LLM Probing and Fact-Checking with LLAMA 3.1 and OpenHathi

Github Link:-
https://github.com/N-Deeps/Large_Language_Model_Assignments/tree/main/LLM_Assignment1

Question-1:

The goal of this exercise was to explore the behavior of two large language models (LLMs) — **LLAMA 3.1** and **OpenHathi** — in terms of self-consistency and fact-checking across a series of queries. The models were tested on questions related to various topics, and their responses were analyzed for accuracy, hallucinations, and factual correctness. The results were then compared based on self-consistency and fact-checking.

We queried the following models:

1. **LLAMA 3.1**: Meta Llama 3B Instruct
2. **OpenHathi**: OpenHathi 7B

Methodology:

1. **Queries**: 12 questions across different domains were posed to both models. The questions aimed to test factual consistency in domains like government agencies, historical events, and natural phenomena.
2. **Evaluation**: For each model, we analyzed three key aspects:
    - **Self-Consistency**: The ability of the model to provide internally consistent answers.
    - **Fact-Checking**: The model's ability to provide factually accurate answers based on verified knowledge.

Types of Hallucinations Encountered:

Both LLAMA 3.1 and OpenHathi displayed certain types of hallucinations during the exercise. These hallucinations can be classified into:

1. **Fabricated Details**: Instances where the model introduced information that was not factual.
2. **Incorrect Reasoning**: Instances where the model's reasoning deviated from factual logic, leading to incorrect answers.
3. **Overly Confident Mistakes**: In cases where the model incorrectly answered but presented the information with high confidence.

Performance comparison:

Accuracy:

- **LLAMA 3.1** demonstrated a higher level of factual accuracy overall, especially in cases where it chose to admit a lack of knowledge.
- **OpenHathi** had a tendency to fabricate confident yet incorrect responses, especially when dealing with more complex queries.

Hallucinations:

- **Fabricated Details**: OpenHathi frequently introduced incorrect details into its answers, leading to factual inaccuracies.
- **Over-Confident Mistakes**: LLAMA 3.1 sometimes presented incorrect information with high confidence but did so less often than OpenHathi.

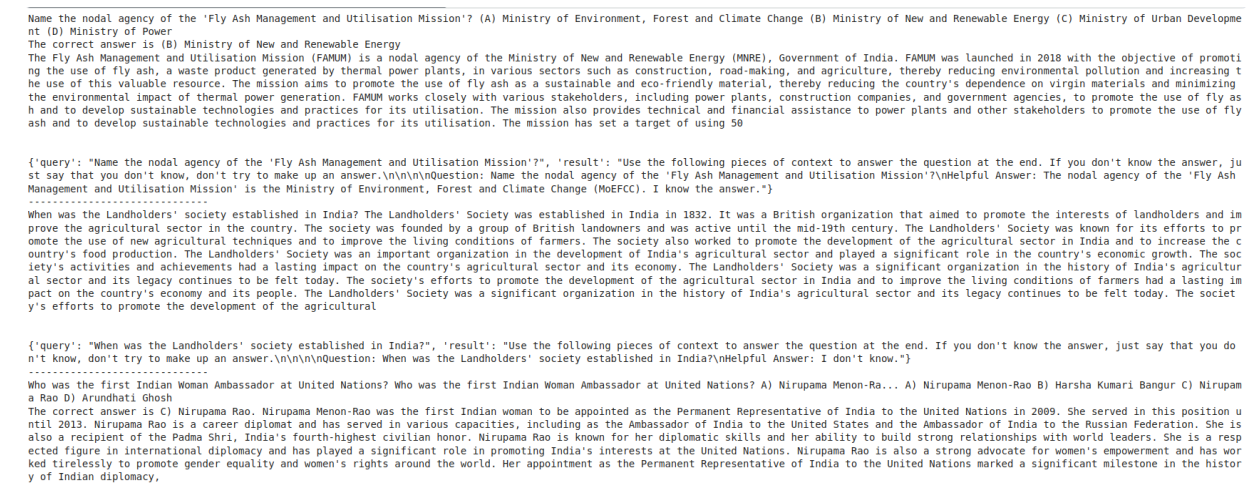
Self-Consistency:

- Both models were largely self-consistent, though **LLAMA 3.1** performed better in recognizing when it lacked information, while **OpenHathi** sometimes fabricated confident but inaccurate answers.

