived from each subsequent unit consumed will tend to decline. It is one of the fundamental rules of economics and is central to our understanding of how markets function.



Videos for Economics Evaluation

The background features a dark blue field with a network of white lines and circular nodes. Overlaid on this are several orange 3D bar charts of varying heights. Specific data points are highlighted with white circles and connected to the nodes by white lines. Numerical values are displayed next to some of these points: 183.102, 154.178, and 245.5. A large white plus sign is positioned on the right side of the image.

245.5
+

183.102

154.178

1

<https://www.loom.com/share/387e61e529ec493fbfc31611c0278ac3?sid=dc397df3-fc63-4eae-a48d-f99c2872a801>

2

<https://www.loom.com/share/8faa02a0e1d54cc6a2ae44bc75c725ae?sid=e7334e16-bac4-4b3e-81de-2325c7bed053>



Experiments for better RAG Performance

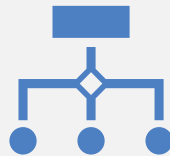
Link: [RAG Experiments + Answer Evaluations.xlsx](#)



Indexing & Chunk Sizes



Batch Size for Indexing: Each index is configured to handle up to 2250 sentence vectors, optimizing the distribution and management of data across multiple indexes.



Upserting Vectors: Vectors are upserted into the index in batches of 1000, allowing for efficient data processing and system scalability.

Ranking Functions



BM25 (All subjects): BM25 is utilized across all subjects for ranking documents based on the frequency of query terms in documents, adjusting for document length and term frequency across documents. This approach improves relevance in search results by prioritizing documents that more closely match the query terms, applicable universally across different academic subjects.



TF-IDF (Economics): For Economics, the TF-IDF (Term Frequency-Inverse Document Frequency) method is specifically used to evaluate how important a word is to a document in a collection or corpus. This technique helps in distinguishing the significance of terms within economic texts and supports more accurate retrieval of subject-specific content.



Relevancy Tracking in Computer Science: This code snippet is designed to identify the most relevant and detailed response from a set of search results in the context of Computer Science. The process focuses on matching the query to the response with the most words, ensuring that the response not only addresses the query but provides a comprehensive explanation.



Embedding Models

Word Embedding Model: Utilized the "word2vec-google-news-300" model for word embeddings to enhance semantic text analysis capabilities in the project, leveraging a pre-trained model to capture nuanced word relationships effectively.

AIMED TO EXPERIMENT WITH

GloVe (Global Vectors for Word Representation): Developed by Stanford, these embeddings are based on matrix factorization

FastText:

BERT (Bidirectional Encoder Representations from Transformers):

GPT (Generative Pre-trained Transformer): While initially designed for text generation, GPT's embeddings can be used as features in downstream tasks, offering benefits from its transformer architecture.

Large Language Models



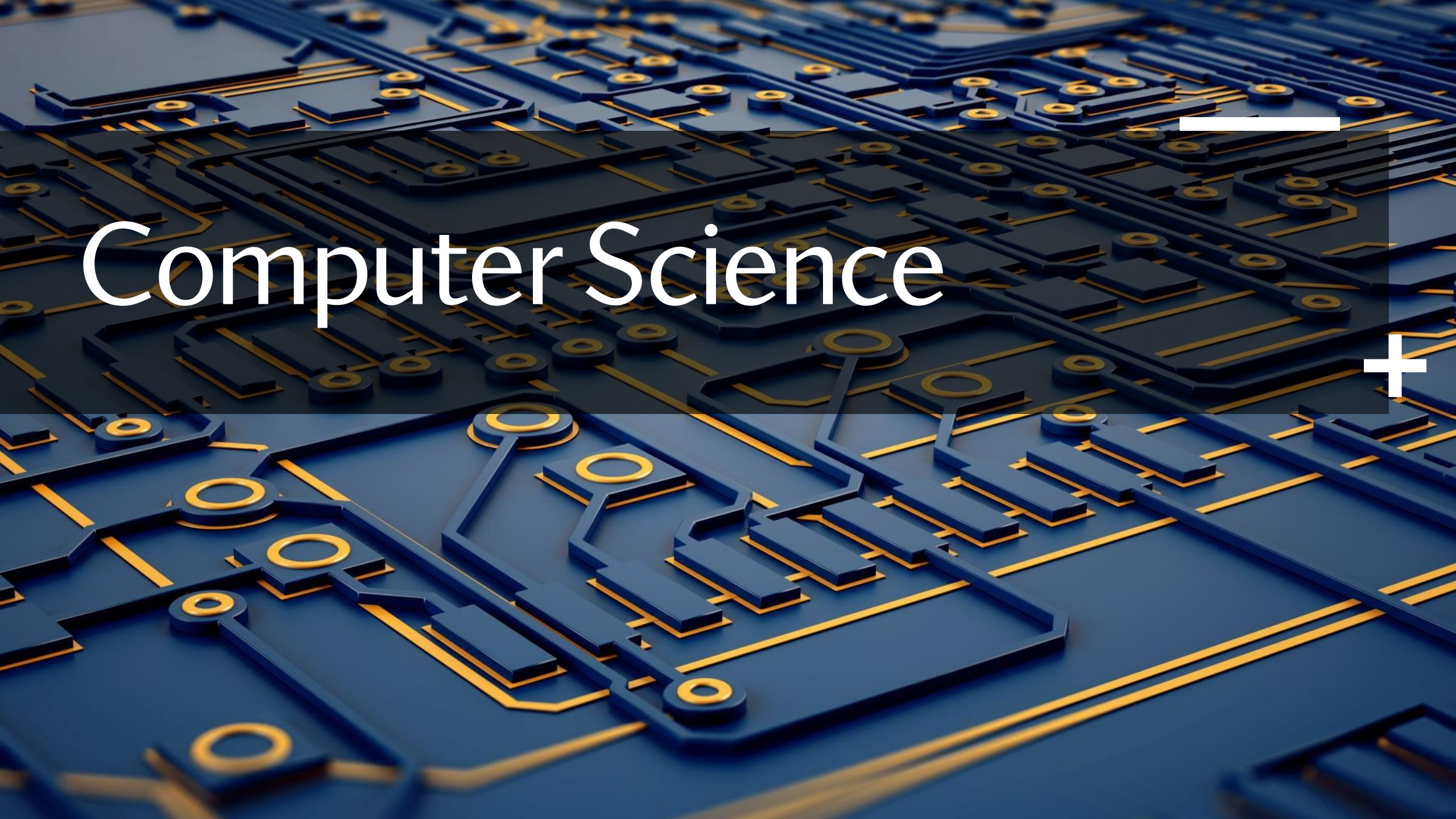
Llama 3 – (Meta-llama-3-70b-instruct) (Replicate)



