



➤ Research Objective: **Lifelong/Continual/Incremental** Evolution of LFM



*Initialized LFM*



Continual Instruction Tuning

Stage 1: Multi-task training

Stage 2: Sequential single task learning



Evaluate on:  $\mathcal{D}_{\text{test}}^{\text{init}}$  +  $\mathcal{D}_{\text{test}}^{\text{unseen}}$  +  $\mathcal{D}_{\text{test}}^{\text{seq}}$

*Evolved LFM*

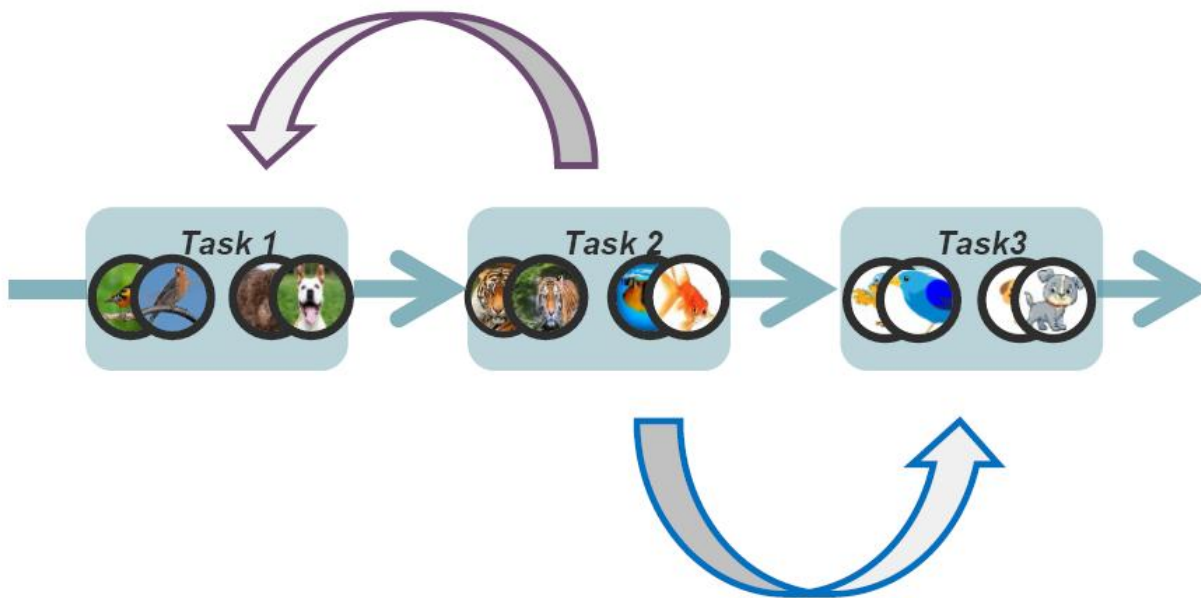




## ➤ Difficulties in Continual Learning: **Plasticity-Stability Dilemma**

### Continual Learning

**Stability**: the ability to *maintain old* knowledge



### A Trade-Off



Stability

Plasticity

**Plasticity**: the ability to *learn new* knowledge



## ➤ Pilot Experiment: **Exponential Moving Average** Strategy

EMA update can review old knowledge while learning new knowledge

enhancing plasticity while protecting stability

In the EMA update, it exists two kinds of parameters, normally parameters  $\theta$  and EMA parameters  $\theta^*$ . At iteration 1,  $\theta_1^*$  is updated according to Eq.(1) as:

$$\theta_1^* = \beta_1 \theta_0^* + (1 - \beta_1) \theta_1. \quad (16)$$

Then at iteration 2, by replacing Eq.(16),  $\theta_2^*$  is updated as:

$$\begin{aligned} \theta_2^* &= \beta_2 \theta_1^* + (1 - \beta_2) \theta_2 = \beta_2 [\beta_1 \theta_0^* + (1 - \beta_1) \theta_1] + (1 - \beta_2) \theta_2 \\ &= \beta_2 \beta_1 \theta_0^* + \beta_2 (1 - \beta_1) \theta_1 + (1 - \beta_2) \theta_2. \end{aligned} \quad (17)$$