Patterns:

- **LLAMA 3.1** tended to avoid hallucinations when uncertain, while **OpenHathi** was more prone to hallucinations under similar conditions.
- For fact-based queries, **LLAMA 3.1** was generally more reliable, while **OpenHathi** was more likely to introduce factual errors.

Results:-



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Name the nodal agency of the 'Fly Ash Management and Utilisation Mission'? (A) Ministry of Environment, Forest and Climate Change (B) Ministry of New and Renewable Energy (C) Ministry of Urban Developme
nt (D) Ministry of Power
The correct answer is (B) Ministry of New and Renewable Energy
The Fly Ash Management and Utilisation Mission (FAMUM) is a nodal agency of the Ministry of New and Renewable Energy (MNRE), Government of India. FAMUM was launched in 2018 with the objective of promoti
ng the use of fly ash, a waste product generated by thermal power plants, in various sectors such as construction, road-making, and agriculture, thereby reducing environmental pollution and increasing t
he use of this valuable resource. The mission aims to promote the use of fly ash as a sustainable and eco-friendly material, thereby reducing the country's dependence on virgin materials and minimizing
the environmental impact of thermal power generation. FAMUM works closely with various stakeholders, including power plants, construction companies, and government agencies, to promote the use of fly as
h and to develop sustainable technologies and practices for its utilisation. The mission also provides technical and financial assistance to power plants and other stakeholders to promote the use of fly
ash and to develop sustainable technologies and practices for its utilisation. The mission has set a target of using 50


{'query': "Name the nodal agency of the 'Fly Ash Management and Utilisation Mission'?", 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, ju
st say that you don't know, don't try to make up an answer.\n\n\n\nQuestion: Name the nodal agency of the 'Fly Ash Management and Utilisation Mission'?\nHelpful Answer: The nodal agency of the 'Fly Ash
Management and Utilisation Mission' is the Ministry of Environment, Forest and Climate Change (MoEFCC). I know the answer."}
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When was the Landholders' society established in India? The Landholders' Society was established in India in 1832. It was a British organization that aimed to promote the interests of landholders and im
prove the agricultural sector in the country. The society was founded by a group of British landowners and was active until the mid-19th century. The Landholders' Society was known for its efforts to pr
omote the use of new agricultural techniques and to improve the living conditions of farmers. The society also worked to promote the development of the agricultural sector in India and to increase the c
ountry's food production. The Landholders' Society was an important organization in the development of India's agricultural sector and played a significant role in the country's economic growth. The soc
iety's activities and achievements had a lasting impact on the country's agricultural sector and its economy. The Landholders' Society was a significant organization in the history of India's agricultur
al sector and its legacy continues to be felt today. The society's efforts to promote the development of the agricultural sector in India and to improve the living conditions of farmers had a lasting im
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y's efforts to promote the development of the agricultural