Mistral v2 – (Mistral-7B-Instruct-v0.2) (Hugging Face)



Falcon – (Falcon-40b-instruct) (Replicate)



Computer Science



CS ANSWER 1

query sentence = "What are binary numbers?"



Response Number	Generated Text
1	<p>Binary code is a sequence of 0s and 1s used to represent data or instructions in computing. While it is commonly used to represent binary numbers, it can also represent other types of data such as text, images, or even instructions for a computer's processor.</p> <p>In the context of the Cambridge AS and A Level Computer Science syllabus (9618), binary code is often used to represent binary numbers, but it can also represent other types of data using different encoding schemes. For example, ASCII (American Standard Code for Information Interchange) is a popular encoding scheme used to represent text data as binary code. Each character in the ASCII table is assigned a unique binary code.</p> <p>Similarly, images can be represented as binary code using various encoding schemes such as JPEG, PNG, or GIF. These encoding schemes use different methods to compress and represent the image data as binary code.</p> <p>Instructions for a computer's processor can also be represented as binary code. Machine code is the lowest level of programming language, consisting of binary instructions that the processor can directly execute. Assembly language is a higher-level programming language that uses mnemonic codes to represent machine instructions, but these mnemonic codes can still be translated into binary code.</p> <p>Therefore, while binary code can represent binary numbers, it is not limited to this use case. It can represent other types of data such as text, images, or instructions for a computer's processor using different encoding schemes.</p>





Videos for Computer Science Evaluation



1

<https://www.loom.com/share/718c5865f8f14b268090813a38f00a0d?sid=562012e1-3b5f-4109-ae63-a821b8b164a6>

2

<https://www.loom.com/share/58c108d8cdb044aaae64217c3aaddc6b?sid=777624d7-b63c-4a13-9cf4-ca895e156691>



Challenges



Improvements in RAG Answers

Summarization Integration: Incorporating summarization into the Retrieval-Augmented Generation (RAG) system could enhance the relevance and conciseness of answers. This allows the model to distill the most pertinent information from retrieved texts, improving clarity and focus.

Enhanced Formatting Options: Adding advanced formatting capabilities can significantly improve the readability and presentation of RAG outputs. This could include structured responses in bullet points, numbered lists, or highlighted sections to better guide users through complex answers.

Detailed Analysis Feature: Providing an option for detailed analysis in responses can cater to needs for deeper insight and extended discussion on specific topics. This feature would be especially valuable for academic or professional contexts where comprehensive explanations are required.

Dynamic Answer Length: Allowing the generation of answers with dynamic lengths rather than fixed-size responses can improve the flexibility and adaptability of the RAG system. This ensures that the completeness of an answer is tailored to the complexity of the question posed, offering a more customized user experience.

Thank you!



<https://www.loom.com/share/88d076f429cb49e0b565705f9c66e9fa?sid=0f449384-841a-4589-8ae5-519cf6410856>