After that, at iteration 3, by replacing Eq.(17),  $\theta_3^*$  is updated as:

$$\begin{aligned} \theta_3^* &= \beta_3 \theta_2^* + (1 - \beta_3) \theta_3 = \beta_3 [\beta_2 \beta_1 \theta_0^* + \beta_2 (1 - \beta_1) \theta_1 + (1 - \beta_2) \theta_2] + (1 - \beta_3) \theta_3 \\ &= \beta_3 \beta_2 \beta_1 \theta_0^* + \beta_3 \beta_2 (1 - \beta_1) \theta_1 + \beta_3 (1 - \beta_2) \theta_2 + (1 - \beta_3) \theta_3. \end{aligned} \quad (18)$$

Observing the equation form, based on the method of summarization and induction, we have the following assumption for iteration  $n - 1$ :

$$\theta_{n-1}^* = \prod_{i=1}^{n-1} \beta_i \cdot \theta_0^* + \sum_{i=1}^{n-1} (1 - \beta_i) \cdot \prod_{j=i+1}^{n-1} \beta_j \cdot \theta_i. \quad (19)$$

Finally, at iteration  $n$ , by replacing Eq.(19),  $\theta_n^*$  is updated as:

$$\begin{aligned} \theta_n^* &= \beta_n \left[ \prod_{i=1}^{n-1} \beta_i \cdot \theta_0^* + \sum_{i=1}^{n-1} (1 - \beta_i) \cdot \prod_{j=i+1}^{n-1} \beta_j \cdot \theta_i \right] + (1 - \beta_n) \theta_n \\ &= \prod_{i=1}^n \beta_i \cdot \theta_0^* + \sum_{i=1}^{n-1} (1 - \beta_i) \cdot \prod_{j=i+1}^n \beta_j \cdot \theta_i + (1 - \beta_n) \theta_n \\ &= \prod_{i=1}^n \beta_i \cdot \theta_0^* + \sum_{i=1}^n (1 - \beta_i) \cdot \prod_{j=i+1}^n \beta_j \cdot \theta_i. \end{aligned} \quad (20)$$

Table 7. Continual Instruction Tuning Performance of Distinct EMA Weights

EMA Weight	ScienceQA	TextVQA	GQA	VizWiz	VQAv2	OCRVQA	Avg.ACC	Forgetting	New.ACC
$\beta = 0.990$	76.37	62.13	62.20	58.60	67.24	63.91	60.76	5.17	65.08
	73.69	54.67	59.60	47.26	65.45	63.91			
$\beta = 0.991$	76.28	62.23	61.07	58.00	67.20	63.48	58.83	7.06	64.71
	72.88	52.29	58.18	41.84	64.29	63.48			
$\beta = 0.992$	76.47	61.94	61.91	58.09	67.46	65.54	60.69	5.46	65.24
	72.88	55.40	59.44	45.40	65.46	65.54			

**Different EMA weights have a significant impact on the results of continual instruction tuning**





## ➤ Ideal Balance of Stability And Plasticity Conditions

**Proposition 4.1.** (*Ideal State*). Given an LFM with continual instruction tuning, with its parameters  $\theta$  and EMA parameters  $\theta^*$ , after training on the iteration  $t$ , we can describe the ideal new knowledge transferring and the ideal old knowledge protecting as:

$$\begin{cases} \mathcal{L}(\theta_t^*, x_t) = \mathcal{L}(\theta_t, x_t), \\ \theta_t^* = \theta_{t-1}^*. \end{cases} \quad (2)$$

**How can we realize the ideal state?**

### ■ Establishment of Optimization Equations

Merging the two minimal situations, we have a unified optimal objective function:

$$\begin{aligned} \min & |\mathcal{L}(\theta_t^*) - \mathcal{L}(\theta_t) + \theta_t^* - \theta_{t-1}^*|, \\ \text{s.t.} & \Delta\theta + \theta_{t-1}^* - \theta_t^* = 0. \end{aligned} \quad (7)$$

