Parameter Efficient Fine-Tuning

Advanced NLP: Summer 2023

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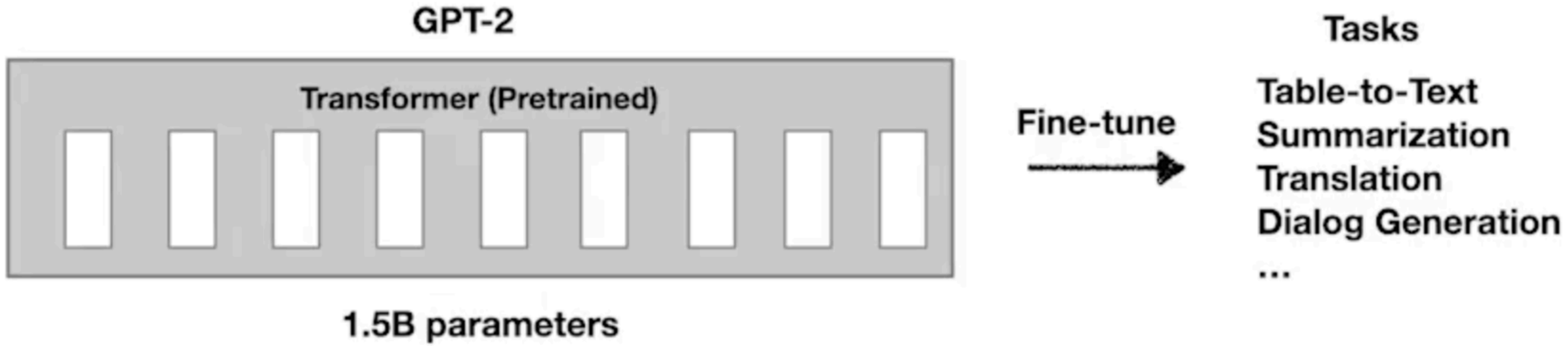
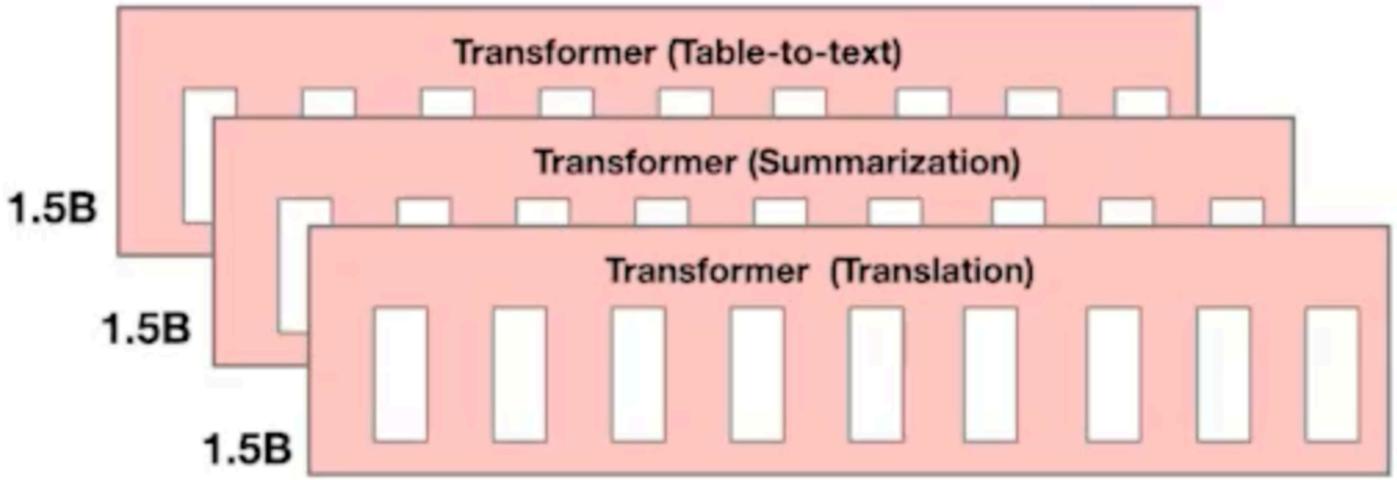
Prefix Tuning

