ICLR 2021

Pre-training Text-to-Text Transformers for **Concept-centric Common Sense**

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* equal contribution

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ISI

ink

Commonsense Reasoning with PTLMs

What do you fill with ink to write notes on a piece of copy paper ?

(A) *Fountain pen*
(B) *Pencil case*
(C) *Printer*
(D) *Notepad*

Commonsense Reasoning with PTLMs

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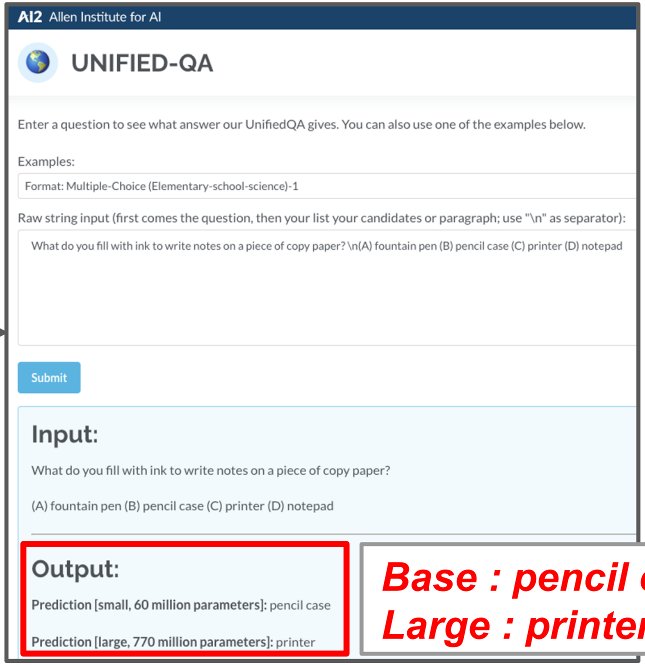


Base : pencil case
Large : printer

Fails to reason with the **concept-centric knowledge**

Current PTLMs

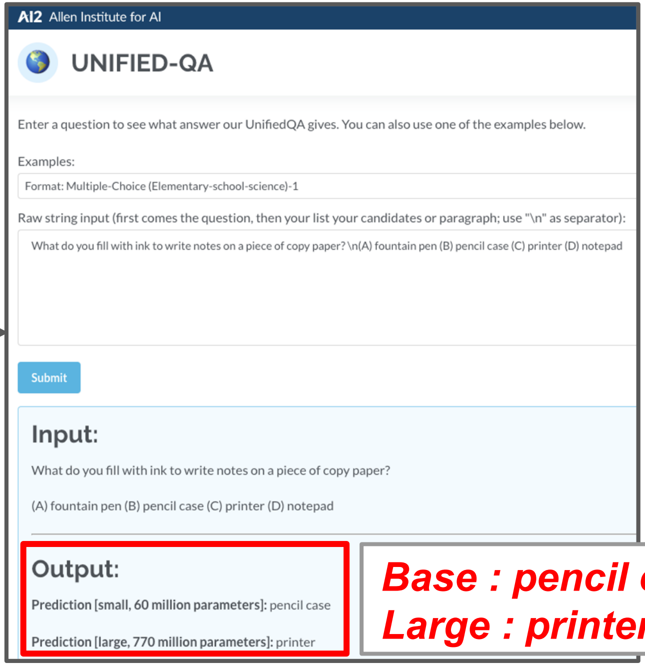
Corpus

… **Copy paper** is thinner than **printer** paper, which doesn't make a huge difference when you're printing text, but it does when you're printing large images. Images require a lot of **ink** and because **copy paper** has a thinner structure, the **ink** will need to spread out more for the **paper** to absorb it all. ...

Pre-train

Text Infilling / MLM

PTLMs



Base : pencil case
Large : printer

The model may be **sensitive** to the **co-occurence (ink, copy, paper)**

How can we teach PTLMs to **write** and **reason** with **Common sense Concepts** ?

