ML4NLP 1

Tutorial 14: Exam preparation

16. December 2024

Schedule & Admin

- This week
    - Exam preparation

- Feedback for Ex. 5 coming soon…
- Peer Review for Ex.6 starts today (deadline:23.12.2024)

General Exam Style

- A4 cheat sheet allowed (both sides handwritten, one side if printed)
- Exam questions: Mostly Conceptual, basic calculations or code snippets can come up
- Primarily open ended questions on the Lecture Content, some True/False and multiple choice (~15-25% of points)
- No negative grading
    - It’s always better to answer something (don’t go off topic, make short and precise guesses)
- Elaborate use case scenarios questions are to be expected
    - (E.G) You are an NLP Engineer and you are asked to design system X using the following material Y.
- Questions about code discussed in tutorials might come up…

Exam: Common Topics

- Historical development of NLP
- High-level questions about challenges in NLP
- General ML concepts
- Word embeddings
- Clustering
- Multitask Learning
- Transfer learning
- Computation Graphs
- Neural Network model types:
  - FFNNs
  - RNNs
  - CNNs
  - Transformers
- Pre-trained LMs
- Pre-trained / Chat-tuned LLMs

Examples of High-level Questions

1. What makes ML for NLP challenging? Mention two important and general sources/types of difficulties of NLP. For each type, mention one current technique that helps to alleviate it and why it roughly works.

2. What are two instances of unsupervised learning techniques used in NLP.

ML

Joe claims that for a complex machine learning task, where various features need to be considered, the following is true: training a single **linear regression model** with 500 features is equivalent to building an ensemble of 500 models each with a single feature.

Would you **agree**, yes or no? Add a **short justification** for your answer.

No, I would not agree with Joe's claim. This assertion overlooks key aspects of model complexity and feature interaction.

- Linear regression with multiple features can capture interactions among variables, which is essential in understanding complex relationships in data.

- An ensemble of single-feature models lacks this capacity, as each model is isolated and unable to account for how features might interact with one another.

This fundamental difference in how these models handle feature interactions leads to distinct outcomes in their predictive capabilities and accuracy.

Word Embeddings

1. What are the commonalities / differences between the following?
   - word2vec
   - Glove
   - ELMo
   - BERT
2. Name two advantages of contextualized word embeddings over static word embeddings

2. Can incorporate syntactic information, don’t mix all meaning of a word in one average representation (e.g., ambiguous words)

1. Commonalities:

- Predictive method to learn word representations given distributional semantics (context)

Differences:

- word2vec uses sliding windows running over all training samples
- GloVe learns from the global co-occurrence matrix directly to leverage statistical information in the entire corpus
- ELMo uses a bidirectional LSTM trained to predict the next word in the sequence (left-to-right and right-to-left) and combines the hidden representations from both LSTM to get contextualised embeddings
- BERT uses a transformer encoder-only architecture trained with MLM