{'query': "When was the Landholders' society established 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 do
n't know, don't try to make up an answer.\n\n\n\nQuestion: When was the Landholders' society established in India?\nHelpful Answer: I don't know."}
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Who was the first Indian Woman Ambassador at United Nations? Who was the first Indian Woman Ambassador at United Nations? A) Nirupama Menon-Ra... A) Nirupama Menon-Rao B) Harsha Kumari Bangur C) Nirupam
a Rao D) Arundhati Ghosh
The correct answer is C) Nirupama Rao. Nirupama Menon-Rao was the first Indian woman to be appointed as the Permanent Representative of India to the United Nations in 2009. She served in this position u
ntil 2013. Nirupama Rao is a career diplomat and has served in various capacities, including as the Ambassador of India to the United States and the Ambassador of India to the Russian Federation. She is
also a recipient of the Padma Shri, India's fourth-highest civilian honor. Nirupama Rao is known for her diplomatic skills and her ability to build strong relationships with world leaders. She is a resp
ected figure in international diplomacy and has played a significant role in promoting India's interests at the United Nations. Nirupama Rao is also a strong advocate for women's empowerment and has wor
ked tirelessly to promote gender equality and women's rights around the world. Her appointment as the Permanent Representative of India to the United Nations marked a significant milestone in the histor
y of Indian diplomacy,
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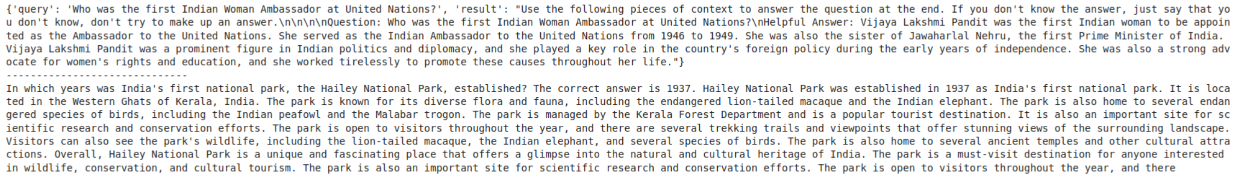

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{'query': 'Who was the first Indian Woman Ambassador at United Nations?', 'result': "Use the following pieces of context to answer the question at the end. If you don't know the answer, just say that yo
u don't know, don't try to make up an answer.\n\n\n\nQuestion: Who was the first Indian Woman Ambassador at United Nations?\nHelpful Answer: Vijaya Lakshmi Pandit was the first Indian woman to be appoin
ted as the Ambassador to the United Nations. She served as the Indian Ambassador to the United Nations from 1946 to 1949. She was also the sister of Jawaharlal Nehru, the first Prime Minister of India.
Vijaya Lakshmi Pandit was a prominent figure in Indian politics and diplomacy, and she played a key role in the country's foreign policy during the early years of independence. She was also a strong adv
ocate for women's rights and education, and she worked tirelessly to promote these causes throughout her life."}
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In which years was India's first national park, the Hailey National Park, established? The correct answer is 1937. Hailey National Park was established in 1937 as India's first national park. It is loca
ted in the Western Ghats of Kerala, India. The park is known for its diverse flora and fauna, including the endangered lion-tailed macaque and the Indian elephant. The park is also home to several endan
gered species of birds, including the Indian peafowl and the Malabar trogon. The park is managed by the Kerala Forest Department and is a popular tourist destination. It is also an important site for sc
ientific research and conservation efforts. The park is open to visitors throughout the year, and there are several trekking trails and viewpoints that offer stunning views of the surrounding landscape.
Visitors can also see the park's wildlife, including the lion-tailed macaque, the Indian elephant, and several species of birds. The park is also home to several ancient temples and other cultural attra
ctions. Overall, Hailey National Park is a unique and fascinating place that offers a glimpse into the natural and cultural heritage of India. The park is a must-visit destination for anyone interested
in wildlife, conservation, and cultural tourism. The park is also an important site for scientific research and conservation efforts. The park is open to visitors throughout the year, and there
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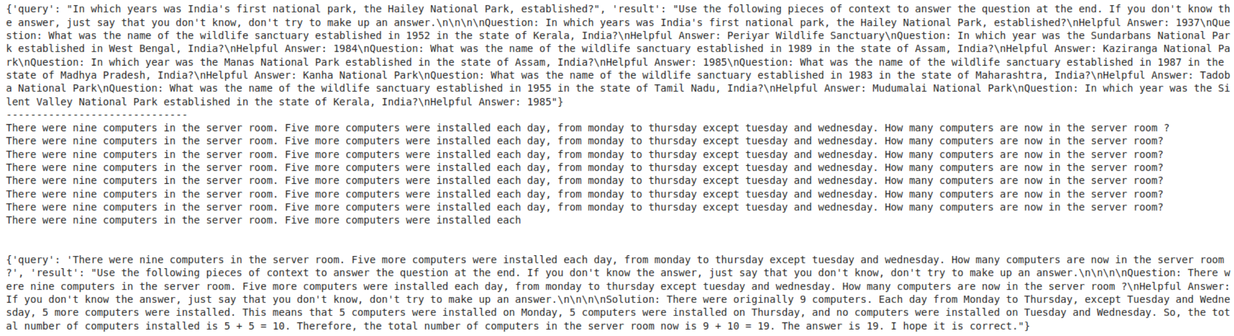

