

Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
Second Semester 2023-2024
M.Tech AIML Batch 2 Semester 3
Batch Name: AIML (AC05_2-2022)
Mid-Semester Test (EC-2 Makeup)

Course No. : AIMLCZG521
Course Title : Conversational AI
Nature of Exam : Closed Book
Weightage : 30%
Duration : 2 Hours
Date of Exam : 26-07-2024_EN

No. of Pages	= 2
No. of Questions	= 4

Note to Students:

1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.

For each multiple question, please answer with the correct choice and it's complete text.

Q.1.

- A. Which of the following is an example of a rule-based Conversational AI system? **(1 marks)**
- a) A virtual assistant like Alexa that can understand and execute complex commands.
 - b) A chatbot on a retail website that recommends products based on customer interactions.
 - c) A simple customer service FAQ where each question has a pre-defined response.
 - d) A language translation tool that uses machine learning to translate text from one language to another.
- B. What is the main benefit of incorporating NLP techniques into Conversational AI systems? **(2 marks)**
- a) It enables systems to understand and respond to complex commands.
 - b) It allows for more efficient data processing.
 - c) It makes the systems more user friendly to people.
 - d) It helps to reduce the cost of developing Conversational AI systems.
- C. Which technique is crucial for understanding the grammatical structure of a sentence? **(1 marks)**
- a) Stemming
 - b) Lemmatization
 - c) POS Tagging
 - d) Named Entity Recognition

D. Describe the different types of Conversational AI systems, highlighting their key differences and providing examples of each. **(4 marks)**

Answer:

Type: Rule-Based Systems	Type: AI-Driven Systems	1 mark
Operate based on predefined responses	Operate using machine learning, NLP to understand context and improve responses i.e. Intent recognition, entity extraction, dialogue management.	1 mark
<ul style="list-style-type: none">• script-based.• limited to specific rules	<ul style="list-style-type: none">• Adaptive Learning• Enhancing Understanding and Interactions	1 mark
Example: Simple customer service FAQs where each question has a pre-defined response.	Example: Google Assistant, Alexa, Chatbots in retail websites providing product recommendations based on customer interactions, etc.	1 mark

Q.2.

A. Explain the importance of text pre-processing in NLP. Discuss two key pre-processing techniques and their respective benefits in building conversational AI systems. **(3 marks)**

Answer:

(1 mark)

Text pre-processing is a crucial step in Natural Language Processing (NLP) that involves cleaning and preparing text data for analysis.

Importance: These steps help in converting raw text into a more manageable and analyzable format, facilitating better model performance and more accurate results.

(2 marks) Discuss (with a simple example) any two of the following techniques and its benefits / importance:

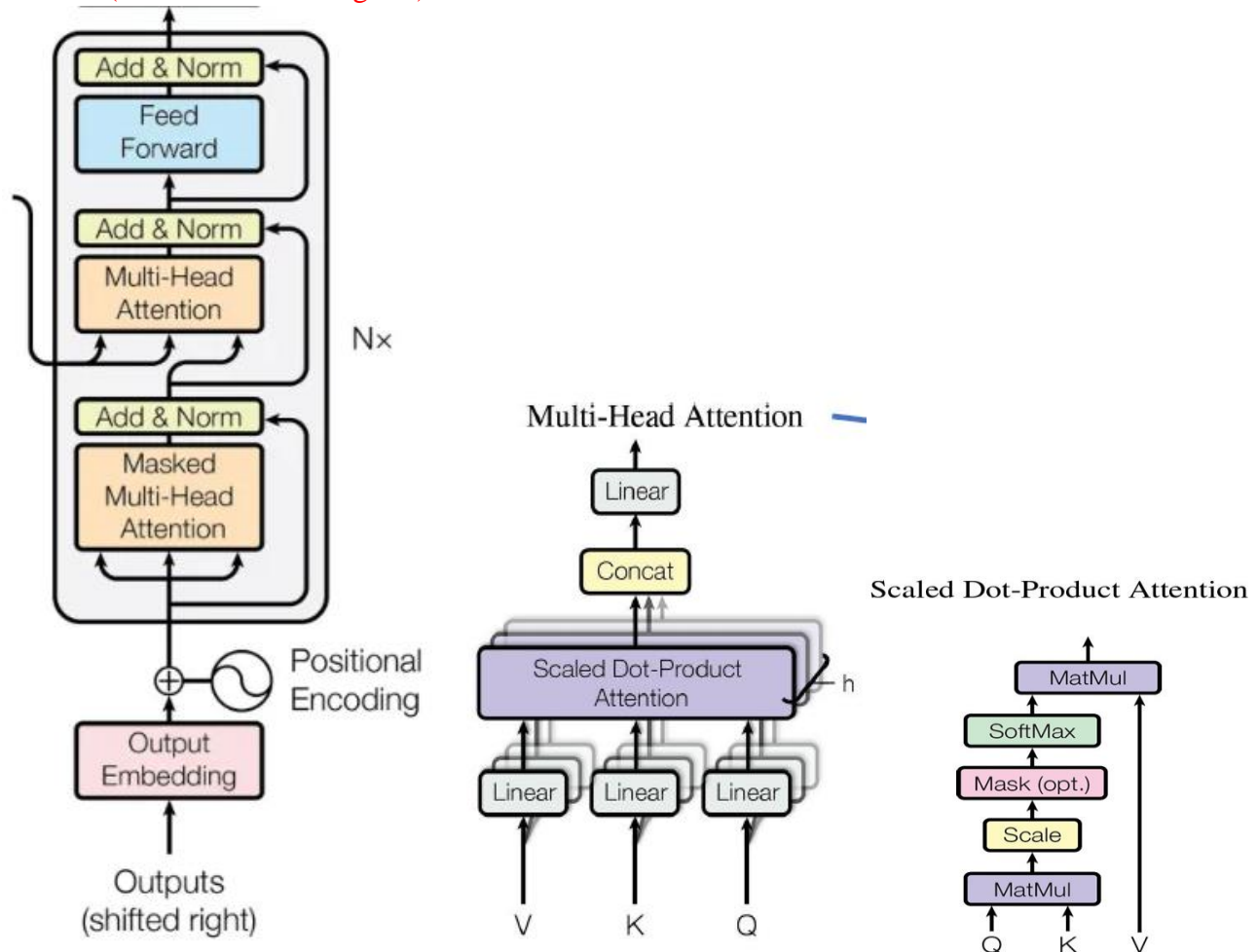
- Tokenization.
- Stop Word Removal
- Stemming
- Lemmatization
- Text Cleaning