GPT

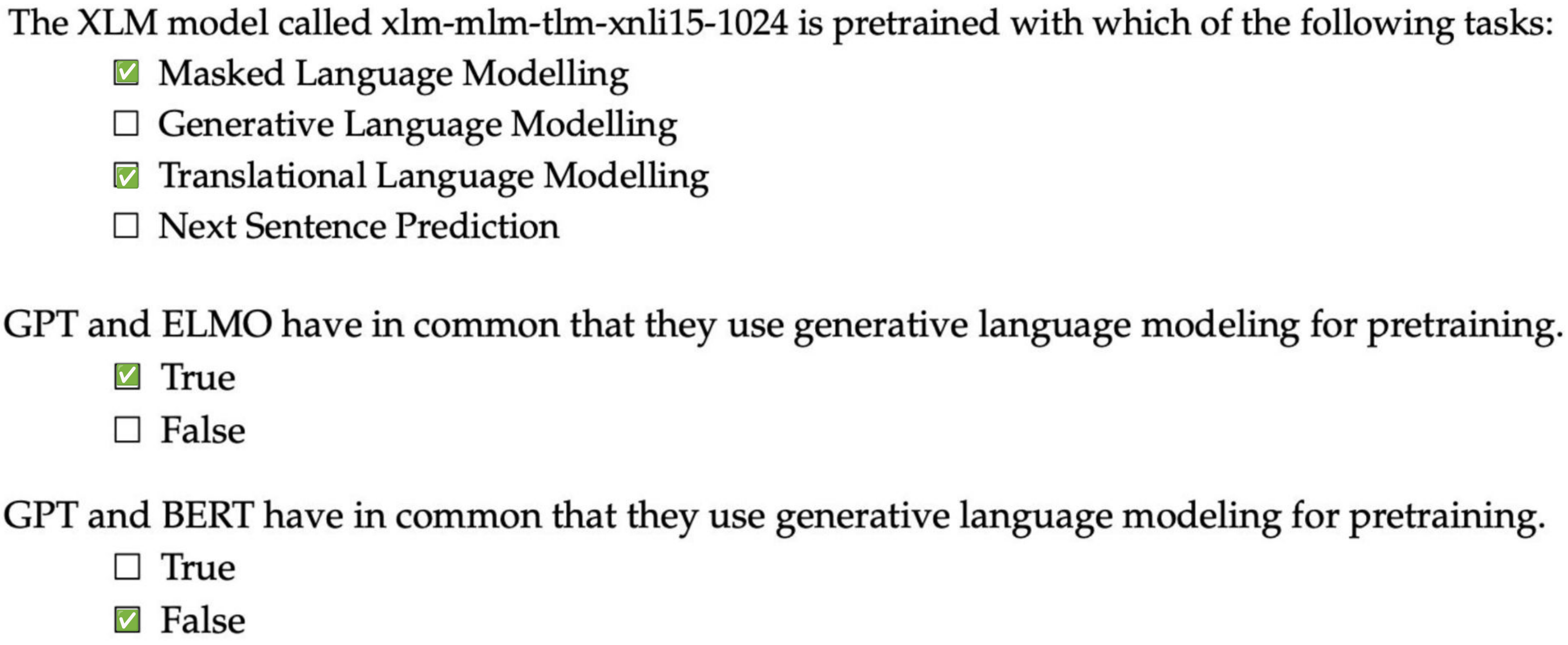
1. How would you explain to a layperson the important ideas behind GPT3 in your own words?

    - 175B parameters and was **trained** on web-crawled text, books and code
    - pretrained using **generative language modeling** - learns to predict the next word in a piece of text
    - words are not “words” per se, but “**subtokens**” - allows GPT to represent and produce also rare words with a limited vocabulary
    - It’s architecture is based on a **transformer decoder** that process a **fixed amount of subtokens** in a single forward pass.
    - A GPT-like model *can* be applied to any text-based task by framing it as a **prompt** that elicits the correct answer as a valid continuation.

Language Modelling Objectives

1. What’s the difference between the following learning objectives?
    - Masked Language Modelling
    - Generative Language Modelling
    - Translational Language Modelling

Language Modelling Objectives ctd.



The XLM model called xlm-mlm-tlm-xnli15-1024 is pretrained with which of the following tasks:

- ☑ Masked Language Modelling
- ☐ Generative Language Modelling
- ☑ Translational Language Modelling
- ☐ Next Sentence Prediction

GPT and ELMO have in common that they use generative language modeling for pretraining.

- ☑ True
- ☐ False

GPT and BERT have in common that they use generative language modeling for pretraining.