Li and Liang, ACL 2021

https://aclanthology.org/2021.acl-long.353

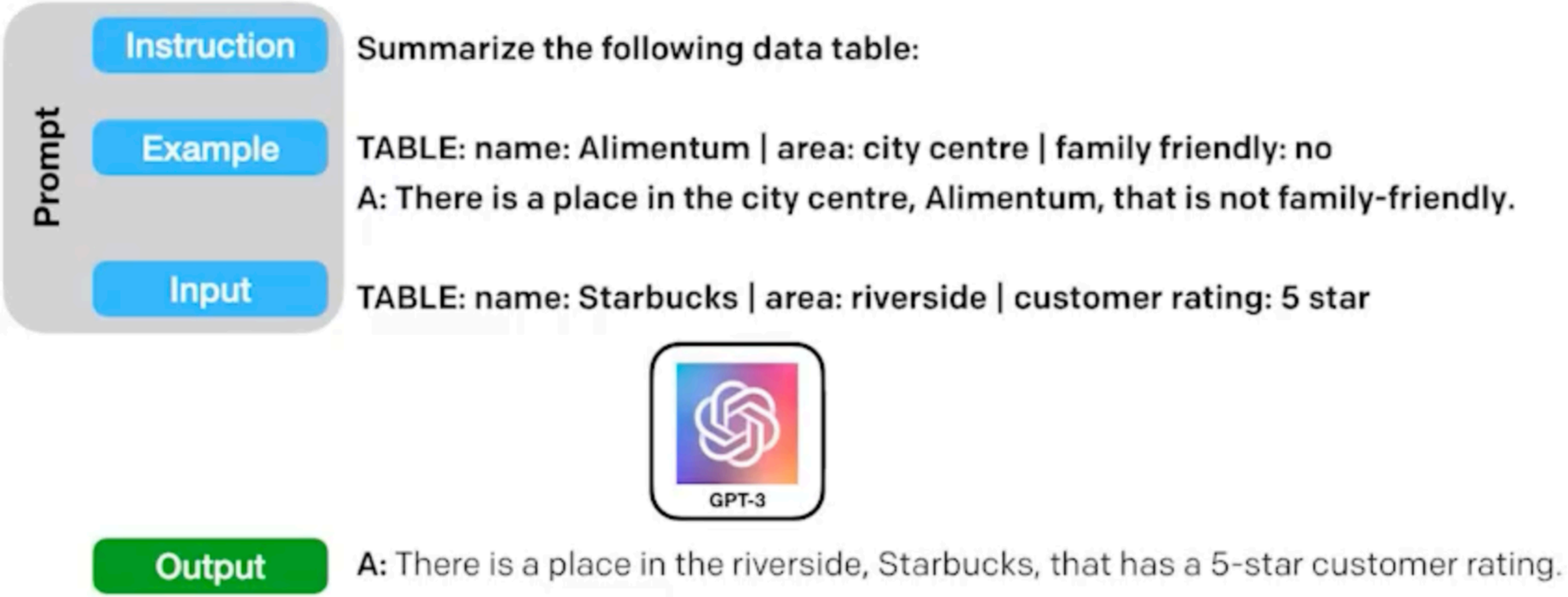
Why not just use fine-tuning





Each task requires a full model copy

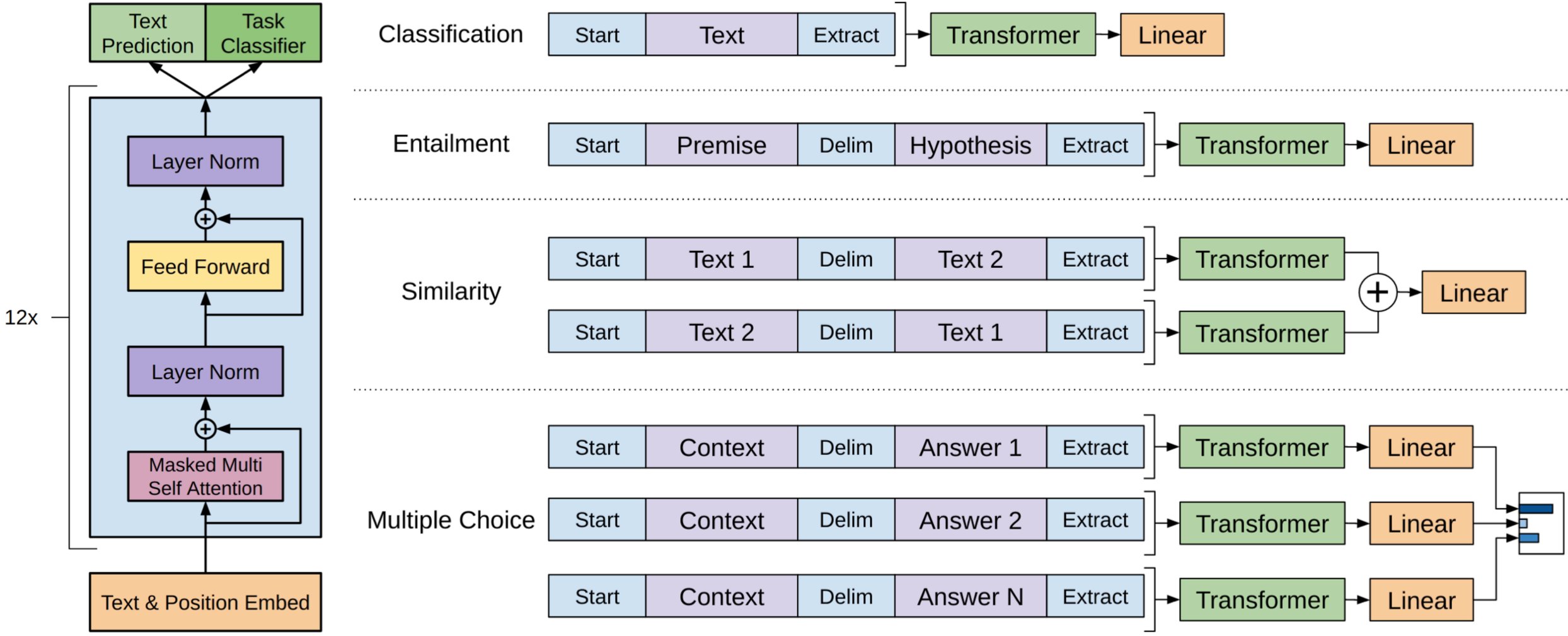
In-context learning using prompts



- No task specific fine-tuning
- Preserves the LM

- Cannot use large training set
- Manual prompts can be suboptimal
- Cannot be used with smaller LMs like GPT-2

In-context learning using prompts



https://arxiv.org/pdf/2005.14165.pdf

In-context learning using prompts

Zero-shot

The model predicts the answer given only a natural language description of the task. No gradient updates are performed.

```
1  Translate English to French:        ← task description
2  cheese =>                           ← prompt
```

One-shot

In addition to the task description, the model sees a single example of the task. No gradient updates are performed.

