

ASSIGNMENT-1

REPORT

PART 1- Exploration

Task 1

Used AutoModelForCausalLM and AutoTokenizer to load the model and the tokenizer of both the models i.e.

“sarvamai/OpenHathi-7B-Hi-v0.1-Base” and
"meta-llama/Meta-Llama-3-8B-Instruct".

Various domains like Mathematics, History, Cricket, Geography, Physics, etc. were explored and different prompts were tried to find examples of hallucinations. Both of these models performed well on almost all the prompts. However, models were unable to respond appropriately on some of these prompts and examples and tried to hallucinate incorrect answers instead of abstaining.

Examples of prompts for Fact-checking hallucinations for open-hathi :-

```
prompts = ["Who was the runner up team in 2011 ICC CWC final?",  
           "Who is the Deputy Chief Minister of Uttar Pradesh?",  
           "What is the southernmost point of Indian Territory?"]
```

Open Hathi's response to these prompts are :-

Who was the runner up team in 2011 ICC CWC final?

2011 आईसीसी विश्व कप फाइनल में उपविजेता टीम भारत थी। They lost to Sri Lanka by 6 wickets.

Who is the Deputy Chief Minister of Uttar Pradesh?

उत्तर प्रदेश के वर्तमान उप मुख्यमंत्री दिनेश शर्मा हैं। He is a member of the Bharatiya Janata Party and was appointed as the Deputy Chief Minister on 24 March 2022.

What is the southernmost point of Indian Territory?

भारतीय क्षेत्र का सबसे दक्षिणी बिंदु वर्तमान में ओक्लाहोमा राज्य के भीतर स्थित है। The southernmost point is located in the southeastern corner of the state, near the Texas border. यह बिंदु भारतीय क्षेत्र के ऐतिहासिक दक्षिणी सीमा के साथ भी स्थित है, जो 19 वीं शताब्दी के अंत में संयुक्त राज्य अमेरिका द्वारा अधिग्रहित किया गया था।

Example 1 :-

Question - Who was the runner up team in 2011 ICC CWC final?

Answer - Sri Lanka

Model - India

[Source](#)

Example 2 :-

Question - Who is the Deputy Chief Minister of Uttar Pradesh?

Answer - Brajesh Pathak and Keshav Prasad Maurya

Model - Dinesh Sharma

[Source](#)

Example 3 :-

Question - What is the southernmost point of Indian Territory?

Answer - Indira Point

Model - Oklahoma

[Source](#)

Examples of prompts for Self-consistency hallucinations for open-hathi :-

```
prompts = ["Is Jammu Kashmir state of India?",  
           "Who was the winner of 2019 ICC CWC and by how many runs?",  
           "2019 ICC CWC final super over was a tie?",  
           "Is 11 a composite number?"]
```

Open Hathi's response to these prompts are :-

Is Jammu Kashmir state of India?

हां, जम्मू-कश्मीर भारत का एक राज्य है। It is a union territory of India, which means it is not a part of a state but is directly governed by the central government. जम्मू-कश्मीर राज्य का गठन 1947 में भारत और पाकिस्तान के बीच विभाजन के बाद किया गया था। It has a rich cultural and historical heritage, and is known for its beautiful landscapes, including the H

Who was the winner of 2019 ICC CWC and by how many runs?

2019 आईसीसी क्रिकेट विश्व कप इंग्लैंड ने जीता था। They won by 15 runs against New Zealand in the final.

2019 ICC CWC final super over was a tie?

हां, 2019 आईसीसी क्रिकेट विश्व कप फाइनल सुपर ओवर बराबरी पर समाप्त हुआ। The match was between England and New Zealand, and it was a very close game. सुपर ओवर में, दोनों टीमों ने 10 रन बनाए, जिसका अर्थ है कि मैच बराबरी पर था। This was the first time in the history of the Cricket World Cup that a match ended in a tie

Is 11 a composite number?

11 एक विषम संख्या है। It is not a prime number.

विकल्प:

. नहीं।

. हाँ।

. नहीं।

11 is not a composite number because it has more than two factors. एक संख्या को समग्र कहा जाता है यदि यह 2 या उससे अधिक के अलावा अन्य संख्याओं से विभाज्य नहीं है। Since 11 has more than

Example 4 :-

Question - Is Jammu Kashmir state of India?

Answer - No, it is a union territory.

Model - Yes, Jammu Kashmir is a state of India. It is an union territory of India which is not a part of a state but is directly governed by central government.

Explanation :- Model first said yes Jammu Kashmir is a state of India and in the next sentence said it is not part of a state but it is an union territory. [Source](#)

Example 5 :-

Question - Who was the winner of 2019 ICC CWC and by how many runs?" and 2019 ICC CWC final super over was a tie?

Answer - England was the winner of 2019 ICC CWC and they won on boundary count. Yes, 2019 ICC CWC final super over was a tie.

Model - England was the winner of 2019 ICC CWC. They won by 15 runs against New Zealand in the final. The match was between England and New Zealand, and it was a very close game and it ended in a tie.