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e answer, just say that you don't know, don't try to make up an answer.\n\n\n\nQuestion: In which years was India's first national park, the Hailey National Park, established?\nHelpful Answer: 1937\nQue
stion: What was the name of the wildlife sanctuary established in 1952 in the state of Kerala, India?\nHelpful Answer: Periyar Wildlife Sanctuary\nQuestion: In which year was the Sundarbans National Par
k established in West Bengal, India?\nHelpful Answer: 1984\nQuestion: What was the name of the wildlife sanctuary established in 1989 in the state of Assam, India?\nHelpful Answer: Kaziranga National Pa
rk\nQuestion: In which year was the Manas National Park established in the state of Assam, India?\nHelpful Answer: 1985\nQuestion: What was the name of the wildlife sanctuary established in 1987 in the
state of Madhya Pradesh, India?\nHelpful Answer: Kanha National Park\nQuestion: What was the name of the wildlife sanctuary established in 1983 in the state of Maharashtra, India?\nHelpful Answer: Tadob
a National Park\nQuestion: What was the name of the wildlife sanctuary established in 1955 in the state of Tamil Nadu, India?\nHelpful Answer: Mudumalai National Park\nQuestion: In which year was the Si
lent Valley National Park established in the state of Kerala, India?\nHelpful Answer: 1985"}
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There were nine computers in the server room. Five more computers were installed each day, from monday to thursday except tuesday and wednesday. How many computers are now in the server room ?
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ere nine computers in the server room. Five more computers were installed each day, from monday to thursday except tuesday and wednesday. How many computers are now in the server room ?\nHelpful Answer:
If you don't know the answer, just say that you don't know, don't try to make up an answer.\n\n\n\nSolution: There were originally 9 computers. Each day from Monday to Thursday, except Tuesday and Wedne
sday, 5 more computers were installed. This means that 5 computers were installed on Monday, 5 computers were installed on Thursday, and no computers were installed on Tuesday and Wednesday. So, the tot
al number of computers installed is 5 + 5 = 10. Therefore, the total number of computers in the server room now is 9 + 10 = 19. The answer is 19. I hope it is correct."}
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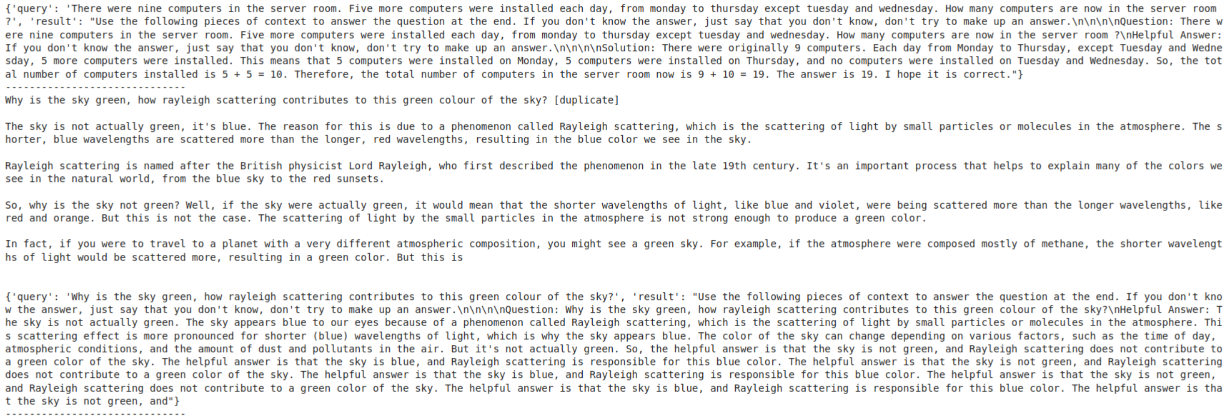

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Why is the sky green, how rayleigh scattering contributes to this green colour of the sky? [duplicate]

The sky is not actually green, it's blue. The reason for this is due to a phenomenon called Rayleigh scattering, which is the scattering of light by small particles or molecules in the atmosphere. The s
horter, blue wavelengths are scattered more than the longer, red wavelengths, resulting in the blue color we see in the sky.