- ☐ True
- ☑ False

Transformer

1. Locate the encoder and the decoder in the figure:

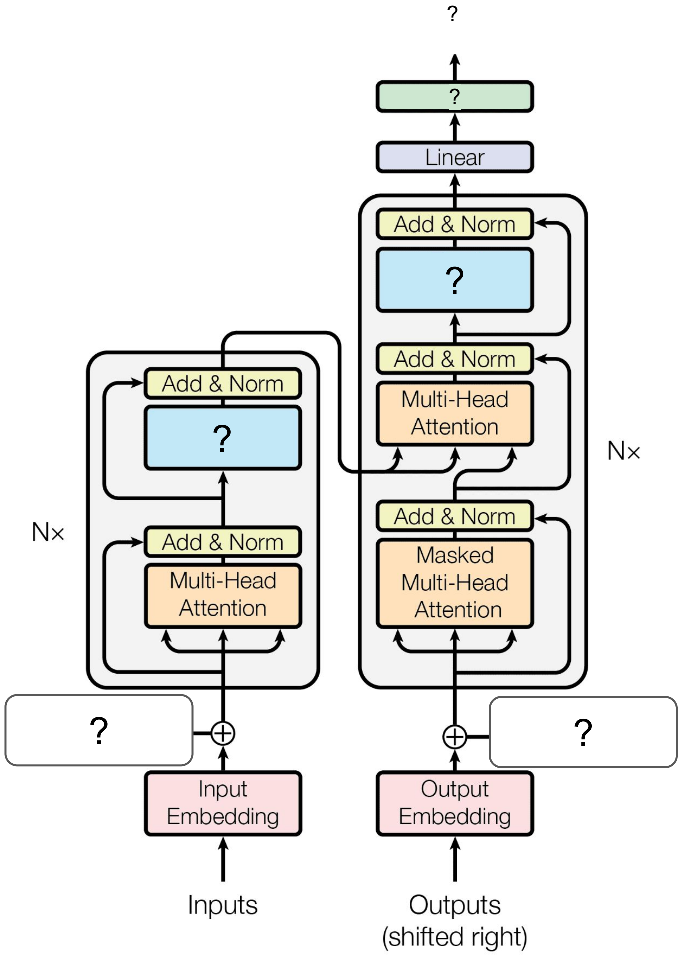
2. Label the parts of the architecture marked with ?

3. What are the differences between the following:

   a. Self-attention in the encoder

   b. Cross-attention

   c. Self-attention in the decoder



Pretrained LMs

1. Given the following parameter dictionary for a mini LM, what it the total parameter count of the model? (keys indicate the named params, values indicate their sizes)

```
m = {'blocks': [
          {'attn': {'c_attn': {'b': [20], 'w': [5, 20]},
                      'c_proj': {'b': [5], 'w': [5, 5]}},
             'ln_1': {'b': [5], 'g': [5]},
             'ln_2': {'b': [5], 'g': [5]},
             'mlp': {'c_fc': {'b': [30], 'w': [5, 30]},
                     'c_proj': {'b': [5], 'w': [30, 5]}}}
     ],
     'ln_f': {'b': [5], 'g': [5]},
     'wpe': [20, 5],
     'wte': [50, 5]
     }
```

Approach:

- vectors: total number
- matrices: rows * columns
- count the number of blocks!
- total = sum of all params