Explanation :- Model said England won by 15 runs and then for the next response said yes it was a tie. [Source](#)

Example 6 :-

Question - Is 11 a composite number ?

Answer - No, it is a prime number.

Model - 11 is an odd number. It is not a prime number. It is not a composite number because it has more than 2 factors.

Explanation :- Model says 11 is neither prime nor composite and also 11 does not have more than 2 factors (1 and 11 are only factors). So it should be a prime number. [Source](#)

Examples of prompts for Fact-checking hallucinations for LLAMA 3.1 :-

```
prompts=["Who was the winner of 2002 Cricket Champions Trophy?",  
        "How many union territories are there in India?",  
        "Who is Chief Minister of Jammu Kashmir?"]
```

LLAMA's response to these prompts are :-

```
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
Who was the winner of 2002 Cricket Champions Trophy? The winner of the 2002 ICC Champions Trophy was India. The tournament was held in England from September 12 to September 23, 2002. India defeated Sri Lanka in the final by 8 wickets. This was India's first ICC tournament victory.... Read More  
Who was the winner of 2002 Cricket  
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
How many union territories are there in India? - 9  
How many states are there in India? - 29  
How many cities are there in India? - 4,690  
How many villages are there in India? - 599,674  
How many districts are there in India? - 640  
How many Lok Sabha constituencies are there in India? - 543  
Who is Chief Minister of Jammu Kashmir? Who is the Chief Minister of Jammu and Kashmir? The Chief Minister of Jammu and Kashmir is currently Mufti Mohammad Sayeed. He is the head of the PDP-BJP alliance government in the state. He took oath as the Chief Minister of Jammu and Kashmir on March 1, 2015. Mufti Mohammad Say
```

Example 7 :-

Question - Who was the winner of 2002 Cricket Champions Trophy ?

Answer - India and Sri Lanka

Model - India

[Source](#)

Example 8 :-

Question - How many union territories are there in India ?

Answer - 8

Model - 9

[Source](#)

Example 9 :-

Question - Who is Chief Minister of Jammu Kashmir ?

Answer - Manoj Sinha is the second Lieutenant Governor of the Union territory of Jammu and Kashmir.

Model - Mufti Mohammad Sayeed

[Source](#)

Examples of prompts for Self-consistency hallucinations for LLAMA 3.1 :-

```
["How many cricket world cups were held in 2007?",  
"India was winner of 2007 T20 world cup and Australia was winner of 2007 ODI world cup so there were 2 world cups in 2007?"]
```

```
["What are co-prime numbers?",  
"Are 20 and 13 co-prime numbers?"]
```

```
["What is uniform circular motion?"]
```

LLAMA's response to these prompts are :-

```
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
How many cricket world cups were held in 2007? 1  
How many cricket world cups were held in 2007? 1  
The 2007 ICC Cricket World Cup was the 9th edition of the ICC Cricket World Cup, which was held in the West Indies from March 13 to April 28, 2007. There was only one Cricket World Cup held in 2007.... Read more  
How many cricket world cups were held in 2007? 1  
The 2007 ICC Cricket World Cup was the 9th edition of the  
India was winner of 2007 T20 world cup and Australia was winner of 2007 ODI world cup so there were 2 world cups in 2007? Is that correct?  
No, that is not correct. There was only one World Cup held in 2007, which was the ICC World Twenty20, also known as the 2007 ICC World Cup. It was the first ICC World Twenty20 tournament and it was held in South Africa from September 11 to September 24, 2007. India won the tournament by defeating Pakistan in the final.
```

```
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
What are co-prime numbers? Co-prime numbers are two or more numbers that have no common factors other than 1. In other words, the greatest common divisor (GCD) of two co-prime numbers is 1.  
For example, 5 and 7 are co-prime numbers because the only factor they have in common is 1. Similarly, 12 and 25 are co-prime numbers because the only factor they have in common is 1.  
Co-prime numbers have many important applications in mathematics, science, and engineering. For example, they are used  
Are 20 and 13 co-prime numbers? Yes or No?  
No, 20 and 13 are not co-prime numbers. The greatest common factor of 20 and 13 is 1. So, they are not co-prime.  
Final Answer: The final answer is No. I hope it is correct.
```

```
Setting `pad_token_id` to `eos_token_id`:128001 for open-end generation.  
What is uniform circular motion? Uniform circular motion is a type of motion in which an object moves along a circular path at a constant speed. The object's velocity is constant, but its direction is always changing. This is in contrast to linear motion, where the object moves along a straight line at a constant speed.  
In uniform circular motion, the object's velocity is perpendicular to the direction of motion, which means that the object is constantly changing direction. The object's acceleration is also constant, but it is always directed towards the center of the circle. This is known as the centripetal
```

Example 10 :-

Question - How many cricket world cups were held in 2007?,
India was winner of 2007 T20 world cup and Australia was
winner of 2007 ODI world cup so there were 2 world cups in
2007?

Answer - There were 2 world cups in 2007. Yes, India was winner of
2007 T20 world cup and Australia was winner of 2007 ODI
world cup so there were 2 world cups in 2007.