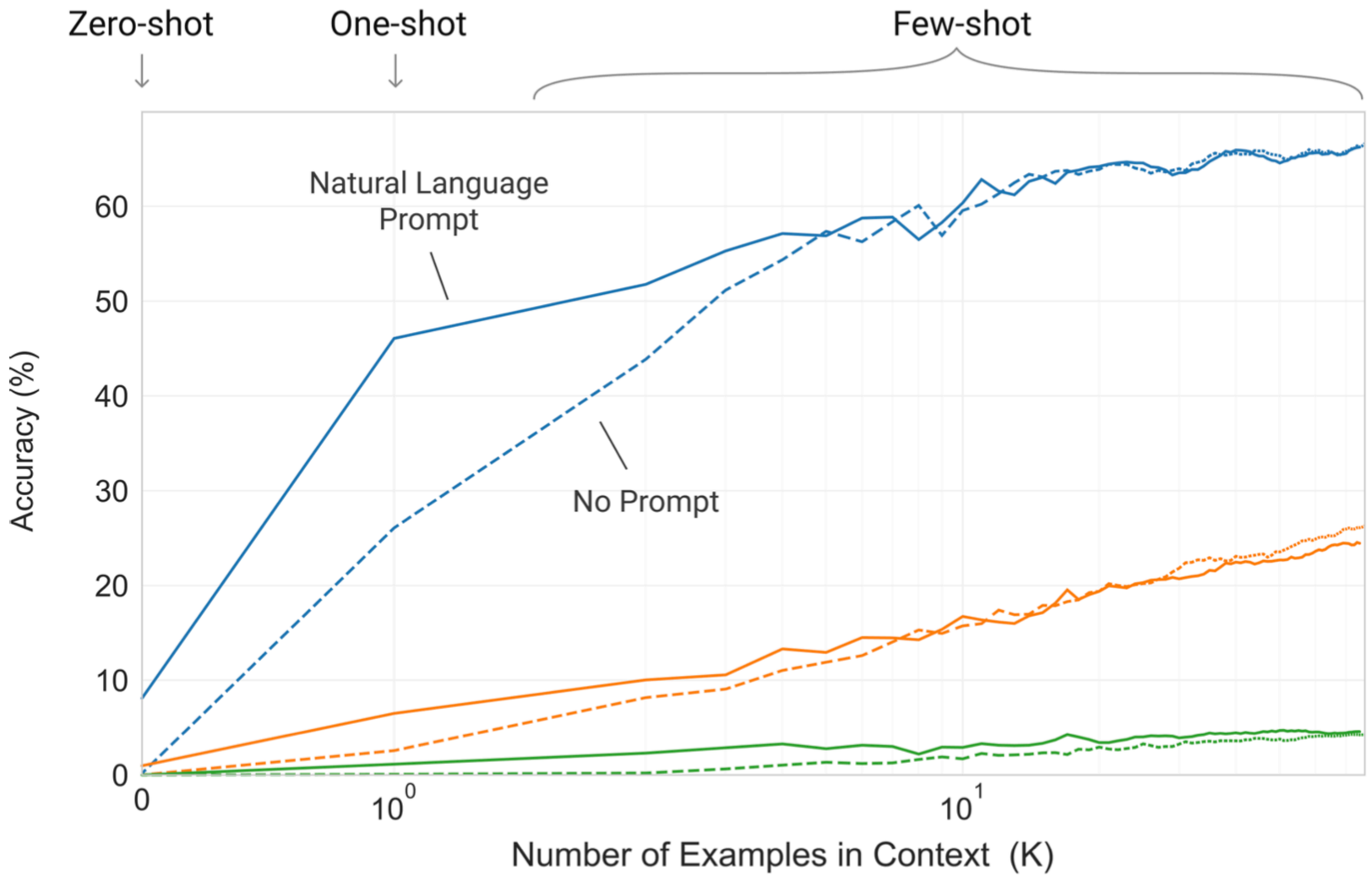
```
1  Translate English to French:        ← task description
2  sea otter => loutre de mer          ← example
3  cheese =>                           ← prompt
```

Few-shot

In addition to the task description, the model sees a few examples of the task. No gradient updates are performed.

```
1  Translate English to French:        ← task description
2  sea otter => loutre de mer          ← examples
3  peppermint => menthe poivrée        ←
4  plush girafe => girafe peluche      ←
5  cheese =>                           ← prompt
```