LLMs

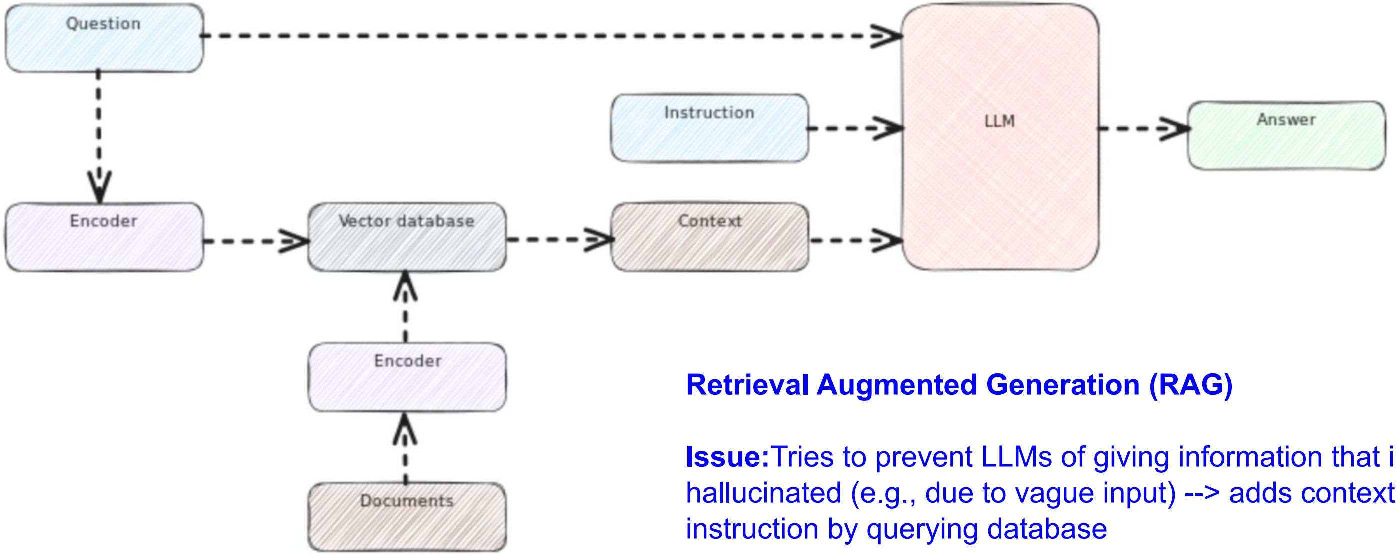
1. What is the main difference between GPT-3 (the base model described in Brown et al., 2020) and GPT-3.5-Turbo (the model that was presumably powering the first instances of ChatGPT)?

GPT-3 is purely a generative language model whilst GPT-3.5-Turbo is an instruction tuned model to be able to be used as a chat agent.

2. The management has decided to get on the Generative AI bandwagon and want LLMs integrated into their product offering. However, they are concerned with data privacy and will not allow the use of paywalled API models. What would you suggest as a way forward? What are the pros and cons?

LLM Inference

1. What type of technique does the following image illustrate? What issue does it try to fix?



Retrieval Augmented Generation (RAG)

Issue: Tries to prevent LLMs of giving information that is outdated or hallucinated (e.g., due to vague input) --> adds context to prompt and instruction by querying database