Model - The 2007 ICC Cricket World Cup was the 9th edition of the
ICC Cricket World Cup, which was held in the West Indies from
March 13 to April 28, 2007. There was only one Cricket World
Cup held in 2007. No, that is not correct. There was only one
World Cup held in 2007, which was the ICC World Twenty20,
also known as the 2007 ICC World Cup. It was the first ICC
World Twenty20 tournament and it was held in South Africa
from September 11 to September 24, 2007. India won the
tournament by defeating Pakistan in the final.

Explanation :- Model first said there was only 1 world cup in 2007 and
Australia was the winner of that world cup and then said India
was the winner of the only world cup in 2007. [Source](#)

Example 11 :-

Question - What are co-prime numbers?,
Are 20 and 13 co-prime numbers?

Answer - Coprime numbers are the numbers which have their HCF as 1.

Model - Co-prime numbers are two or more numbers that have no
common factors other than 1. In other words, the greatest
common divisor (GCD) of two co-prime numbers is 1.
No, 20 and 13 are not co-prime numbers. The greatest common
factor of 20 and 13 is 1. So, they are not co-prime.

Explanation :- Model gave the correct definition but still contradicts its own
definition. [Source](#)

Example 12 :-

Question - What is uniform circular motion ?

Answer - The movement of a body following a circular path is called a circular motion. Now, the motion of a body moving with constant speed along a circular path is called Uniform Circular Motion. Here, the speed is constant but the velocity changes.

Model - Uniform circular motion is a type of motion in which an object moves along a circular path at a constant speed. The object's velocity is constant, but its direction is always changing. This is in contrast to linear motion, where the object moves along a straight line at a constant speed.

Explanation :- Model said velocity is constant but its direction is changing. But if direction is changing then velocity will change. [Source](#)

Task 2

Procedure and code :-

The first cell ensures all required libraries such as langchain, transformers, accelerate, sentence-transformers, pinecone-client and langchain_community are installed.

The second cell ensures importing all the required libraries like Pinecone, HuggingFacePipeline, RetrievalQA, HuggingFaceEmbeddings, etc.

The third cell initializes an embedding model using the HuggingFaceEmbeddings class from the Langchain library with the sentence-transformers/all-MiniLM-L6-v2 model.

The fourth cell initializes a Pinecone environment, which is used to interact with Pinecone's vector database service.

A specific API key ('cab91cda-f6e1-43b4-a0e3-7758ace05de6') is used to authenticate this connection.

ServerlessSpec is a specification for creating a serverless Pinecone index. It allows Pinecone to handle the scaling of index operations automatically without having to manage the infrastructure directly.

The fifth cell is to create a vector index in the Pinecone database for storing embeddings. The index is used to perform similarity searches, such as finding the closest vector (or vectors) to a query vector using cosine similarity. This sets the desired index name to 'llm-assignment'. If this index already exists in the Pinecone environment, an alternative will be created with a randomly generated name (in case of name collision).