In-context learning using prompts



https://arxiv.org/pdf/2005.14165.pdf

Prompt tuning: enabling smaller LMs

iPet: better prompts for each task improves accuracy for small LMs

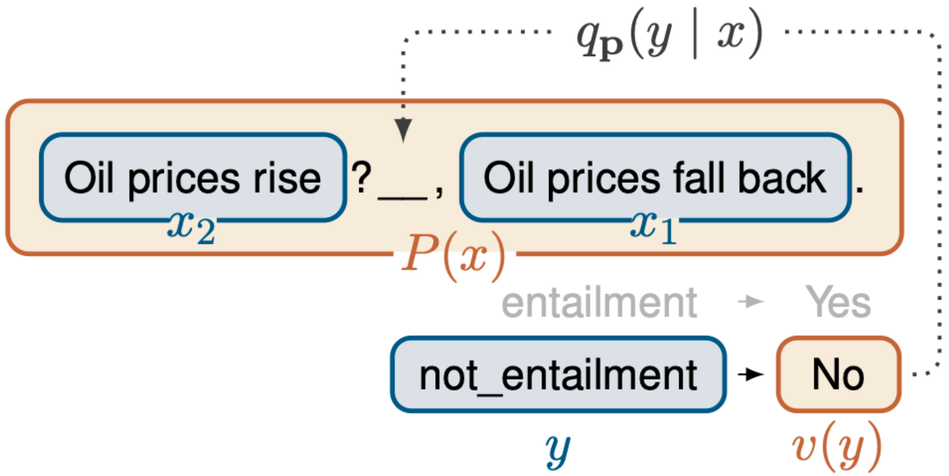


Figure 2: Application of a PVP $\mathbf{p} = (P, v)$ for recognizing textual entailment: An input $x = (x_1, x_2)$ is converted into a cloze question $P(x)$; $q_{\mathbf{p}}(y \mid x)$ for each y is derived from the probability of $v(y)$ being a plausible choice for the masked position.

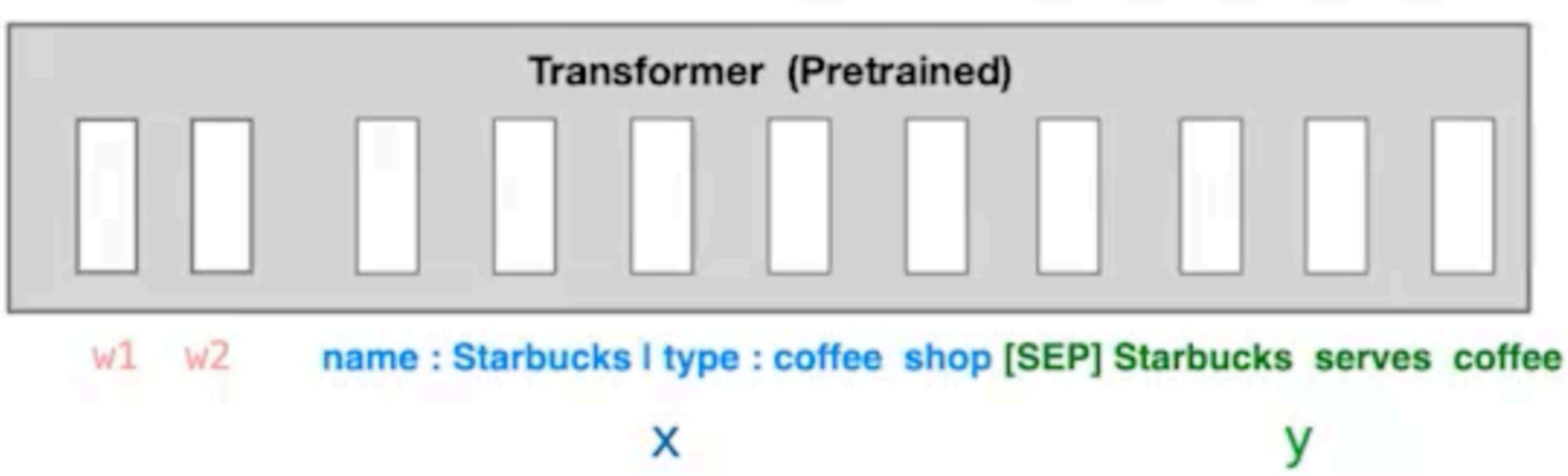
test	GPT-3	175,000	71.8	prompt
	PET	223	74.0	prompt FT
	iPET	223	**75.4**	prompt FT
	SotA	11,000	*89.3*	full FT