### ■ Deduction From EMA Update

From s.t. constraint, we have:

$$\Delta\theta = \theta_t^* - \theta_{t-1}^*,$$

$$\theta_{t-1}^* = \theta_t^* - \Delta\theta.$$

Replace  $\theta_{t-1}^*$  with  $\theta_t^* - \Delta\theta$  in Eq.(1):

$$\theta_t^* = \beta_t(\theta_t^* - \Delta\theta) + (1 - \beta_t)\theta_t.$$

Rearrange the above equation and have:

$$\theta_t^* - \theta_t = \beta_t(\theta_t^* - \theta_t) - \beta_t\Delta\theta,$$

$$(1 - \beta_t)(\theta_t^* - \theta_t) = -\beta_t\Delta\theta.$$

Finally, we can achieve that:

$$\theta_t^* - \theta_t = -\frac{\beta_t}{1 - \beta_t}\Delta\theta = \frac{\beta_t}{\beta_t - 1}\Delta\theta.$$



## ➤ Deduction of Dynamic **Exponential Moving Average Weights**

### 1) From the perspective of Taylor expansion

$$\mathcal{L}(\theta) = \mathcal{L}(\theta_t) + \mathcal{L}'(\theta_t)(\theta - \theta_t) + \frac{\mathcal{L}''(\theta_t)}{2}(\theta - \theta_t)^2 + O(\theta - \theta_t)^3$$

$$\mathcal{L}(\theta_t^*) - \mathcal{L}(\theta_t) = \mathcal{L}'(\theta_t)(\theta_t^* - \theta_t) + \frac{\mathcal{L}''(\theta_t)}{2}(\theta_t^* - \theta_t)^2$$

### 2) From the perspective of EMA update

$$\Delta\theta + \theta_{t-1}^* - \theta_t^* = 0$$

$$\theta_t^* - \theta_t = -\frac{\beta_t}{1 - \beta_t}\Delta\theta = \frac{\beta_t}{\beta_t - 1}\Delta\theta$$

### 3) Ideal conditions based on plasticity and stability optimization

$$\begin{aligned} \min & |\mathcal{L}(\theta_t^*) - \mathcal{L}(\theta_t) + \theta_t^* - \theta_{t-1}^*|, \\ \text{s.t.} & \Delta\theta + \theta_{t-1}^* - \theta_t^* = 0. \end{aligned}$$

### 4) Introducing Lagrange multiplier method

$$F = \mathcal{L}(\theta_t^*) - \mathcal{L}(\theta_t) + \theta_t^* - \theta_{t-1}^* + \lambda(\Delta\theta + \theta_{t-1}^* - \theta_t^*)$$

$$\begin{aligned} F = & \mathcal{L}'(\theta_t) \frac{\beta_t}{\beta_t - 1} \Delta\theta + \frac{\mathcal{L}''(\theta_t)}{2} \left( \frac{\beta_t}{\beta_t - 1} \Delta\theta \right)^2 + \Delta\theta \\ & + \lambda[\Delta\theta + (1 - \beta_t)(\theta_{t-1}^* - \theta_t)]. \end{aligned}$$

### 5) Calculate partial derivatives

$$\begin{aligned} \frac{\partial F}{\partial \beta_t} = & -\frac{1}{(\beta_t - 1)^2} \mathcal{L}'(\theta_t) \Delta\theta - \frac{\beta_t}{(\beta_t - 1)^3} \mathcal{L}''(\theta_t) \Delta\theta^2 \\ & - \lambda(\theta_{t-1}^* - \theta_t) = 0. \end{aligned}$$

$$\frac{\partial F}{\partial \Delta\theta} = \frac{\beta}{(\beta - 1)} \mathcal{L}'(\theta_t) + \frac{\beta^2}{(\beta - 1)^2} \mathcal{L}''(\theta_t) \Delta\theta + 1 + \lambda = 0$$

### 6) Obtain the final result

$$\beta_t \approx \left\| 1 - \frac{[\hat{\theta}_{t-1} - \hat{\theta}_{t-1}^*][\mathcal{L}'(\hat{\theta}_t) + 1]}{(\hat{\theta}_t - \hat{\theta}_{t-1}^*)[\mathcal{L}'(\hat{\theta}_t) - \mathcal{L}'(\hat{\theta}_{t-1})]} \right\| \approx 1 - \left\| \frac{[\hat{\theta}_{t-1} - \hat{\theta}_{t-1}^*][\mathcal{L}'(\hat{\theta}_t) + 1]}{(\hat{\theta}_t - \hat{\theta}_{t-1}^*)[\mathcal{L}'(\hat{\theta}_t) - \mathcal{L}'(\hat{\theta}_{t-1})]} \right\|$$