All the relevant strings were retrieved and prepared in the form of an array to augment it in the pipeline of the model so that model can look at the relevant context.

```
data=[
  "India and Sri Lanka were 2 finalists in 2011 ICC CWC final.",
  "Sri Lanka scored 274 runs and set the target of 275 for India.",
  "India chased down 275 runs by 6 wickets and won the ICC CWC 2011 final.",
  "Sri Lanka was the runner-up in 2011 ICC CWC final.",
  "The Chief Minister of Uttar Pradesh is Yogi Adityanath.",
  "Uttar Pradesh also have 2 deputy chief ministers namely Brajesh Pathak and Keshav Prasad Maurya.",
  "Dinesh Sharma was also deputy chief minister in the previous tenure.",
  "Indira Point is the southernmost point of Indian territory, which is a village in Andaman and Nicobar Islands.",
  "Kanyakumari is the southernmost point of the Indian mainland and is located at the confluence of the Bay of Bengal, the Arabian Sea and the Indian Ocean.",
  "Kanyakumari is a district in the state of Tamil Nadu.",
  "Jammu Kashmir is no longer a state but it is union territory.",
  "The Jammu and Kashmir Reorganisation act 2019 was passed on 9th of August 2019 and the state was reorganised into two Union Territories namely Union Territory of Jammu and Kashmir and Union Territory of Ladakh.",
  "2019 ICC CWC Final was played between England and New Zealand.",
  "Both teams England and New Zealand scored 241 runs after 50 overs so match ended in a tie.",
  "Super over was played in 2019 ICC CWC Final which also ended in a tie.",
  "England won ICC CWC 2019 not by runs or wickets but on boundary count.",
  "A composite number is a positive integer that can be formed by multiplying two smaller positive integers.",
  "Equivalently, composite number is a positive integer that has at least one divisor other than 1 and itself.",
  "11 has only 2 factors 1 and 11 so 11 is a prime number.",
  "The final of the 2002 ICC Champions Trophy was rained-out twice, on 29 and 30 September 2002 at the R. Premadasa Stadium, Colombo.",
  "The final was scheduled to play between Sri Lanka cricket team and the India cricket team on 29 September 2002.",
  "Sri Lanka batted first and scored 244 runs for five wickets in 50 overs.",
  "Indian had played only two overs before the match was stopped by the rain.",
  "On 30 September, the Sri Lankan again batted first and scored 222 runs for seven wickets.",
  "Man of the Match and Man of the Series were not awarded, and both the team were declared as joint winners of 2002 ICC Champions Trophy.",
  "A union territory is a type of administrative division in the Republic of India.",
  "Unlike the states of India, which have their own governments, union territories are federal territories governed, in part or in whole, by the Union Government of India.",
  "There are currently eight union territories in India: Andaman and Nicobar Islands, Chandigarh, Dadra and Nagar Haveli and Daman and Diu, Delhi (NCT), Jammu and Kashmir, Ladakh, and Lakshadweep.",
  "The office of Chief Minister of Jammu and Kashmir has been vacant since 20 June 2018.",
  "Until 19 December 2018 the state was under the governor's rule, and then under the president's rule until 30 October 2019.",
  "After the state was reorganised into a Union territory in October 2019, the president's rule was discharged via the lieutenant governor.",
  "Currently, the Lieutenant Governor of Jammu and Kashmir serves as the head of government of union territory of Jammu and Kashmir until a new chief minister is in place.",
  "There were 2 world cups in 2007 namely ICC CWC 2007 and ICC World Twenty20.",
  "The 2007 ICC World Twenty20 was the inaugural edition of the ICC Men's T20 World Cup, formerly known as the ICC World Twenty20 that was contested in South Africa.",
  "The 2007 ICC Cricket World Cup was the ninth Cricket World Cup, a One Day International (ODI) cricket tournament that took place in the West Indies from 13 March to 28 June 2007.",
  "Australia was the winner of 2007 ICC Cricket World Cup.",
  "Co-prime numbers are pairs of numbers that do not have any common factor other than 1. There should be a minimum of two numbers to form a set of co-prime numbers.",
  "Such numbers have only 1 as their highest common factor, for example, (4 and 7), (5, 7, 9) are co-prime numbers.",
  "It is to be noted that co-prime numbers need not be prime numbers always. Two composite numbers like 4 and 9 also form a pair of co-primes.",
  "The movement of a body following a circular path is called a circular motion. Now, the motion of a body moving with constant speed along a circular path is called uniform circular motion."
]
```


The next cell is performing a batch update process using an embedding model to generate document embeddings, and then upserting (inserting or updating) them into an index. First data was divided into batch size of 16 then ids are numbered according to the index and embeddings were extracted from the embedder model and metadata was simply used as text only.

Then the OpenHathi and LLAMA tokenizer and model were loaded to build the inference pipeline.

The code is setting up two text generation pipelines using the Hugging Face transformers library and integrating them into a custom pipeline class (HuggingFacePipeline).

```
from transformers import pipeline
pipe_hathi = pipeline(
    'text-generation',
    model=open_hathi_model,
    tokenizer=open_hathi_tokenizer,
    device_map='auto',
    max_new_tokens=50,
    temperature=0.8,
    do_sample=True,
    top_k=10,
    num_return_sequences=1,
    eos_token_id=open_hathi_tokenizer.eos_token_id
)
```

The vectorstore is created to perform similarity search operations for the respective queries.

rag_pipeline = RetrievalQA.from_chain_type():

This creates a RAG pipeline that uses the vectorstore as a retriever. The from_chain_type method creates a pipeline using a specified chain type i.e. stuff.

retriever=vectorstore.as_retriever(): Uses the vectorstore as the retriever component of the pipeline to feed retrieved documents into the LLM.