https://arxiv.org/pdf/2009.07118.pdf

Prefix Tuning

Intuition

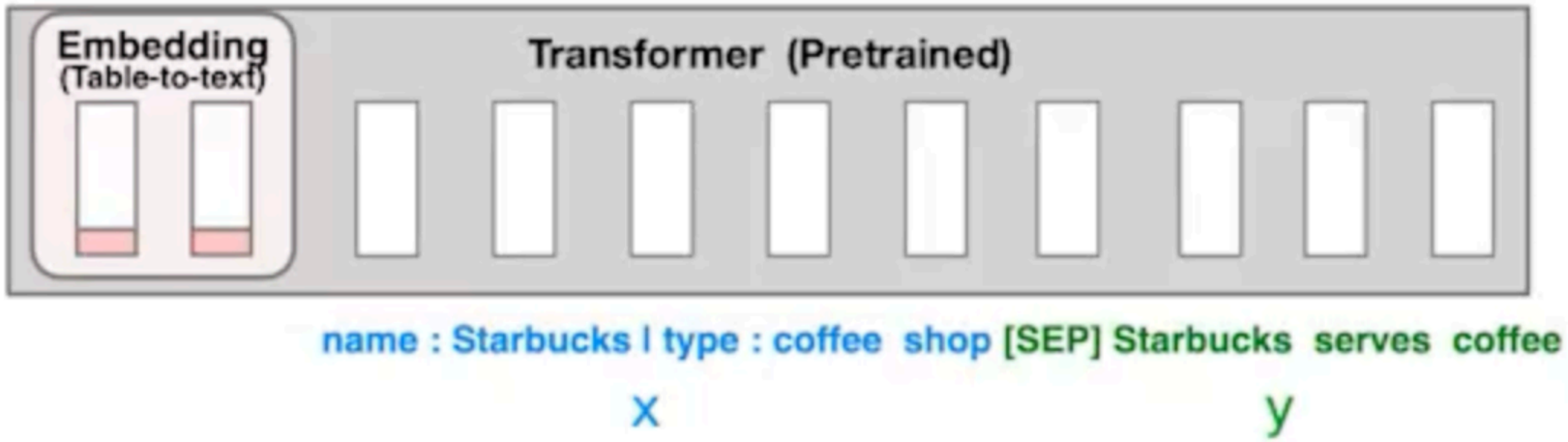
- Learn a good instruction that can steer the LM to produce the right output
- Optimize finding actual words
- Involves discrete optimization which is challenging and not expressive



Prefix Tuning

Intuition

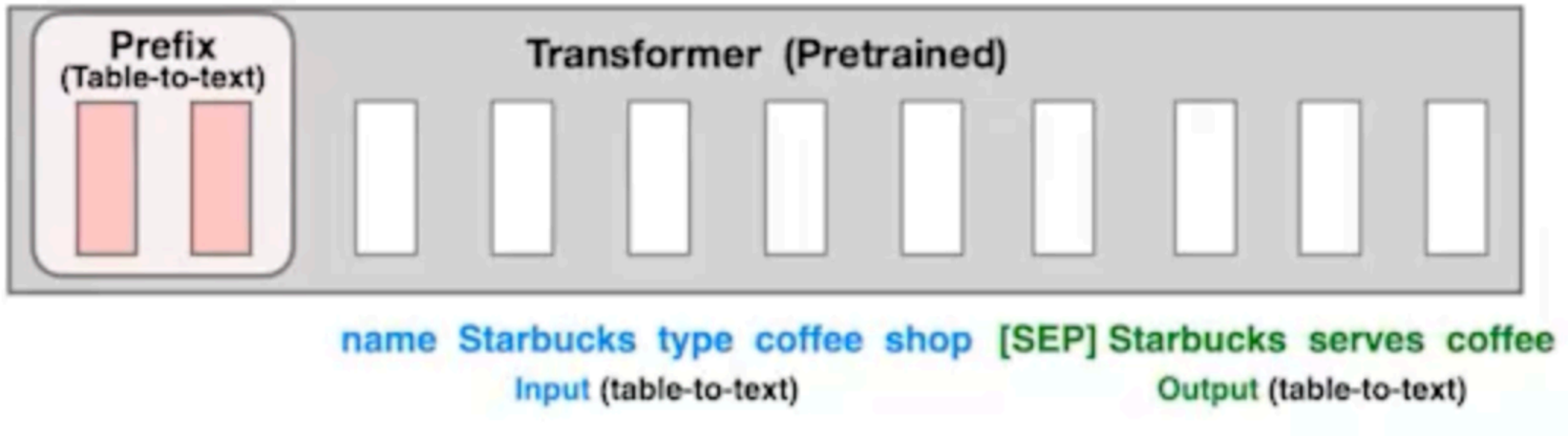
- Optimize the instruction as continuous word embeddings
- More expressive
- Limits the scope of the prompt to a input embeddings