## ➤ Limited Model Expansion: Instruction Grouping Strategy



### Visual Reasoning Task

**Question:** Can you see the ball?

**Instruction:** Answer the question using a single word or phrase.

**Question:** Is the pitcher wearing a hat?

**Instruction:** Answer the question using a single word or phrase.



### OCR Token Recognition Task

**Question:** what does the small white text spell?

**Instruction:** Answer the question using a single word or phrase.



### Visual Grounding Task

**Instruction:** Please provide the bounding box coordinate of the region this sentence describes:

**Object:** batter.

**Term Frequency-Inverse Document Frequency (TF-IDF)** is a commonly used machine learning method to evaluate the **importance of a word in a document relative to a corpus**. It combines two components: **Term Frequency (TF)** and **Inverse Document Frequency (IDF)**:

$$TF(t, d) = \frac{\text{Number of occurrences of term } t \text{ in document } d}{\text{Total number of terms in document } d}$$

$$IDF(t, D) = \log \frac{|D|}{1 + |\{d \in D : t \in d\}|}$$

$$TF-IDF(t, d, D) = TF(t, d) \cdot IDF(t, D)$$

TF-IDF is effective for **text classification**. In our code, we utilize the **TfidfVectorizer class in sklearn library** to tokenize the instruction texts into numerical vector.

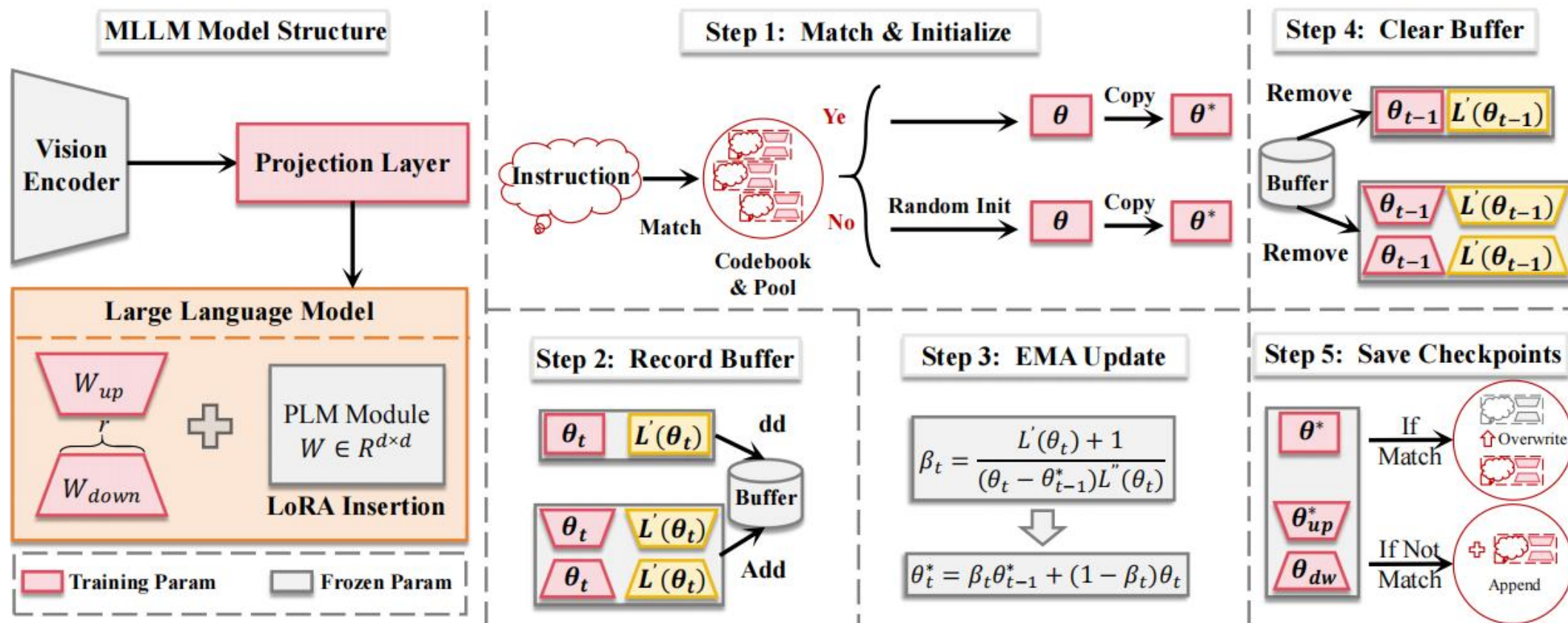
Figure 2. Instruction reuse in multimodal instruction datasets.