B. Which of the following pre-trained language model architectures is known for its ability to understand language from both sides of a masked word? **(1 mark)**

- a) GPT
- b) BERT**
- c) T5
- d) BART

C. Explain in detail how the input text ‘The cat sat on the mat’ is transformed in a masked decoder block with masked multi-head attention layer in a Transformer model. What is causal masking? Illustrate your answer with a diagram of the decoder coder block and inner sub-blocks, as required. Numbers in the vectors shall be random – but logical. (5 marks)

Answer (2 marks for the diagram):



Students are expected to explain in brief about the following:

1. Tokenization, Input Embeddings and Positional Encoding (0.5 mark)
2. Masked Multi-Head Self-Attention Layer (1 mark)

This is the first sub-block in the decoder. It's similar to the standard multi-head attention mechanism, but with a twist - it uses a mask to prevent each token from attending to subsequent tokens in the sequence. This is known as **causal masking** or auto-regressive masking, and it ensures that the prediction for a certain position is only dependent on known words, not future words.

3. Cross-Attention or Encoder-Decoder Attention (1 mark)

The inputs to this attention layer are the queries (Q) from the previous decoder layer, and the keys (K) and values (V) from the output of the encoder.

4. Residual Connection, Layer Normalization and Feed Forward Block (0.5 mark)

Q.3.

- A. Explain the key components of RLHF (Reinforcement Learning from Human Feedback) in aligning language models and how Proximal Policy Optimization (PPO) is used in this framework. Briefly discuss the advantages and limitations of PPO. **(6 marks)**

Answer:

RLHF (Reinforcement Learning from Human Feedback) is a technique for aligning language models with human preferences. It involves three main components:

1. Pre-trained Language Model: This is the foundation of the system, already trained on a massive dataset. **(1 mark)**
2. Reward Model: This model learns to predict human preferences by being trained on human-labeled examples of model outputs. Humans rate different outputs for a given prompt, and the reward model learns to associate high scores with outputs that humans prefer. **(1 mark)**
3. Policy Model: This is the language model itself, which is fine-tuned using reinforcement learning to maximize the expected reward from the reward model. **(1 mark)**

Proximal Policy Optimization (PPO) is a reinforcement learning algorithm that is commonly used in the RLHF process. PPO improves the training stability of the policy by limiting the change made to the policy at each training epoch. This is achieved by using a ratio that indicates the difference between the current and old policy and clipping this ratio from a specific range $[1 - \epsilon, 1 + \epsilon]$. This ensures that the policy update will not be too large and that the training is more stable. **(1 mark)**

Advantages of PPO (any two for 1 mark):

- **Stability:** PPO is known for its stability, making it less prone to drastic changes in the policy model that could lead to poor performance.
- **Sample Efficiency:** PPO uses the previous policy as a reference, requiring fewer samples to learn a new policy.
- **Handling Complex Rewards:** PPO can be applied to scenarios with complex and multi-dimensional reward functions.
- **Simple:** Easy to implement and tune because it doesn't require a second-order optimization.

Limitations of PPO (any two for 1 mark):

- **Hyperparameter Tuning:** Selecting the appropriate hyperparameters for PPO can be challenging and requires careful experimentation.
- **Reward Model Accuracy:** The accuracy of the reward model is crucial for the success of PPO. A poorly trained reward model could lead to the policy model learning undesirable behaviors.
- **Scalability:** Training large language models with RLHF using PPO can be computationally expensive, requiring significant resources.

- B. Why is LoRA fine-tuning preferred over traditional fine-tuning methods? **(2 marks)**

Answer (Any two points for 2 marks):

- **Reduced Memory Usage** / smaller low-rank matrices
- **Lower Computational Cost**
- **Faster Training**
- **Improved Generalization**

Q.4.

A. What is the primary goal of Retrieval Augmented Generation (RAG)? **(1 mark)**

- a) To improve the accuracy and reliability of generative AI models.
- b) To enhance the creativity of AI models in generating responses.
- c) To reduce the computational complexity of language models.
- d) To enable AI models to understand and respond to complex emotions.

B. Which of the following is NOT a key component of RAG? **(1 mark)**

- a) Ingestion
- b) Retrieval
- c) Synthesis
- d) Parameterization

C. Which of the following is an example of a chatbot? **(1 mark)**

- a) Siri
- b) Domino's Facebook Messenger Bot
- c) Duolingo
- d) Erica

D. What is the main finding of the kNN-LM paper regarding the performance on different datasets? **(2 marks)**

- a) kNN-LM consistently outperforms standard language models on all datasets.
- b) kNN-LM performs best on datasets with a high degree of repetition.
- c) kNN-LM performs best on datasets with a wide variety of vocabulary.
- d) kNN-LM performs best on datasets where the training data is similar to the test data.