Prefix Tuning

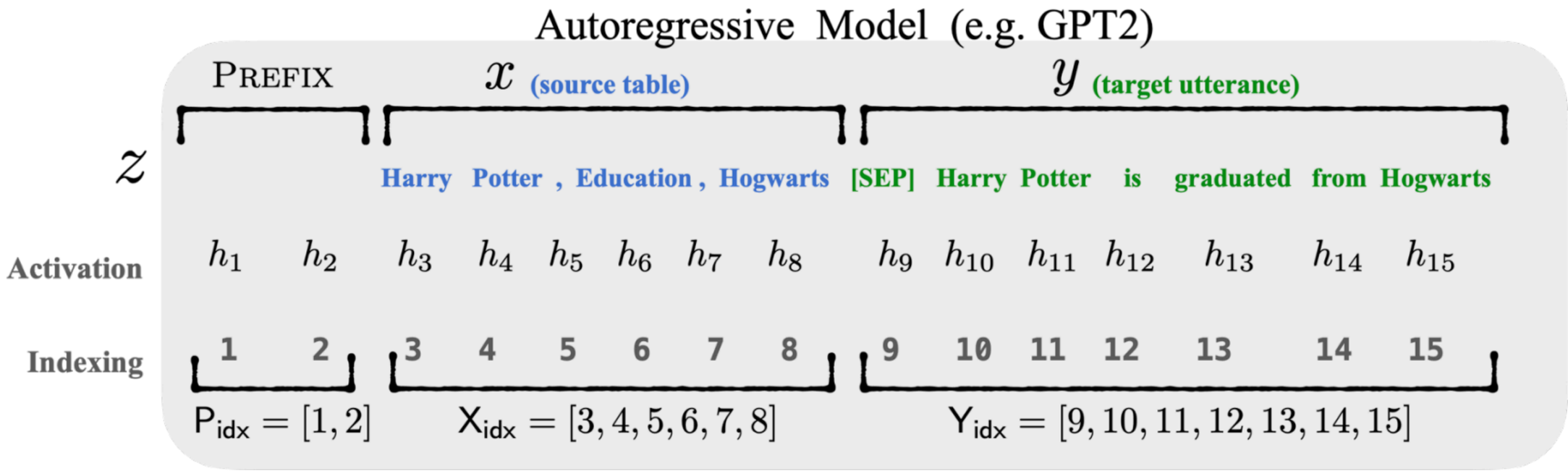
Intuition

- Optimize the instruction as prefix activation for all layers in the instruction
- Very expressive
- All the layers of the prefix can be tuned to create the most expressive prompt