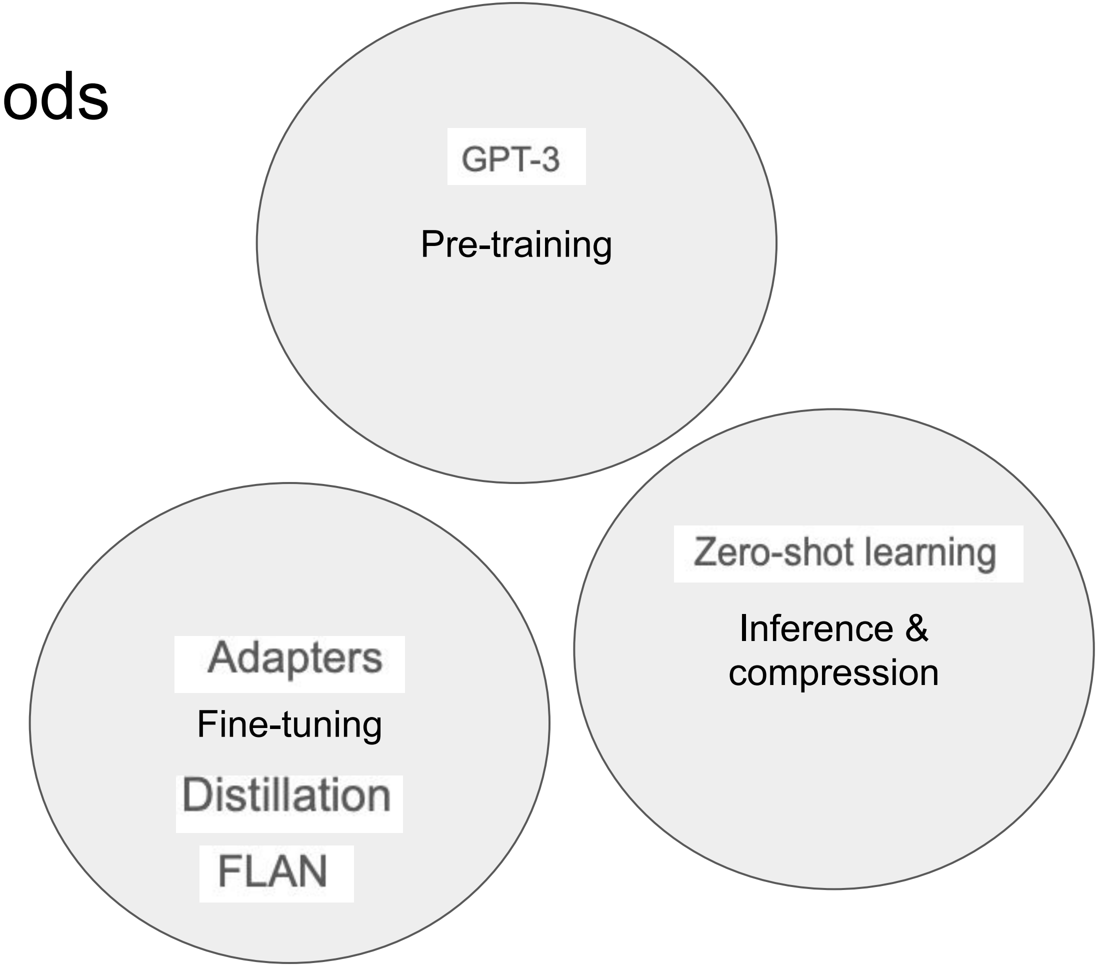
Parameter-efficient methods

Assign the following models/techniques to their umbrella term(s) (can be more than 1).

- GPT-3
- Zero-shot learning
- Distillation
- FLAN
- Adapters

Recommended reading:

[Treviso et al. 2022: Efficient Methods for Natural Language Processing: A Survey]()



GPT-3

Pre-training

Zero-shot learning

Inference & compression

Adapters

Fine-tuning

Distillation

FLAN

Parameter-efficient methods

1. Name one advantage and one disadvantage of adapters.

    - Advantage: need to adapt fewer parameters than a full model fine-tuning;

    - Disadvantage: Increased inference time due to more parameters (-> techniques to mitigate this)

2. What’s the difference between prompt-tuning and prefix-tuning? And which of the two is more parameter-efficient?

Prompt-tuning:

- no changes are required in the pretrained model weights (parameters)
- Soft prompts differ from the discrete text prompts in that they are acquired through back-propagation and is thus adjusted based on loss feedback from a labeled dataset.

Prefix tuning

- adds trainable tensors to each transformer block instead of only the input embeddings, as in soft prompt tuning.
- Also, we obtain the soft prompt embedding via fully connected layers. These fully connected layers embed the soft prompt in a feature space with the same dimensionality as the transformer-block input to ensure compatibility for concatenation.

Blackbox NLP

1. What are some techniques/approaches that we can use to take a look into the black box?

2. Name a specific example where the inner workings of the blackbox would be worthwhile/important to investigate.

Clustering

1. What is the difference between clustering and classification?

2. Given the primary goals of clustering, what concrete evaluation measurements can be used to assess the quality of topic modeling?

Further Involvement with CL / NLP

Interesting classes (that are also applicable for Informatics, CL people know what exists):

Fall Semester:

- Advanced Techniques of Machine Translation
- Machine Learning for Natural Language Processing 1

Spring semester:

- Advanced Machine Learning
- Machine Learning for Natural Language Processing 2

Open Master Thesis topics within Computational Linguistics / NLP:

https://www.cl.uzh.ch/en/studies/studies-BA-MA/teaching/BaMasterArbeit.html