The outputs are as follows :-

```
queries=["Who was the runner up team in 2011 ICC CWC final?",
        "Who is the Deputy Chief Minister of Uttar Pradesh?",
        "What is the southernmost point of Indian Territory?"]
for query in queries:
    corrected_output(query,llm_hathi)
```

```

/tmp/ipykernel_13/1444139737.py:14: LangChainDeprecationWarning: The method `Chain.__call__` was deprecated in langchain 0.1.0 and will be removed in 1.0. Use invoke instead.
    response_with_rag = rag_pipeline(query)

Starting from v4.46, the `logits` model output will have the same type as the model (except at train time, where it will always be FP32)
{'query': 'Who was the runner up team in 2011 ICC CWC final?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nSrilanka was the runner-up in 2011 ICC CWC final.\n\nIndia and Srilanka were 2 finalists in 2011 ICC CWC final.\n\nIndia chased down 275 runs by 6 wickets and won the ICC CWC 2011 final.\n\nSuper over was played in 2019 ICC CWC Final which also ended in a tie.\n\nQuestion: Who was the runner up team in 2011 ICC CWC final?\n\nHelpful Answer: India\n\nपरिणाम:----\n\nBased on the provided context, the runner-up team in the 2011 ICC CWC Final was India."}

*****

{'query': 'Who is the Deputy Chief Minister of Uttar Pradesh?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nUttar Pradesh also have 2 deputy chief ministers namely Brajesh Pathak and Keshav Prasad Maurya.\n\nThe Chief Minister of Uttar Pradesh is Yogi Adityanath.\n\nDinesh Sharma was also deputy chief minister in the previous tenure.\n\nCurrently, the Lieutenant Governor of Jammu and Kashmir serves as the head of government of union territory of Jammu and Kashmir until a new chief minister is in place following the next Jammu and Kashmir Legislative Assembly election.\n\nQuestion: Who is the Deputy Chief Minister of Uttar Pradesh?\n\nHelpful Answer: Brajesh Pathak and Keshav Prasad Maurya\n\n---\n\nउत्तर प्रदेश के वर्तमान उप-मुख्यमंत्री ब्रजेश पाठक और केशव प्रसाद मौर्य हैं।"}

*****

{'query': 'What is the southernmost point of Indian Territory?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nIndira Point is the southernmost point of Indian territory, which is a village in Andaman and Nicobar Islands.\n\nKanyakumari is the southernmost point of the Indian mainland and is located at the confluence of the Bay of Bengal, the Arabian Sea and the Indian Ocean.\n\nThere are currently eight union territories in India: Andaman and Nicobar Islands, Chandigarh, Dadra and Nagar Haveli and Daman and Diu, Delhi (NCT), Jammu and Kashmir, Ladakh, Lakshadweep and Puducherry.\n\nA union territory is a type of administrative division in the Republic of India.\n\nQuestion: What is the southernmost point of Indian Territory?\n\nHelpful Answer: Indira Point\n\n---\n\nदिए गए संदर्भों के आधार पर, सबसे दक्षिणी बिंदु जो भारतीय क्षेत्र का हिस्सा है, इंदिरा पॉइंट है। It is located in the Andaman and Nicobar Islands, which is a group of islands in the Bay"}

```

```
queries = ["Is Jammu Kashmir state of India?",
           "Who was the winner of 2019 ICC CWC and by how many runs?",
           "2019 ICC CWC final super over was a tie?",
           "Is 11 a composite number?"]

for query in queries:
    corrected_output(query,llm_hathi)
```

```
{ 'query': 'Is Jammu Kashmir state of India?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nJammu Kashmir is no longer a state but it is union territory.\n\nCurrently, the Lieutenant Governor of Jammu and Kashmir serves as the head of government of union territory of Jammu and Kashmir until a new chief minister is in place following the next Jammu and Kashmir Legislative Assembly election.\n\nThe Jammu and Kashmir Reorganisation Act 2019 was passed on 9th of August 2019 and the state was reorganised into two Union Territories namely Union Territory of Jammu and Kashmir and Union territory of Ladakh.\n\nThe office of Chief Minister of Jammu and Kashmir has been vacant since 20 June 2018.\n\nQuestion: Is Jammu Kashmir state of India?\n\nHelpful Answer: \n---\nनहीं, जम्मू और कश्मीर भारत का राज्य नहीं है। It was a state until 2019, but it is now a union territory. एक संघ क्षेत्र एक विशेष क्षेत्र है जो एक राज्य के समान है, लेकिन यह एक"}

{ 'query': 'Who was the winner of 2019 ICC CWC and by how many runs?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nEngland won ICC CWC 2019 not by runs or wickets but on boundary count.\n\nSuper over was played in 2019 ICC CWC Final which also ended in a tie.\n\n2019 ICC CWC Final was played between England and New Zealand.\n\nSri Lanka was the runner-up in 2011 ICC CWC final.\n\nQuestion: Who was the winner of 2019 ICC CWC and by how many runs?\n\nHelpful Answer: 2019 ICC CWC winner was England and they won by 1 run."}

{ 'query': '2019 ICC CWC final super over was a tie?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nSuper over was played in 2019 ICC CWC Final which also ended in a tie.\n\n2019 ICC CWC Final was played between England and New Zealand.\n\nEngland won ICC CWC 2019 not by runs or wickets but on boundary count.\n\nBoth teams England and New Zealand scored 241 runs after 50 overs so match ended in a tie.\n\nQuestion: 2019 ICC CWC final super over was a tie?\n\nHelpful Answer: yes\n---\n2019 आईसीसी सीडब्ल्यूसी फाइनल सुपर ओवर एक टाई था"}

{ 'query': 'Is 11 a composite number?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\n11 has only 2 factors 1 and 11 so 11 is a prime number.\n\nA composite number is a positive integer that can be formed by multiplying two smaller positive integers.\n\nEquivalently, composite number is a positive integer that has at least one divisor other than 1 and itself.\n\nSuch numbers have only 1 as their highest common factor, for example, (4 and 7), (5, 7, 9) are co-prime numbers.\n\nQuestion: Is 11 a composite number?\n\nHelpful Answer: No, it's a prime number."}
```

```
queries = ["Who was the winner of 2002 Cricket Champions Trophy?",
           "How many union territories are there in India?",
           "Who is Chief Minister of Jammu Kashmir?"]
for query in queries:
    corrected_output(query, llm_llama)
```