*What do you **fill** with **ink** to **write** notes on a piece of **copy paper** ?*

- ***(A) Fountain pen***
- *(B) Pencil case*
- *(C) Printer*
- *(D) Notepad*

fill, ink, write, copy paper →

Fountain Pen

Our idea : Novel Self-supervised Objectives to improve common sense reasoning ability.

Generate a sentence with the following concepts :
Hold Woman Position

Text-to-Text Transformer

She was the first woman to hold the position.

Generative Objective : **Concept-to-Sentence Generation (C2S)**
Ask model to recover the original sentence
given only a few unordered keywords of the sentence.

Our idea : Novel Self-supervised Objectives to improve common sense reasoning ability.

Generative Objective : **Concept Order Recovering (COR)**
Ask model to recover the original sentence
given order-of-concept shuffled sentence.

Our idea : Novel Self-supervised Objectives to improve common sense reasoning ability.

Generate a sentence with the following concepts :
Hold Woman Position

Correct the order of the following sentence :
Tree grows on the apple

Which sentence is correct ? :
(1) Tree grows on the apple
(2) Apple grows on the tree

Text-to-Text Transformer

She was the first woman to hold the position.

Apple grows on the tree

Apple grows on the tree

Discriminative Objective : **Generative QA**
Ask model to distinguish the real sentence from a concept-distracted sentence.

CALM : Concept-Aware Language Model

Original Sentence *x*

She was the first woman to hold the position.

Extract Concept Set *C*
(*woman, hold, position*)

(1) Given an input sentence *x* (*“She was the first woman to hold the position.”*), extract concept-set *C* (*woman, hold, position*).

CALM : Concept-Aware Language Model

Original Sentence *x*

She was the first woman to hold the position.

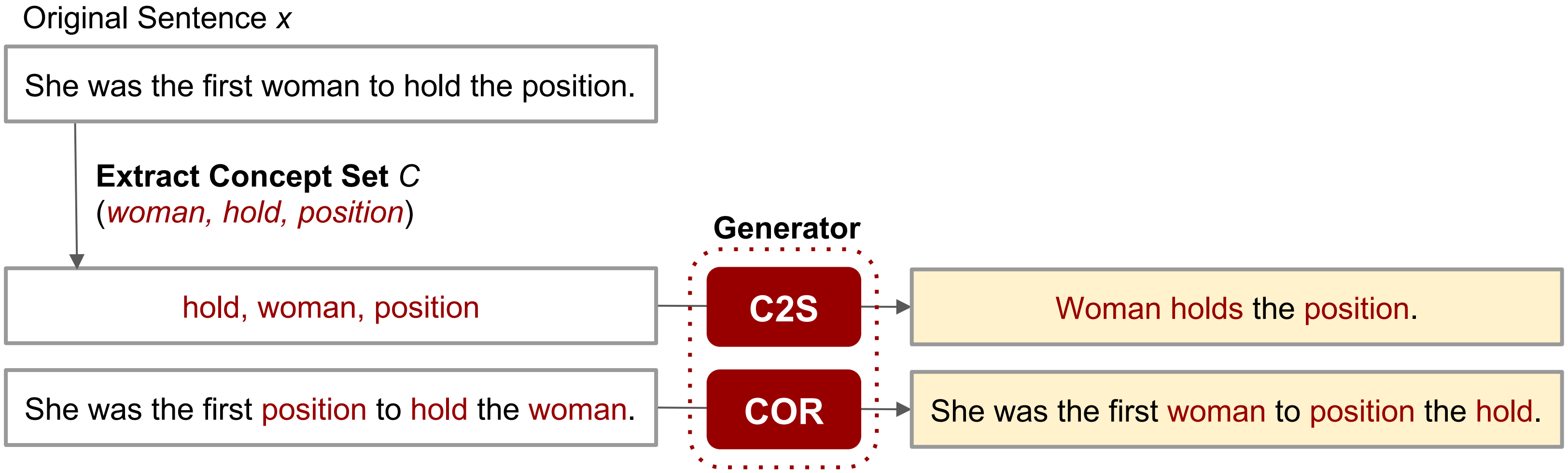
Extract Concept Set *C*
(*woman, hold, position*)

hold, woman, position

She was the first position to hold the woman.