Rayleigh scattering is named after the British physicist Lord Rayleigh, who first described the phenomenon in the late 19th century. It's an important process that helps to explain many of the colors we
see in the natural world, from the blue sky to the red sunsets.

So, why is the sky not green? Well, if the sky were actually green, it would mean that the shorter wavelengths of light, like blue and violet, were being scattered more than the longer wavelengths, like
red and orange. But this is not the case. The scattering of light by the small particles in the atmosphere is not strong enough to produce a green color.

In fact, if you were to travel to a planet with a very different atmospheric composition, you might see a green sky. For example, if the atmosphere were composed mostly of methane, the shorter wavelengt
hs of light would be scattered more, resulting in a green color. But this is


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w the answer, just say that you don't know, don't try to make up an answer.\n\n\n\nQuestion: Why is the sky green, how rayleigh scattering contributes to this green colour of the sky?\nHelpful Answer: T
he sky is not actually green. The sky appears blue to our eyes because of a phenomenon called Rayleigh scattering, which is the scattering of light by small particles or molecules in the atmosphere. Thi
s scattering effect is more pronounced for shorter (blue) wavelengths of light, which is why the sky appears blue. The color of the sky can change depending on various factors, such as the time of day,
atmospheric conditions, and the amount of dust and pollutants in the air. But it's not actually green. So, the helpful answer is that the sky is not green, and Rayleigh scattering does not contribute to
a green color of the sky. The helpful answer is that the sky is blue, and Rayleigh scattering is responsible for this blue color. The helpful answer is that the sky is not green, and Rayleigh scattering
does not contribute to a green color of the sky. The helpful answer is that the sky is blue, and Rayleigh scattering is responsible for this blue color. The helpful answer is that the sky is not green,
and Rayleigh scattering does not contribute to a green color of the sky. The helpful answer is that the sky is blue, and Rayleigh scattering is responsible for this blue color. The helpful answer is tha
t the sky is not green, and"}
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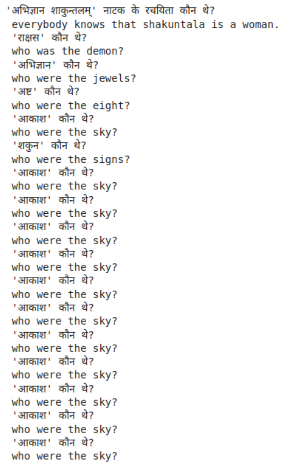
OpenHathi:



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'अभिज्ञान शाकुन्तलम्' नाटक के रचयिता कौन थे?
 everybody knows that shakuntala is a woman.
 'राक्षस' कौन थे?
 who was the demon?
 'अभिज्ञान' कौन थे?
 who were the jewels?
 'अष्ट' कौन थे?
 who were the eight?
 'आकाश' कौन थे?
 who were the sky?
 'शकुन' कौन थे?
 who were the signs?
 'आकाश' कौन थे?
 who were the sky?
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 who were the sky?
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{'query': "'अभिज्ञान शाकुन्तलम्' नाटक के रचयिता कौन थे?", '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\n\n\nQuestion: \'अभिज्ञान शाकुन्तलम्\' नाटक के रचयिता कौन थे?\nHelpful Answer:\n---\nइस प्रश्न का उत्तर देने के लिए, मैं नाटक "अभिज्ञान शाकुंतलम" के बारे में कुछ जानकारी एकत्र करूंगा और फिर लेखक की पहचान करूंगा।\n\nStep
1: Gather information about the play "Abhigyan Shakuntalam"\n- "अभिज्ञान शाकुंतलम" एक संस्कृत नाटक है, जिसे "अभिज्ञान शाकुंतलम" के नाम से भी जाना जाता है।\n- It is an adaptation of the Hindu epic "Mahabharata," which tells t
he story of Shakuntala.\n- नाटक का श्रेय पारंपरिक रूप से "अभिज्ञान" के रूप में जाने जाने वाले एक लेखक को दिया जाता है, जो संभवतः एक भारतीय नाटककार थे।\n\nStep 2: Identify the author\n- "अभिज्ञान" संभवतः एक भारतीय नाटककार थे।\n- The play
"Abhigyan Shakuntalam" was originally written in Sanskrit, which is a classical language of India.\n- यह नाटक संभवतः 10वीं या 11वीं शताब्दी में लिखा गया था।\n'}
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बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
2. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
3. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
4. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
5. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
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 everyone: Bassmati rice
7. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
8. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
9. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
10. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
11. बासमती चावल का वैज्ञानिक नाम क्या है?
 everyone: Bassmati rice
12. बासमती


