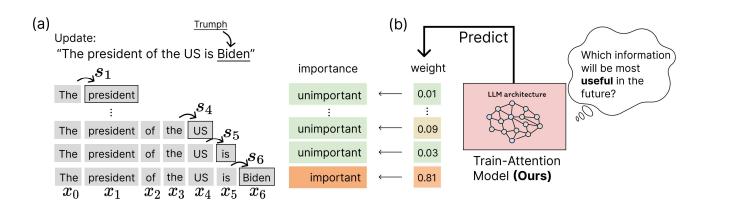
### Train-Attention: Meta-Learning Where to Focus in Continual Knowledge Learning

Yeongbin Seo, Dongha Lee\*, Jinyoung Yeo\*







### Background: Continual Knowledge Learning (CKL)

Ex)

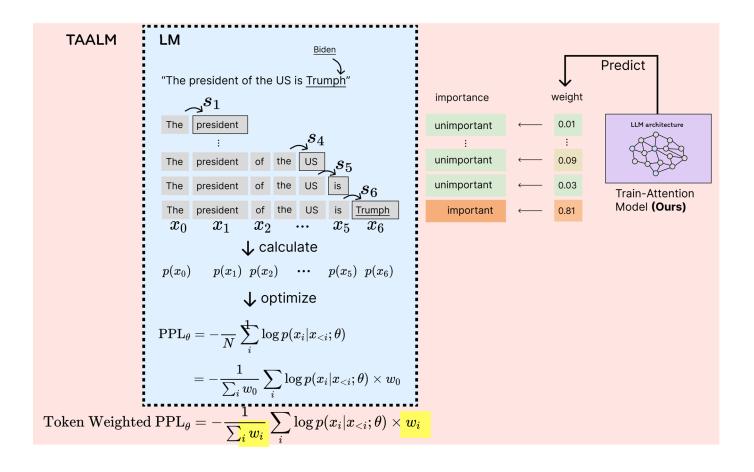
The president of the US is Biden

 $\rightarrow$  The president of the US is <u>Trumph</u>

- CKL : Enabling LMs to constantly obtain new and updated knowledge while mitigating forgetting of previous learned
- Two dimensions of evaluating CKL
  - Plasticity : How well obtained
  - Stability : How well preserved
- Previous approach
  - 1) Adapter
  - 2) Regularization
  - 3) Review
- Our approach : Learn only important (useful) information, skip un-important.

# Learning only **useful** information

**Train-Attention (TA)** : detecting and highlighting useful token in the document (D). **TA-augmented LM (TAALM)** : LMs learning new information with the aid of TA.



## What is **importance**? : **Usefulness**

$$\mathcal{D}_{i} = \{x_0, x_1, \dots, x_i, \dots x_n\}$$
  
: a text data (document), that  
consists of tokens ( $\mathcal{X}_i$ )

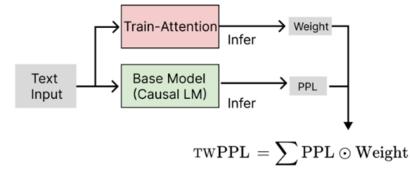
$$\mathcal{T}_{\mathcal{D}_{-}}$$
 : a task related to  $_{\mathcal{D}_{-}}$ 

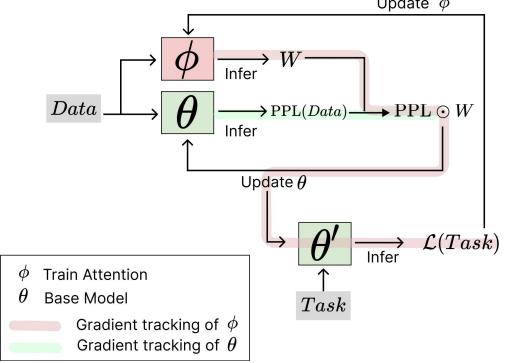


•  $x_i$  is **useful** if learning it is expected to help solving some tasks (i.e., improves the performance on tasks) in the future.