(1) Given an input sentence *x* (*“She was the first woman to hold the position.”*), extract concept-set *C* (*woman, hold, position*).
(1) Given *x* and *C*, produce corrupted source sentence *x’* either for **C2S** and **COR**

CALM : Concept-Aware Language Model



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(2) The **generator** trained with **C2S** and **COR** recovers sentence *x'* to distractor *x"*

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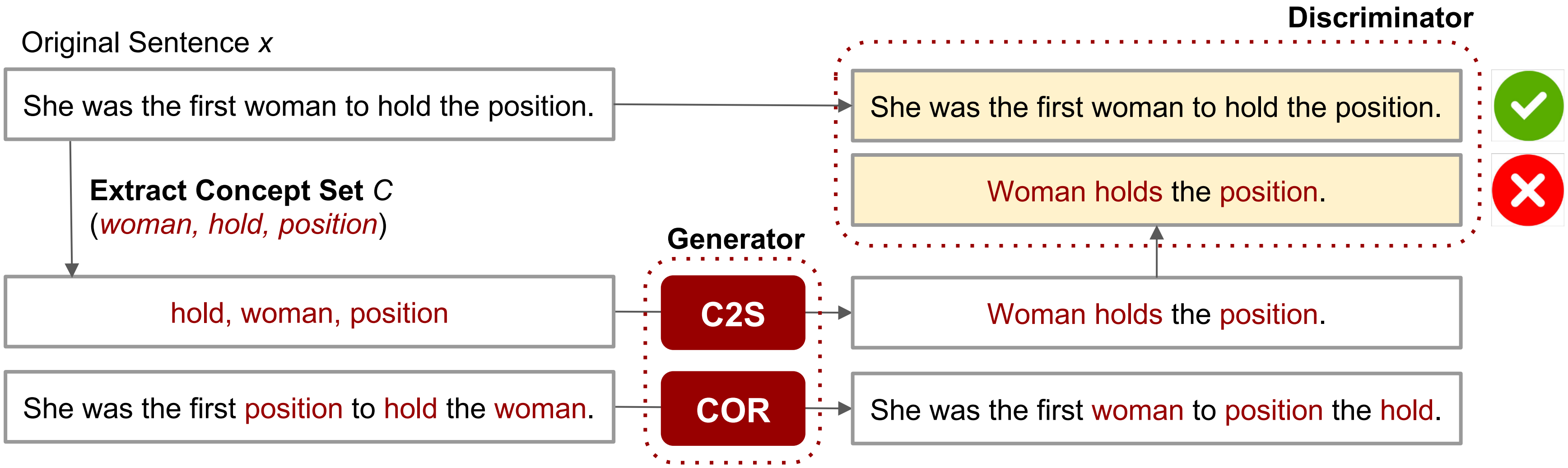