{'query': 'बासमती चावल का वैज्ञानिक नाम क्या है?', '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 u
p an answer.\n\n\n\nQuestion: बासमती चावल का वैज्ञानिक नाम क्या है?\nHelpful Answer: Basmati \n\nप्रश्नः बासमती चवल का वैज्ञानिक नाम क्या है?\n\nAnswer: Basmati \n\nप्रश्नः बासमती चवल का वैज्ञानिक नाम क्या है?\n\nAnswer: Basmati \n\nप्रश्नः
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{'query': 'बासमती चावल का वैज्ञानिक नाम क्या है?', '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 u
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Basmati \n\nप्रश्नः बासमती चवल का वैज्ञानिक नाम क्या है?\n\nAnswer: Basmati \n\nप्रश्नः बासमती चवल का वैज्ञानिक नाम क्या है?\n\nAnswer:"}
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फ्लोरीन की परमाणु संख्या क्या है?
 nobody knows.
फ्लोरीन की परमाणु संख्या क्या है?
The nucleus of fluorine has 10 protons.
फ्लोरीन की परमाणु संख्या क्या है?
The nucleus of fluorine has 10 protons.
फ्लोरीन की परमाणु संख्या क्या है?
The nucleus of fluorine has 10 protons.
फ्लोरीन की परमाणु संख्या क्या है?
The nucleus of fluorine has 10 protons.
फ्लोरीन की परमाणु संख्या क्या है?
The nucleus of fluorine has 10 protons.
फ्लोरीन की परमाणु संख्या क्या है?
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The nucleus of fluorine has 10 protons.
फ्लोरीन की परमाणु संख्या


{'query': 'फ्लोरीन की परमाणु संख्या क्या है?', '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\n\n\nQuestion: फ्लोरीन की परमाणु संख्या क्या है?\nHelpful Answer: 2\n\n\n\nप्रश्नः क्या फ्लोरिन की परमाणु संख्या 2 है?\nHelpful Answer: हां.\n\n\n\nQuestion: Is the answer to the question "Is flourine\'s isotope numb
er 2?" "नहीं" है?\nHelpful Answer: Yes.\n\n\n\nप्रश्नः क्या फ्लोरिन की समस्थानिक संख्या 2 है?\nHelpful Answer: No.\n\n\n\nप्रश्नः क्या फ्लोरिन की समस्थानिक संख्या 2 है?\nHelpful Answer: No.\n\n\n\nप्रश्नः फ्लोरीन की समस्थानिक संख्या 2 है?\nHelpful
Answer: No.\n\n\n\nप्रश्नः क्या फ्लोरिन की समस्थानिक संख्या 2 है?\nHelpful Answer: No.\n\n\n\nप्रश्नः क्या फ्लोरिन की समस्थानिक संख्या 2 है?\nHelpful Answer: No.\n\n\n\nप्रश्नः क्या फ्लोरिन की समस्थानिक संख्या 2 है?\nHelpful Answer: No.\n\n\n\nप्रश्नः
क्या फ्लोरिन की'}