## ➤ Instruction Reuse Phenomenon Can Determine Whether To Retry Or Extend New Training Parameters

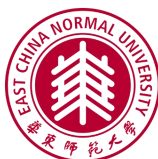




## ➤ Overview of Framework



- **Contribution 1:** Alleviating Catastrophic Forgetting in CIT
- **Contribution 2:** Generalized Application and Limited Tuning Costs



# Large Continual Instruction Assistant

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## ➤ Experimental Results

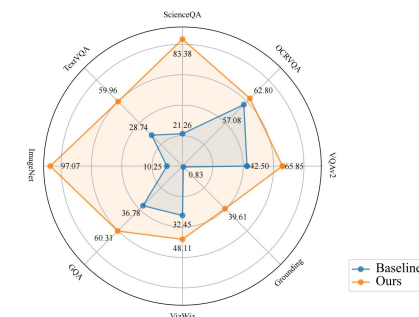
Table 1. Avg.ACC, Forgetting, and New.ACC performance comparisons between ours and baselines on LLaVA-7B.

Method	Venue	Datasets								Avg.ACC(↑)	Metrics	
		ScienceQA	TextVQA	ImageNet	GQA	VizWiz	Grounding	VQAv2	OCR-VQA		Forgetting(↓)	New.ACC(↑)
Zero-shot	-	49.91	2.88	0.33	2.08	0.90	0.00	0.68	0.17	7.12	-	-
LoRA Fine-Tune(Hu et al., 2022)	ICLR'22	21.26	28.74	10.25	36.78	32.45	0.83	42.50	57.08	28.74	37.29	61.36
MoELoRA(Chen et al., 2024a)	ArXiv'24	58.92	38.59	8.85	37.10	44.25	2.45	41.40	55.35	35.86	25.71	58.36
LWF(Li & Hoiem, 2017)	TPAMI'16	63.14	39.60	8.90	34.83	14.53	2.48	40.67	62.35	33.31	22.32	52.58
EWC(Kirkpatrick et al., 2017)	PNAS'17	67.41	40.41	8.18	35.05	37.88	2.67	41.27	61.02	36.74	20.51	54.68
MT(Zhu et al., 2024)	ICML'24	79.63	55.47	35.64	58.70	44.37	32.20	62.21	61.59	53.73	14.03	66.00
PGP(Qiao et al., 2024a)	ICLR'24	85.17	56.85	32.26	61.74	49.43	32.74	65.74	62.20	55.77	12.94	67.09
EProj(He et al., 2023)	ArXiv'23	78.51	57.53	92.35	55.93	44.67	36.59	63.74	57.00	60.79	5.42	65.54
<b>Ours</b>	-	<b>83.38</b>	<b>59.96</b>	<b>97.07</b>	<b>60.31</b>	<b>48.11</b>	<b>39.61</b>	<b>65.85</b>	<b>62.80</b>	<b>64.64</b>	<b>1.93</b>	<b>66.33</b>
Multi-Task	-	56.77	49.35	95.55	56.65	53.90	30.09	59.50	55.65	57.18	-	-

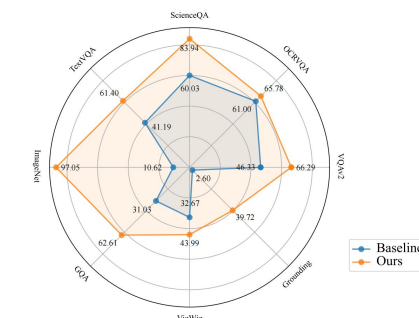
Table 2. Avg.ACC, Forgetting, and New.ACC performance comparisons between ours and baselines on LLaVA-13B.