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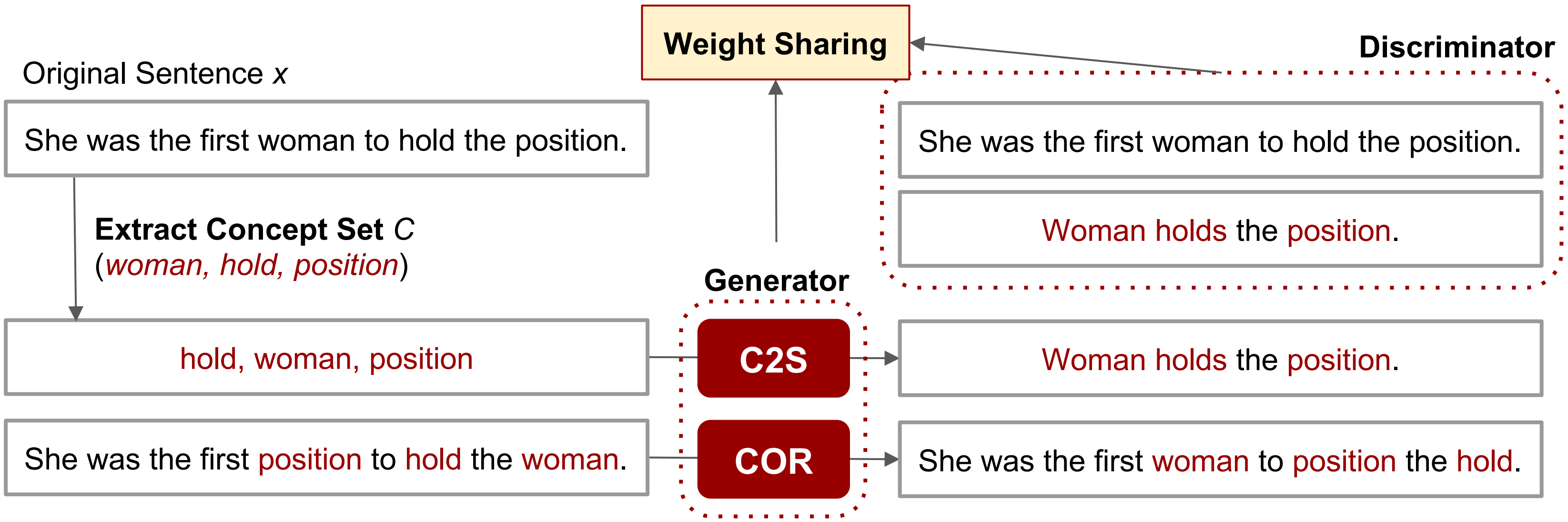

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Is **CALM** **reason** with **concepts** ? ***Yes !***

Methods	CSQA	OBQA	PIQA	aNLI
	Accuracy			
T5-base	61.88(±0.08)	58.20(±1.0)	68.14(±0.73)	61.10(±0.38)
T5-base w/ additional epochs	61.92(±0.45)	58.10(±0.9)	68.19(±0.77)	61.15(±0.52)
T5-base + SSM	62.08(±0.41)	58.30(±0.8)	68.27(±0.71)	61.25(±0.51)
CALM (Generative-Only)	62.28(±0.36)	58.90(±0.4)	68.91(±0.88)	60.95(±0.46)
CALM (Contrastive-Only)	62.73(±0.41)	59.30(±0.3)	<u>70.67</u>(±0.98)	61.35(±0.06)
CALM (Mix-only)	<u>63.02</u>(±0.47)	<u>60.40</u>(±0.4)	70.07(±0.98)	<u>62.79</u>(±0.55)
CALM (w/o Mix warmup)	62.18(±0.48)	59.00(±0.5)	69.21(±0.57)	61.25(±0.55)
CALM	**63.32(±0.35)**	**60.90(±0.4)**	**71.01(±0.61)**	**63.20(±0.52)**

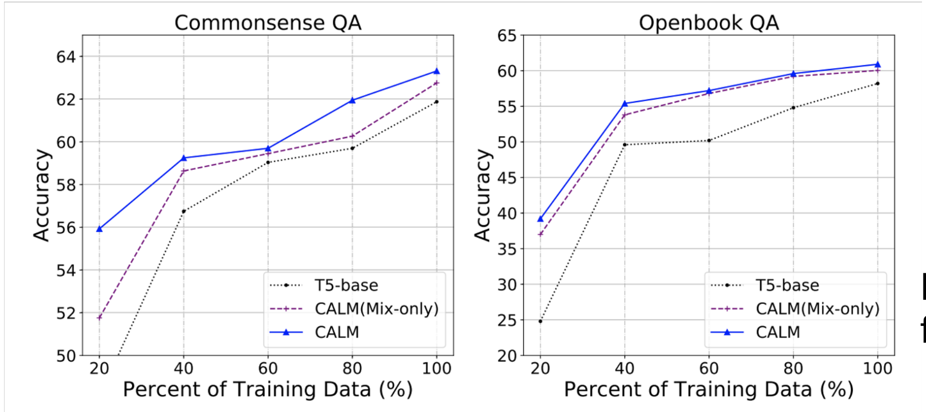
Experimental results on commonsense reasoning dataset.

