NLP: Prompting

Philippe Schläpfer

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Pre-trained Language Models

- Large LMs capture the language very good!
- Before prompting was a thing: Fine-tuning
  - Trying to model $P(y|x; \Theta)$

GPT-3: 175 billion parameters

Image credit: https://www.ibm.com/cloud/learn/neural-networks
Prompts

Trigger language model to give an output

Not to confuse with **Prompting**: Whole area of research
Example: Factual Knowledge

What is the capital of Brazil?

Language Model

Pre-trained; no fine-tuning

The capital of Brazil is Brasília.
Example: Translation

Translate this into German: I'm feeling very good today.

Ich bin heute sehr gut drauf.
Example: Summarization

TL;DR

Language Model

<Summarization of the text>
Prompting

Model $P(x; \Theta)$ directly $\iff$ fine-tuning: $P(y|x; \Theta)$
GPT-3 Demo
Why should we do research in this area?

• No fine-tuning
• Small datasets
• No retraining\textsuperscript{[1]}

\textsuperscript{[1]} Madaan, Tandon, Clark, Yang: "Memory-assisted prompt editing to improve GPT-3 after deployment". arXiv:2201.06009 (2022)
Cloze Tasks

Today, I went to the ___________ and bought some milk and eggs.

In NLP:
Today, I went to the [MASK] and bought some milk and eggs.
Example task: Text classification

Given a text, classify it into one of the given classes

Input sequence
\[ x = (x_1, x_2, ..., x_n) \]

Classifier

Label \( y \in Y \)
Prompting Pipeline

Step 1: Prompting function

It’s one of the best movies I’ve ever seen.

It was [MASK]. It’s one of the best movies I’ve ever seen.
Prompting Pipeline

Step 2: Language Model

$X'$ \rightarrow \text{Language Model} \rightarrow Z

It was [MASK]. It’s one of the best movies I’ve ever seen.

It was [MASK]. It’s one of the best movies I’ve ever seen.
Prompting Pipeline

Step 3: Answer search

It was [MASK]. It’s one of the best movies I’ve ever seen.

amazing – 62%

stunning – 26%

cool – 3%

....

Answer search

\( \hat{z} \)
Prompting Pipeline

Step 4: Answer mapping

\[ \hat{z} \xrightarrow{\text{Answer mapping}} \hat{y} \]

- amazing
- label: positive
Prompting for Text Classification

\[ x \xrightarrow{f_{prompt}(x)} x' \xrightarrow{\text{Language Model}} y \]

It's one of the best movies I've ever seen.

It was [MASK]. It's one of the best movies I've ever seen.

\[ \hat{y} \xleftarrow{\text{Answer mapping}} \hat{z} \xleftarrow{\text{Answer search}} z \]

label: positive

amazing – 62%

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Prompt Engineering

• Goal: Create prompting function $f_{prompt}(x)$ that gives best performance
  • Obama is a _____ by profession.
  • Obama worked as a _____.

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  • Obama worked as a ____.
Prompt Engineering: Two types of prompts

• Prefix prompts: e.g. Translation
  Translate this into 1. German, 2. Italian and 3. Japanese:
  Should we meet at 10 o'clock?

• Cloze prompts: It’s a [MASK] movie to watch and [MASK] painful to watch.
Prompt Engineering: Automatic template learning

- Discrete prompts
  - Paraphrasing (back translation, replacement of phrases from a thesaurus, ...)

Prompt: "x shares a border with y"
"x has a common border with y"
"x adjoins y"
Prompt Engineering: Automatic template learning

• Drawbacks of the prompts we’ve seen so far?
  • Prompts are in natural language (discrete optimization is challenging)
  • Template is parameterized by the parameters of the pre-trained LMs

• Continuous prompts: Perform prompting in the embedding space of the LM
I really enjoyed this movie. The movie was ______.

\( \epsilon \) good, amazing, phenomenal, awesome, ...

• Straightforward: directly map answer \( z \) to the final output \( y \)
• More sophisticated: Have a mapping function from words to labels
  \( \rightarrow \) Verbalizer
How to map the output of the LM to the labels?

Incorporate Knowledge Base into verbalizer (e.g. WordNet)

Prompting for text classification: results

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Label</th>
<th>Label Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG’s News</td>
<td>POLITICS</td>
<td>politics, government, diplomatic, law, aristotle, diplomatical, governance...</td>
</tr>
<tr>
<td></td>
<td>SPORTS</td>
<td>sports, athletics, gymnastics, sportsman, competition, cycling, soccer...</td>
</tr>
<tr>
<td>IMDB</td>
<td>NEGATIVE</td>
<td>abysmal, adverse, alarming, angry, annoy, anxious, apathy, appalling...</td>
</tr>
<tr>
<td></td>
<td>POSITIVE</td>
<td>absolutely, accepted, acclaimed, accomplish, accomplishment...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th>AG News</th>
<th>DBPedia</th>
<th>Yahoo</th>
<th>Amazon</th>
<th>IMDB</th>
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</thead>
<tbody>
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<td>66.6</td>
<td>45.4</td>
<td>80.2</td>
<td>86.4</td>
</tr>
<tr>
<td>Label words</td>
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<td>61.6</td>
<td>92.8</td>
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<td>99.38</td>
<td>77.62</td>
<td>97.37</td>
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</tr>
</tbody>
</table>
Training Strategies

• Promptless Fine-tuning
• Tuning-free Prompting
• Fixed-LM Prompt Tuning
• Fixed-prompt LM Tuning
• Prompt+LM Tuning

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Additional Task: Question Answering

• Question in natural language

• Different forms (extractive, multiple choice, free form)

Passage Sentence
In meteorology, precipitation is any product of the condensation of atmospheric water vapor that falls under gravity.

Question
What causes precipitation to fall?

Answer Candidate
gravity
Question Answering

• Question + \n + additional information + \n + candidate answers

In meteorology, precipitation is any product of the condensation of atmospheric water vapor that falls under gravity.

What causes precipitation to fall?

In meteorology precipitation is any product of the condensation of atmospheric water vapor that falls under gravity.

Summarization

• <...some text...> + TL;DR

• Summarize this text: <...some text...>

• Text: [X] Summary: [Z]

• [X] In summary, [Z]
Challenges / Open Questions

• New field of research
• Structured information (trees, graphs, etc.)
• Theoretical guarantees are scarce
• Still need labeled data for evaluation
References

• Madaan, Tandon, Clark, Yang: "Memory-assisted prompt editing to improve GPT-3 after deployment". arXiv:2201.06009 (2022)
Thanks!

Questions?