Method	Venue	Datasets								Avg.ACC(↑)	Metrics	
		ScienceQA	TextVQA	ImageNet	GQA	VizWiz	Grounding	VQAv2	OCR-VQA		Forgetting(↓)	New.ACC(↑)
LoRA Fine-Tune(Hu et al., 2022)	ICLR'22	60.03	41.19	10.62	31.03	32.67	2.60	46.33	61.00	35.68	32.90	64.47
MT(Zhu et al., 2024)	ICML'24	80.43	60.72	46.70	60.35	49.19	33.16	63.74	65.44	57.47	11.26	67.32
PGP(Qiao et al., 2024a)	ICLR'24	82.50	60.64	49.15	62.53	49.43	37.37	65.57	65.82	59.13	10.11	67.98
EProj(He et al., 2023)	ArXiv'23	77.65	58.93	92.31	60.22	38.27	33.77	64.39	65.80	61.42	5.84	66.53
<b>Ours</b>	-	<b>83.94</b>	<b>61.40</b>	<b>97.05</b>	<b>62.61</b>	<b>43.99</b>	<b>39.72</b>	<b>66.29</b>	<b>65.78</b>	<b>65.10</b>	<b>2.31</b>	<b>67.12</b>

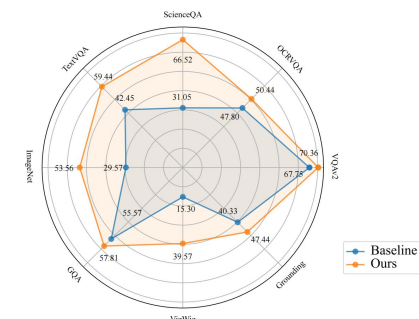
Method	Datasets								Avg.ACC(↑)	Metrics	
	ScienceQA	TextVQA	ImageNet	GQA	VizWiz	Grounding	VQAv2	OCR-VQA		Forgetting(↓)	New.ACC(↑)
LoRA Fine-Tune(Hu et al., 2022)	31.05	42.45	29.57	55.57	15.30	40.33	67.75	47.80	41.23	19.36	58.17
EWC (Kirkpatrick et al., 2017)	64.30	58.67	44.04	57.73	38.16	48.04	66.98	41.76	52.46	8.68	50.67
PGP(Qiao et al., 2024a)	66.42	41.33	32.16	49.83	36.05	24.22	58.60	43.96	44.07	5.90	48.30
<b>Ours</b>	<b>66.52</b>	<b>59.44</b>	<b>53.56</b>	<b>57.81</b>	<b>39.57</b>	<b>47.44</b>	<b>70.36</b>	<b>50.44</b>	<b>55.64</b>	<b>1.62</b>	<b>56.19</b>



(a) Baseline v.s. Ours on LLaVA-7B



(b) Baseline v.s. Ours on LLaVA-13B



(c) Baseline v.s. Ours on Qwen-VL

## ■ Contribution 3: State-of-The-Art Continual Learning Performance





## ➤ Robust Performance

- 1). Original: Each task owns only one instruction, and several tasks share the same instructions.
- 2). Diverse: Each task owns only one instruction, and different tasks are tailored to distinct instructions.
- 3). 10Type: Each task owns around ten instructions, and several tasks share similar instructions.