Prefix Tuning

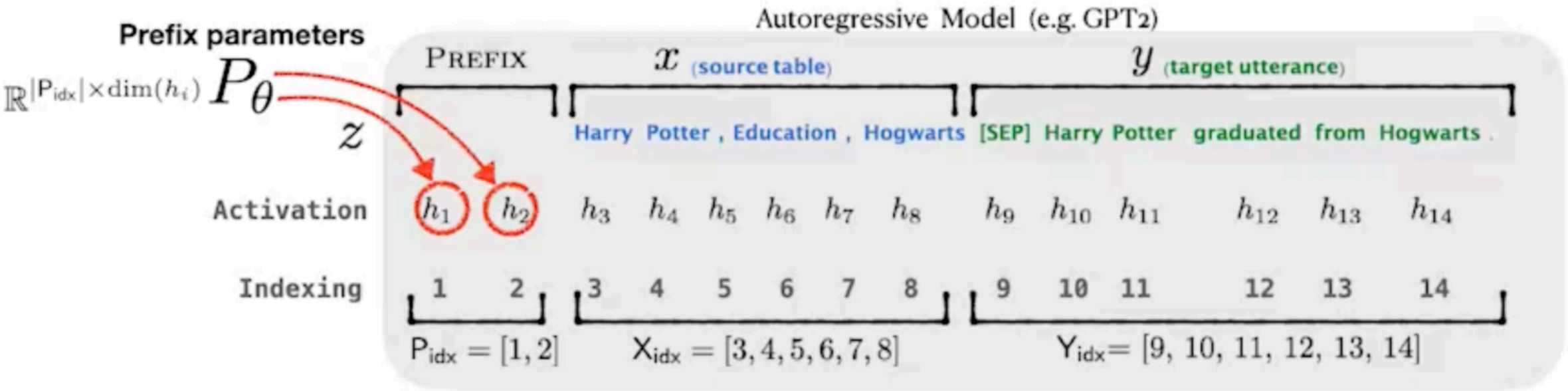
Autoregressive Modelling



Prefix Tuning

Prefix Re-parametrization

$$h_i = \begin{cases} P_\theta[i,:], & \text{if } i \in \mathsf{P}_{\text{idx}}, \\ \mathrm{LM}_\phi(z_i, h_{<i}), & \text{otherwise.} \end{cases}$$



$$\max_\theta \log p_{\phi,\theta}(y \mid x) = \sum_{i \in \mathsf{Y}_{\text{idx}}} \log p_{\phi,\theta}(z_i \mid h_{<i})$$

freeze LM parameters ϕ
update prefix parameters θ

Prefix Tuning

Vs. Finetuning

Source	name : The Eagle | type : coffee shop | food : Chinese | price : cheap | customer rating : average | area : riverside | family friendly : no | near : Burger King
Prefix (50)	The Eagle is a cheap Chinese coffee shop located near Burger King.
Prefix (100)	The Eagle is a cheap coffee shop located in the riverside near Burger King. It has average customer ratings.
Prefix (200)	The Eagle is a cheap Chinese coffee shop located in the riverside area near Burger King. It has average customer ratings.
Prefix (500)	The Eagle is a coffee shop that serves Chinese food. It is located in the riverside area near Burger King. It has an average customer rating and is not family friendly.
FT (50)	The Eagle coffee shop is located in the riverside area near Burger King.
FT (100)	The Eagle is a cheap coffee shop near Burger King in the riverside area. It has a low customer rating and is not family friendly.
FT (200)	The Eagle is a cheap Chinese coffee shop with a low customer rating. It is located near Burger King in the riverside area.
FT (500)	The Eagle is a cheap Chinese coffee shop with average customer ratings. It is located in the riverside area near Burger King.

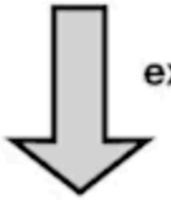
* The number in the parenthesis refers to the training size.

Prefix Tuning

Extrapolation to unseen categories

Trained on 9 categories

Astronaut, University, Monument, Building, ComicsCharacter, Food, Airport, SportsTeam, City, and WrittenWork



extrapolates

Test on 5 unseen categories

Athlete, Artist, MeanOfTransportation, CelestialBody, Politician

x: [103_Colmore_Row | architect | John_Madin]
[John_Madin | birthPlace | Birmingham]
[Birmingham | leaderName | Andrew_Mitchell]

y: John Madin was born in Birmingham (with Andrew Mitchell as a key leader) and became an architect, designing 103 Colmore Row.

x: [Albennie_Jones | genre | Rhythm_and_blues]
[Albennie_Jones | birthPlace | Errata,_Mississippi]
[Rhythm_and_blues | derivative | Disco]

y: Albennie Jones, born in Errata, Mississippi, is a performer of rhythm and blues, of which disco is a derivative.

Prefix Tuning

Extrapolation to unseen categories