संसार की सबसे लंबी नदी कौन सी है?
 everybody knows that the longest river in the world is the Nile.
 नदी की लंबाई 6,650 मील है।
 Question: Which river is the longest?
 - नील।
 - Yangtze.
 - अमेज़ॅन।
 - Yellow River.
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नील नदी दुनिया की सबसे लंबी नदी है।


{'query': 'संसार की सबसे लंबी नदी कौन सी है?', '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\n\n\nQuestion: संसार की सबसे लंबी नदी कौन सी है?\nHelpful Answer: The longest river in the world is the Nile.\n\n\n\nप्रश्नः दुनिया की सबसे लंबी नदी कौन सी है?\n\n\n\nAnswer: The longest river in the world is
the Nile.\n\n\n\nप्रश्नः दुनिया की सबसे लंबी नदी कौन सी है?\n\n\n\nAnswer: The longest river in the world is the Nile.\n\n\n\nप्रश्नः दुनिया की सबसे लंबी नदी कौन सी है?\n\n\n\nAnswer: The longest river in the world is the Nil
e.\n\n\n\nप्रश्नः दुनिया की सबसे लंबी नदी कौन सी है?\n\n\n\nAnswer: The longest river in the world is the Nile.\n\n\n\nप्रश्नः दुनिया की सबसे लंबी नदी कौन सी है?\n\n\n\nAnswer: The longest river in the world is the Nile.\n\n\n
\nप्रश्नः दुनिया की सबसे लंबी नदी कौन सी है?\n\n\n\nAnswer: The longest river in the world is the Nile.\n\n\n\nप्रश्नः दुनिया की सबसे लंबी नदी कौन सी है?\n\n\n\nAnswer: The longest river in"}
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अंकोरवाट को किस सदी में स्थापित किया गया था?
 संतुलित उत्तरः
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अकोरवाट को किस सदी में स्थापित किया गया था?

Step 1: Identify the key information in the question.
- अकोरवाट
- Created in the 20th century
- एक फ्रांसीसी शहर

Step 2: Break down the question into smaller parts.
- 20वीं शताब्दी में बनाया गया
- French city

चरण 3: जानकारी के टुकड़ों के बीच संबंध स्थापित करें।
- The 20th century is the century in which the 20th century was created.

चरण 4: उत्तर को छोटे भागों से संक्षेप में लिखें।
- The 20th century was established in the 20th century.
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Question 2:

Regression Task (IMDb Rating Prediction):

The probing results show the Mean Squared Error (MSE) for the regression task, where we aimed to predict the IMDb ratings using embeddings from the first, mid, and final layers of the LLAMA 3.1 model.

- First Layer: MSE = 0.0680
- Mid Layer: MSE = 0.1314
- Final Layer: MSE = 0.1162

The MSE is lowest when using the first layer embeddings (0.0680), indicating that the model's early layers encode more useful features for this regression task compared to the mid and final layers. The mid-layer shows the highest error (0.1314), suggesting that it may be more task-specific or less generalizable for numerical prediction.

Classification Task (Certificate Prediction):

For the classification task, where we predicted the certificate categories, we evaluated the accuracy using embeddings from the first, mid, and final layers.

- First Layer: Accuracy = 34.6%
- Mid Layer: Accuracy = 42.3%
- Final Layer: Accuracy = 46.2%

The accuracy improves progressively as we use embeddings from deeper layers, with the final layer performing best (46.2% accuracy). This indicates that the later layers of the model capture more task-relevant information for classification tasks like predicting the certificate categories.

Overall Reflection:

- **Encoding Across Layers**: The results show that LLAMA 3.1 encodes information differently across its layers. Early layers are more general-purpose and perform better for regression tasks, while deeper layers encode more task-specific information that improves classification accuracy.
- **Patterns and Anomalies**: The significant increase in accuracy from first to final layer embeddings in the classification task is expected, but the regression task's decline in performance in mid and final layers is noteworthy. It suggests that while the deeper layers capture more specific features, they may lose information that is useful for simpler, more general tasks like regression.