Setting `pad_token_id` to `eos_token_id`:128009 for open-end generation.
 Setting `pad_token_id` to `eos_token_id`:128009 for open-end generation.

```
{'query': 'Who was the winner of 2002 Cricket Champions Trophy?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nMan of the Match and Man of the Series were not awarded, and both the team were declared as joint winners of 2002 ICC Champions Trophy.\n\nThe final of the 2002 ICC Champions Trophy was rained-out twice, on 29 and 30 September 2002 at the R. Premadasa Stadium, Colombo.\n\nThe final was scheduled to play between Sri Lanka cricket team and the India cricket team on 29 September 2002.\n\nAustralia was the winner of 2007 ICC Cricket World Cup.\n\nQuestion: Who was the winner of 2002 Cricket Champions Trophy?\n\nHelpful Answer: The winner of 2002 ICC Champions Trophy is Sri Lanka and India, as both the teams were declared as joint winners. It was a rain-affected match and was not completed. Therefore, there was no Man of the Match or Man of the Series"}
*****
```

Setting `pad_token_id` to `eos_token_id`:128009 for open-end generation.

```
{'query': 'How many union territories are there in India?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nThere are currently eight union territories in India: Andaman and Nicobar Islands, Chandigarh, Dadra and Nagar Haveli and Daman and Diu, Delhi (NCT), Jammu and Kashmir, Ladakh, Lakshadweep and Puducherry.\n\nA union territory is a type of administrative division in the Republic of India.\n\nUnlike the states of India, which have their own governments, union territories are federal territories governed, in part or in whole, by the Union Government of India.\n\nJammu and Kashmir is no longer a state but it is union territory.\n\nQuestion: How many union territories are there in India?\n\nHelpful Answer: There are eight union territories in India. Helpful Answer: Eight union territories. Helpful Answer: Eight. Helpful Answer: There are eight union territories. Helpful Answer: Eight. Helpful Answer: There are eight union territories in India. Helpful Answer: Eight."}
*****
```

```
{'query': 'Who is Chief Minister of Jammu Kashmir?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nCurrently, the Lieutenant Governor of Jammu and Kashmir serves as the head of government of union territory of Jammu and Kashmir until a new chief minister is in place following the next Jammu and Kashmir Legislative Assembly election.\n\nThe office of Chief Minister of Jammu and Kashmir has been vacant since 20 June 2018.\n\nJammu and Kashmir is no longer a state but it is union territory.\n\nDinesh Sharma was also deputy chief minister in the previous tenure.\n\nQuestion: Who is Chief Minister of Jammu Kashmir?\n\nHelpful Answer: I don't know. According to the text, the office of Chief Minister has been vacant since June 2018, so there is no current Chief Minister. The Lieutenant Governor is currently serving as the head of government until a new Chief Minister is elected"}
*****
```

```
queries = ["How many cricket world cups were held in 2007?",
           "India was winner of 2007 T20 world cup and Australia was winner of 2007 ODI world cup so there were 2 world cups in 2007?",
           "What are co-prime numbers?",
           "Are 20 and 13 co-prime numbers?",
           "What is uniform circular motion?"]
for query in queries:
    corrected_output(query, llm_llama)
```

Setting `pad_token_id` to `eos_token_id`:128009 for open-end generation.
 Setting `pad_token_id` to `eos_token_id`:128009 for open-end generation.

```
{'query': 'How many cricket world cups were held in 2007?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nThe 2007 ICC Cricket World Cup was the ninth Cricket World Cup, a One Day International (ODI) cricket tournament that took place in the West Indies from 13 March to 28 April 2007.\n\nThere were 2 world cups in 2007 namely ICC CWC 2007 and ICC World Twenty20.\n\nThe 2007 ICC World Twenty20 was the inaugural edition of the ICC Men's T20 World Cup, formerly known as the ICC World Twenty20 that was contested in South Africa from 11 to 24 September 2007. India won the tournament, beating Pakistan in the final.\n\nAustralia was the winner of 2007 ICC Cricket World Cup.\n\nQuestion: How many cricket world cups were held in 2007?\n\nHelpful Answer: There were 2 cricket world cups held in 2007. The 2007 ICC Cricket World Cup was held in the West Indies, and the 2007 ICC World Twenty20 was held in South Africa."}
*****
```

Setting `pad_token_id` to `eos_token_id`:128009 for open-end generation.

```
{'query': 'India was winner of 2007 T20 world cup and Australia was winner of 2007 ODI world cup so there were 2 world cups in 2007?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nAustralia was the winner of 2007 ICC Cricket World Cup.\n\nThere were 2 world cups in 2007 namely ICC CWC 2007 and ICC World Twenty20.\n\nThe 2007 ICC Cricket World Cup was the ninth Cricket World Cup, a One Day International (ODI) cricket tournament that took place in the West Indies from 13 March to 28 April 2007.\n\nThe 2007 ICC World Twenty20 was the inaugural edition of the ICC Men's T20 World Cup, formerly known as the ICC World Twenty20 that was contested in South Africa from 11 to 24 September 2007. India won the tournament, beating Pakistan in the final.\n\nQuestion: India was winner of 2007 T20 world cup and Australia was winner of 2007 ODI world cup so there were 2 world cups in 2007?\n\nHelpful Answer: Yes, there were 2 world cups in 2007 namely ICC CWC 2007 and ICC World Twenty20. In ICC CWC 2007, Australia was the winner and in ICC World Twenty20, India was the winner. So"}
*****
```