#### Formulate into Meta-learning problem $heta' \leftarrow heta - lpha abla_{ heta} tw \operatorname{PPL}_{ heta}(\mathcal{D}, W_{\mathcal{D}, \phi})$ $\phi \leftarrow \phi - \beta abla_{\phi} \mathcal{L}_{ heta'}(\mathcal{T}_{\mathcal{D}})$ Update $\phi$ $\rightarrow W$ Infer Data θ $\rightarrow \operatorname{PPL}(Data)$ - $\rightarrow$ PPL $\odot W$ Infer

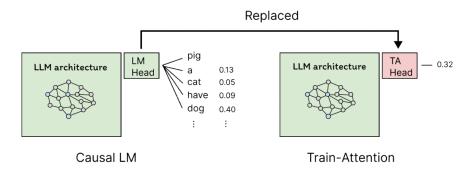
Train-Attention-Augmented Language Model



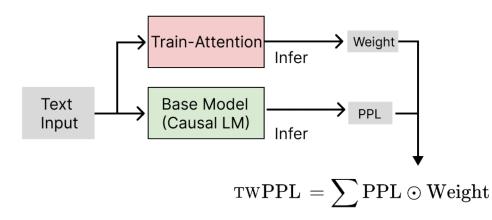


### Architecture

**TA** : Replace decoder layer of transformer model into  $hidden_{size} \times 1$  TA head.



**TAALM** : Apply TA when training.



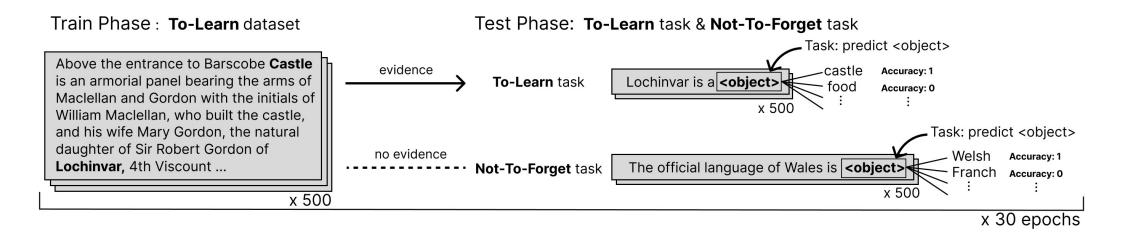
the weight map generated by the trained TA. Orange light highlight key information, such as the subject's name, occupation, or date of birth.

Scott	a.	OSS	(	born	\s	<u>, i</u>	9	6	2	1	is	a	song	writer	<b>a</b> .	guitar	ist	¥(	mand
olin	player	-11	singer		and	fiddle	player	primarily	in	the	American	Country	music	tradition	who	has	performed	with	Mer
lë:	H	agg	ard	8	Ð	w	ight	¥	0	ak	am		P:	ete	Anderson	4	Ŧ	iny	Moore
*	Roy	Nich	ols		D	ust	У	W	ak	eman		and	3	ana	J	ae	and	İS	a
successfu	solo	artist	32																

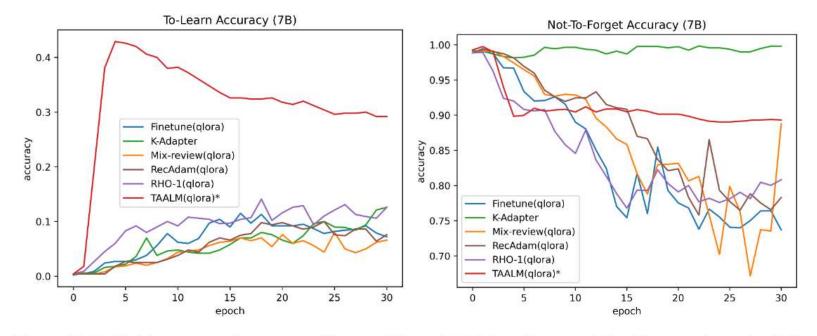
Origin	ally	from	the	Amer	icas	where	at .	is	native	to	Argentina		Boliv	ia	<i>6</i>	Brazil	2	E	cuador
	Par	agu	ay	and	Uruguay		it.	has	become	natural	ised	in	Asia	in .	Bh	ut	ari	6	China
1	Indones	ia	i de la compañía de la	Japan		New	C	aled	onia	9	Philippin		Singapore		Sri	E	anka	2	Рар
ua	New	Guinea	1	Taiwan		Th	ailand	a .	Vietnam		New	Zealand		Christma	Island	and	Australia	1	and
Hawai	<u>, 1</u>	in:	the	Pacific	region	<i>3</i>	while	(in	the	Africa	region	(it:	is	found	in:	B)	ots	w	ana
	Cam	ero	on		Egypt	le h	É.	rit	rea		Eth	юр	ia		Gh	ana		Guinea	
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amb	ique		Nam	ib	ia		RD	union		ß	w	anda		Soc	ot	ra		South	Africa
	SW	az	11	and	b	т	anz	ania	6	บ	g	anda	6	z	aire	a -	Z	amb	a.
and	Z	imb	ab	we															