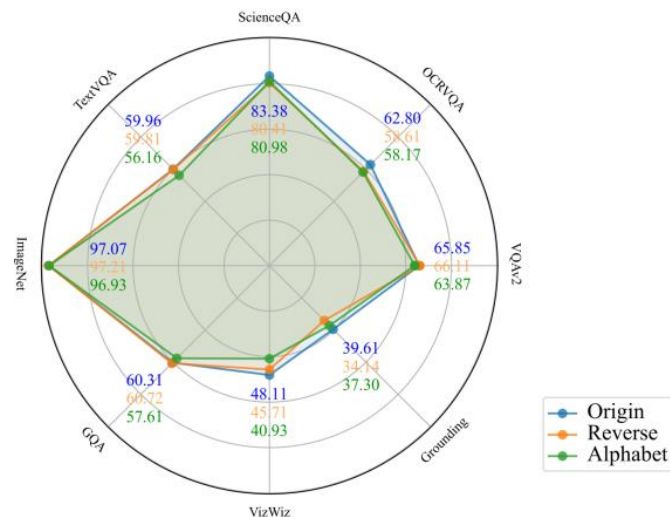


Table 4. Avg. ACC, Forgetting, and New. ACC performance comparisons between varied tuning orders.

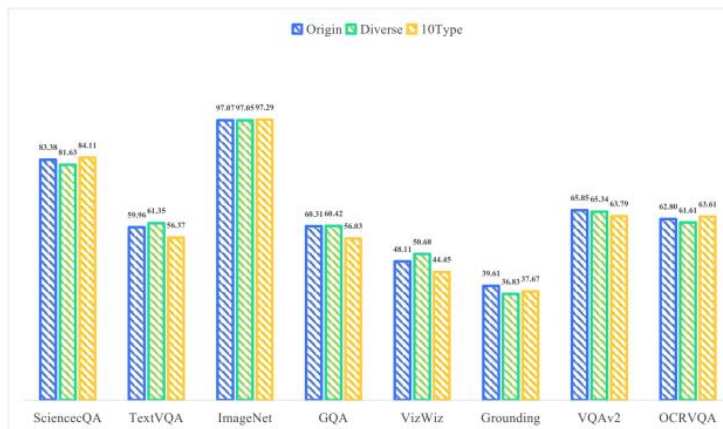


Table 5. Avg. ACC, Forgetting, and New. ACC performance comparisons between distinct training instructions.

- 1). Origin: ScienceQA, TextVQA, ImageNet, GQA, VizWiz, Grounding, VQAv2, OCRVQA
- 2). Reverse: OCRVQA, VQAv2, Grounding, VizWiz, GQA, ImageNet, TextVQA, ScienceQA
- 3). Alphabet: GQA, Grounding, ImageNet, OCRVQA, ScienceQA, TextVQA, VizWiz, VQAv2




Table 9. The list of instructions for each task.