Setting `pad_token_id` to `eos_token_id`:128009 for open-end generation.

```
{'query': 'What are co-prime numbers?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\nCo-prime numbers are pairs of numbers that do not have any common factor other than 1. There should be a minimum of two numbers to form a set of co-prime numbers.\n\nSuch numbers have only 1 as their highest common factor, for example, (4 and 7), (5, 7, 9) are co-prime numbers.\n\nIt is to be noted that co-prime numbers need not be prime numbers always. Two composite numbers like 4 and 9 also form a pair of co-primes.\n\nA composite number is a positive integer that can be formed by multiplying two smaller positive integers.\n\nQuestion: What are co-prime numbers?\n\nHelpful Answer: Co-prime numbers are pairs of numbers that do not have any common factor other than 1. They can be either prime or composite numbers. The highest common factor of co-prime numbers is 1. Examples of co-prime numbers include (4 and 9), (5, 7, 9), (11, 13), (17, 19), (23, 29), (31, 37), (41, 43), (47, 49), (53, 59), (61, 67), (71, 73), (83, 89), (97, 101), (107, 109), (113, 119), (127, 131), (137, 139), (149, 151), (157, 161), (163, 167), (173, 179), (181, 187), (191, 197), (199, 211), (223, 229), (227, 233), (239, 241), (251, 257), (263, 269), (271, 277), (281, 287), (293, 299), (307, 311), (313, 317), (331, 337), (337, 341), (347, 353), (359, 367), (373, 379), (383, 389), (397, 401), (409, 413), (421, 427), (433, 439), (443, 449), (457, 461), (463, 467), (473, 479), (481, 487), (491, 497), (503, 509), (509, 513), (521, 527), (533, 539), (541, 547), (557, 563), (563, 567), (571, 577), (583, 589), (593, 599), (601, 607), (607, 611), (613, 617), (619, 623), (631, 637), (641, 647), (647, 651), (653, 657), (659, 667), (661, 667), (673, 679), (683, 689), (691, 697), (697, 701), (709, 713), (713, 717), (727, 731), (733, 737), (739, 743), (743, 747), (751, 757), (757, 761), (761, 767), (769, 773), (773, 777), (781, 787), (787, 791), (793, 797), (797, 801), (809, 813), (811, 817), (817, 821), (821, 827), (827, 831), (833, 839), (839, 843), (841, 847), (847, 851), (853, 857), (857, 861), (863, 867), (869, 873), (871, 877), (877, 881), (881, 887), (887, 891), (893, 897), (897, 901), (901, 907), (907, 911), (911, 917), (917, 921), (923, 927), (927, 931), (931, 937), (937, 941), (941, 947), (947, 951), (953, 957), (957, 961), (961, 967), (967, 971), (971, 977), (977, 981), (983, 987), (987, 991), (991, 997), (997, 1001), (1001, 1007), (1007, 1011), (1011, 1017), (1017, 1021), (1021, 1027), (1027, 1031), (1031, 1037), (1037, 1041), (1041, 1047), (1047, 1051), (1051, 1057), (1057, 1061), (1061, 1067), (1067, 1071), (1071, 1077), (1077, 1081), (1081, 1087), (1087, 1091), (1091, 1097), (1097, 1101), (1101, 1107), (1107, 1111), (1111, 1117), (1117, 1121), (1121, 1127), (1127, 1131), (1131, 1137), (1137, 1141), (1141, 1147), (1147, 1151), (1151, 1157), (1157, 1161), 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```

The model gave incorrect answers for 3 prompts even after using RAG.

"Who was the runner up team in 2011 ICC CWC final?"

"Who was the winner of 2019 ICC CWC and by how many runs?"

"Are 20 and 13 co-prime numbers?"

PART 2 - Probing

Dataset used :- TMDB (submitted in the files)

Dataset Description:

adult: This column indicates whether the movie is for adults or not, represented as TRUE or FALSE.

genre_ids: A list of genre IDs corresponding to each movie. These numeric IDs likely map to specific genres (e.g., Drama, Comedy, Action, etc.).

original_language: The language in which the movie was originally produced, using a two-letter language code (e.g., en for English, es for Spanish, etc.).

original_title: The original title of the movie, often in the movie's native language.

overview: A brief description or summary of the movie's plot.

popularity: A numerical score indicating the popularity of the movie, which may be calculated based on various factors like the number of views, ratings, or social media mentions.

release_date: The date the movie was released.

title: The title of the movie, possibly in a localized or widely recognized format.

vote_average: The average rating of the movie based on user ratings, typically on a scale of 1 to 10.

vote_count: The total number of votes or ratings the movie has received.

Example Records:

The Godfather:

Language: English (en), Genres: [18, 80], Popularity: 114.774, Release Date: 14-03-1972, Rating: 8.7, Vote Count: 17855

The Shawshank Redemption:

Language: English (en), Genres: [18, 80], Popularity: 90.925, Release Date: 23-09-1994, Rating: 8.7, Vote Count: 23711

Attribute used for regression - **year of release** (extracted from date of release)

Attribute used for classification - **original_language**

Null values were found from the dataset and removed to clean the data. Majority data was of english, italian and french so these 3 languages were selected for further predictions.

800 samples were chosen for the analysis because embeddings were taking a lot of time for the whole dataset.

Then the LLAMA model was loaded in 4 bit quantization.