This	IS	a	dialog	ше	#	James	10	What	kind	of	dogs	do	уоц	have	2	*	Ме	<u>1</u> 0	One
5	a	ter	ner	and	one	IS	a	sheep	dog	-	\s	How	long	have	you	been	volunte	ering	7
#	James		1	have	been	volunte	ering	for	last	\s	7	years	#	Me	8	Nice		1	try
to		but	1	98. 	ve	been	working	on	the	two	Must	angs		One	15	3	8	6	8
and	the	other	is	(a)	\s	6	6	H	ert	z	clone		*	James	35	What	are	doing	with
those	two	7	4	Me		The	15	6	8	IS		daily	driver		at	least	during	the	summer
	The	Н	ert	z	clone	is	a	tra	iler	queen	4	1	4	m	too	afraid	of	pay	ing
for	on	the	road	ins	urance		15	*	James		How	long	have	you	been	doing	this	7	#
Ме		U	mm	mm	1	off	and	on	2	since	As:	1	9	8	9		lt:	<u>81</u>	s
a	h	ob	by	that	takes	â	lot	of	dev	otion	4	lt.	can	be	expensive		but	it	doesn
	1	always	have	to	be		#	James	3	This	sounds	fun		Do	you	have	any	other	h
ob	by	7	#	Me		Well	1	do	like	to	listen	to	classic	country		and	1	do	have
my	two	dogs		a#	Bar	on	Z	emo	ALC: NO	and	<u>.</u>	S	pi	ke	38	\s	What	about	you
	how	do	you	like	wrest	ling	85	your	day	job	7		James	8 10	J.	й.	m	riot	super
into	wrest	ling	2	*	Ме	£1.	Ah	2	now	that	makes	sense	1	1	guess	(itt)	1	s	like
an	engineer	that	doesn	54	t.	like	to	†ix	stuff	around	the	house		Well		work	is	work	
	guess																		

## Benchmark: LamaCKL



```
pre-test accuracy 1 -> Not-To-Forget set -> evaluate stability
pre-test accuracy 0 -> To-Learn set -> evaluate plasticity
```



# Figure 7: LAMA-CKL performance of large (Llama2-7B) baseline models. The graph on the left represents TO-LEARN task, and the graph on the right represents NOT-TO-FORGET task performance. The x-axis is the learning epoch, and the y-axis is accuracy.

	Top Acc	Epoch	NF Acc	Total Knowledge
Finetune(QLoRA)	0.1150	16	0.8174	0.9324
K-Adapter	0.1260	30	0.9980	1.1240
Mix-review(QLoRA)	0.0800	25	0.7988	0.8788
RecAdam(QLoRA)	0.1000	24	0.7933	0.8933
RHO-1(QLoRA)	<u>0.1410</u>	18	0.8223	0.9633
TAALM(QLoRA)	0.4290	4	0.8983	1.3273

### Results

	TWi	ki-Probes	-0910	TWil	ki-Probes	s- <u>1011</u>	TWiki-Probes-1112			
	Un	С	Avg	Un	С	Avg	Un	С	Avg	
Finetune(QLoRA)	9.999	10.057	10.028	9.554	9.531	9.543	9.736	9.632	9.684	
Mix-review(QLoRA)	9.529	9.579	9.554	9.514	9.486	9.501	9.562	9.452	9.507	
RecAdam(QLoRA)	9.514	9.604	9.559	8.992	9.031	9.012	9.579	9.479	9.529	
RHO-1(QLoRA)	4.389	4.624	4.507	4.360	4.395	4.3775	4.471	<u>4.717</u>	4.594	
TAALM(QLoRA)	4.019	4.268	4.1435	4.030	4.154	4.092	4.036	4.357	4.197	