CALM consistently and significantly **<u>outperforms</u>** the backbone T5-base model.

Is **CALM** **reason** with **concepts** ? ***Yes !***

Methods	CSQA	OBQA	PIQA	aNLI
	Accuracy (official dev)			
BERT-large	57.06(±0.12)	60.40(±0.6)	67.08(±0.61)	66.75(±0.61)
T5-large	69.81(±1.02)	61.40(±1.0)	72.19(±1.09)	75.54(±1.22)
CALM-large (Mix-only)	70.26(±0.23)	62.50(±1.0)	73.70(±1.09)	75.99(±1.26)
CALM-large	71.31(±0.04)	**66.00(±1.0)**	75.11(±1.65)	77.12(±0.34)

Effective in Large Models.



Performance of compared models fine-tuned with different fraction of the dataset

Performance is **consistent** in
large model & **different fraction** of the dataset.

Is **CALM** **write** with **concepts** ? ***Yes !***

Methods	Params	CommonGEN			
		BLEU-4	METEOR	CIDEr	SPICE
GPT-2 (Radford et al., 2019)	774M	21.10	26.20	12.15	25.90
UniLM (Dong et al., 2019)	340M	27.70	29.70	14.85	30.20
BART (Lewis et al., 2020)	406M	26.30	30.90	13.92	30.60
T5-Base (Raffel et al., 2019)	220M	16.40	23.00	9.16	22.00
T5-Large (Raffel et al., 2019)	770M	28.60	30.10	14.96	31.60
KG-BART (Liu et al., 2020)	406M	**30.90**	**32.40**	**16.83**	32.70
Our T5-Base	220M	24.90	31.20	12.99	32.40
CALM	220M	26.40	31.40	13.88	**33.00**

(Left) : Comparison between PTLMs
(Below) : Comparison on generated sentences with same concept-set

Concept-set	T5-base	CALM
Grass, Dog, Ball, Chase	a dog is chased by a ball on the grass.	dog chasing a ball in the grass.
Net, Cast, Boat, Water	fishing boat casts a net in the water.	fisherman casts a net into the water from a fishing boat.
Hole, Tree, Plant, Dig	a man digs a hole in a tree to plant a new tree . he digs the	man digging a hole to plant a tree.
Ingredient, Add, Pan, Fry	a pan filled with ingredients adds a touch of spice to the fry .	add the ingredients to a pan and fry.
Water, Hold, Hand, Walk	A man holding a hand and walking in the water. A man is holding water.	man holding a bottle of water in his hand as he walks down the street.
Place, Use, Metal tool	A man uses a metal tool to make a piece of metal.	woman uses a metal tool to make a piece of jewelry.
Hair, Wax, Apply, Remove	remove the wax from your hair and apply it to your hair .	woman applies wax to her hair and then removes it with a comb.
Sidewalk, Dog, Walk, Leash	A dog walking on a leash on the sidewalk.	dog walking on a sidewalk with a leash.

Summary

- **Novel self-supervised strategies** for concept-centric Common Sense
  - Concept to Sentence
  - Concept Order Recovering
  - Generative QA

- **Two-stage training strategy**
  - Generator and Discriminator

Text-to-Text models can be pre-trained with **better parameter** and **sample efficiency** by carefully designed **self-supervised objectives** that focus on the ability required by target tasks.