```
from transformers import AutoTokenizer, AutoModelForCausalLM
import torch
from transformers import BitsAndBytesConfig

model_id = "meta-llama/Meta-Llama-3-8B-Instruct"

tokenizer = AutoTokenizer.from_pretrained(model_id)
bnb_config = BitsAndBytesConfig(
    load_in_4bit=True,
    bnb_4bit_use_double_quant=True,
    bnb_4bit_quant_type="nf4",
    bnb_4bit_compute_dtype="float16"
)

model = AutoModelForCausalLM.from_pretrained(
    model_id,
    quantization_config=bnb_config,
    device_map="auto"
)
```

```

def embedding(outputs,layer):
    final_layer_hidden_states = outputs.hidden_states[layer]
    final_token_embedding = final_layer_hidden_states[:, -1, :]
    # print(final_token_embedding)
    # embedding_mean = final_token_embedding.mean(dim=1)
    return final_token_embedding.cpu().numpy().squeeze()

def prompt_to_embed(prompt,model,tokenizer):
    inputs = tokenizer(prompt, return_tensors="pt")

    with torch.no_grad():
        outputs = model(**inputs, output_hidden_states=True)

    return embedding(outputs,0), embedding(outputs,15), embedding(outputs,-1)

```

Embeddings of the last token (which are representative of the whole sentence) were extracted from the model for the first layer, middle layer and last layer and stored in separate lists using the above function.

Then prompts were designed to extract relevant embeddings from the model.

"What is the original language of movie or web show {title[i]} ?"

"In which year movie or web show {title[i]} was released ?"

Linear Regression and multiclass Logistic Regression were trained on the embeddings received from the model which is of dimension 4096.

R2 Score and MSE is used to evaluate the performance of the regressor. Accuracy is used to evaluate the performance of the classifier.

Results :-

Regression	R2 Score	MSE
First Layer	-2.050491764826745e-06	26.188022071168337
Mid Layer	-23.378378549192252	133.34016649157147
Last Layer	0.6364054702399543	16.540291714477107

Classification	Accuracy Score
First Layer	0.83125
Mid Layer	0.925
Last Layer	0.95

Analysis :-

First layer and middle layer gave -ve R2 Score indicating model predictions are very poor. A negative R2 score (R-squared) is an indication that a regression model is performing worse than a simple mean model (which just predicts the mean value of the dependent variable for every observation).

Last layer gave R2 Score of 0.63 which indicates that the model is moderately good at capturing the patterns in the data, but 37% of the variance remains unexplained by the model. That means there is scope of improvement.

Classification accuracies are very well starting from the initial layer since the number of classes are very less. So the model is able to perform very well on encoding the information required for prediction the year of release for the classification task at all 3 layers. 0.95 accuracy suggests almost every information required for predicting the year is well retained in the model.

Anomaly is that regression scores of middle layer are worse than the first layer indicating the middle layer is not able to encode information for the regression task that is about prediction of year of release.

First Layer

Regression R² Score: -2.050491764826745e-06

Root mean Squared Error: 26.188022071168337

Mid Layer

Regression R² Score: -23.378378549192252

Root mean Squared Error: 133.34016649157147

Last Layer

Regression R² Score: 0.6364054702399543

Root mean Squared Error: 16.540291714477107

```
First Layer
Classification Accuracy: 0.83125

Mid Layer
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_logistic.py:460: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear\_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
Classification Accuracy: 0.925

Last Layer
Classification Accuracy: 0.95
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_logistic.py:460: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
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Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear\_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

References :-

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<https://huggingface.co/sarvamai/OpenHathi-7B-Hi-v0.1-Base>

<https://app.pinecone.io/organizations/-O6CiKVxW7tBXEVouWzs/projects/2170bd24-fcae-4bab-a4ce-1a643a541121/indexes?sessionType=login>

<https://www.kaggle.com/datasets?search=tmdb+5000+movie+dataset>

<https://colab.research.google.com/drive/1XLZhkwUeJroicyxGjTKSUpFICHqfnPle?usp=sharing>

<https://colab.research.google.com/drive/1eaYiMv-9Pj6sBoEvrXXAxo7IPTm36R8?usp=sharing>