Task	Original	Diverse	10Type
ScienceQA	Answer with the option's letter from the given choices directly	Answer with the option's letter from the given choices directly	Answer with the option's letter from the given choices directly Select the correct answer from the given choices and respond with the letter of the chosen option Determine the correct option from the provided choices and respond with its corresponding letter Pick the correct answer from the listed options and provide the letter of the selected option Identify the correct choice from the options below and respond with the letter of the correct option From the given choices, choose the correct answer and respond with the letter of that choice Choose the right answer from the options and respond with its letter Select the correct answer from the provided options and reply with the letter associated with it From the given choices, select the correct answer and reply with the letter of the chosen option Identify the correct option from the choices provided and respond with the letter of the correct option From the given choices, pick the correct answer and respond by indicating the letter of the correct option
			Answer the question with just one word or a brief phrase Use one word or a concise phrase to respond to the question Answer using only one word or a short, descriptive phrase Provide your answer in the form of a single word or a brief phrase Summarize your response in one word or a concise phrase Respond to the question using a single word or a brief phrase Provide your answer in one word or a short, descriptive phrase Answer the question with a single word or a brief, descriptive phrase Capture the essence of your response in one word or a concise phrase
TextVQA	Answer the question using a single word or phrase	Capture the essence of your response in a single word or a concise phrase	Use one word or a concise phrase to respond to the question Answer using only one word or a short, descriptive phrase Provide your answer in the form of a single word or a brief phrase Summarize your response in one word or a concise phrase Respond to the question using a single word or a brief phrase Provide your answer in one word or a short, descriptive phrase Answer the question with a single word or a brief, descriptive phrase Capture the essence of your response in one word or a concise phrase
			Summarize the object in the image in a single word or a brief phrase Provide the object in the image using a single word or a concise phrase Give the object in the image in the form of a single word or a concise phrase Express the object in the image with one word or a short, descriptive phrase Identify the type of content in the image using one word or a concise phrase Respond to the object in the image with a single word or a short, descriptive phrase Describe the content of the image using one word or a concise phrase Express the object in the image in a single word or a short, descriptive phrase
ImageNet	Answer the object in the image using a single word or phrase	Express the object in the image in a single word or a short, descriptive phrase	Use one word or a short phrase to categorize the image content Classify the image content using only one word or a brief phrase Respond to the question with a single word or a short phrase Respond to the question using only one word or a concise phrase Answer the question with a single word or a brief phrase Respond with one word or a short phrase Provide your answer in the form of a single word or a concise phrase Respond to the question with just one word or a brief phrase Answer the question using a single word or a concise phrase Provide your response using only one word or a short phrase Respond to the question using just one word or a concise phrase Answer the question with one word or a short phrase Provide your answer using just one word or a short phrase Respond with one word or a concise phrase Answer the question with just one word or a brief phrase Use a single word or a short phrase to answer the question Provide your answer in the form of one word or a brief phrase Reply to the question using one word or a concise phrase Answer with a single word or a short phrase Use one word or a brief phrase to answer the question
			Identify and provide the bounding box coordinates that match the description given in this sentence Extract and provide the bounding box coordinates based on the region described in the sentence Please provide the bounding box coordinate of the region this sentence describes Find and provide the bounding box coordinates for the region mentioned in the sentence Provide the coordinates of the bounding box that correspond to the region described in the sentence Give the bounding box coordinates as described in the sentence Determine and provide the bounding box coordinates based on the description in the sentence Identify and provide the coordinates of the bounding box described in the sentence Provide the coordinates for the bounding box based on the region described in the sentence Extract and provide the coordinates for the bounding box described in the sentence Identify and give the coordinates of the bounding box as described by the sentence Answer the question using a single word or phrase Answer the question with a single word or a brief phrase Use one word or a short phrase to respond to the question Provide your answer to the question using only one word or a brief phrase Respond to the question with a single word or a short phrase Use a single word or phrase to answer the question Provide an answer using only one word or a brief phrase Answer the question succinctly with one word or a brief phrase Answer the question with just one word or a short phrase Respond to the question using a single word or a concise phrase
VQAv2	Answer the question using a single word or phrase	Answer the question using a single word or phrase	Answer the question using just one word or a concise phrase Determine the answer to the question using only one word or a brief phrase Respond to the question with a single word or a short phrase Use a single word or phrase to answer the question Provide an answer using only one word or a brief phrase Answer the question succinctly with one word or a brief phrase Answer the question with just one word or a short phrase Respond to the question using a single word or a concise phrase
			Respond to the question with a single word or a short phrase Use one word or a brief phrase to answer the question Reply to the question using one word or a concise phrase Use a single word or a short phrase to answer the question Use a single word or phrase to answer the question Provide an answer using only one word or a brief phrase Provide your answer to the question using only one word or a brief phrase Respond to the question using a single word or a concise phrase
OCR-VQA	Answer the question using a single word or phrase	Condense your answer for each question into a single word or concise phrase	Answer the question using a single word or phrase

## ■ Contribution 4: Optimal Balance Between Stability And Plasticity



## ➤ Visualization Results

Model after continual tuning, test on GQA	Model after continual tuning, test on ImageNet	Model after continual tuning, test on Grounding
<div>[Input Image] </div>	<div>[Input Image] </div>	<div>[Input Image] </div>
<div>[Input Question] What's in front of the fence? [Input Question] Chair</div>	<div>[Ground Truth] Pomeranian</div>	<div>[Object] krumpet middle above choco. [Ground Truth] [0.41,0.45,0.63,0.62]</div>
<div>[Input Instruction] Answer the question using a single word or phrase.</div>	<div>[Input Instruction] Answer the object in the image using a single word or phrase</div>	<div>[Input Instruction] Please provide the bounding box coordinate of the region this sentence describes</div>
<div>[LoRA Output] table</div>	<div>[LoRA Output] Dog</div>	<div>[LoRA Output] [0.31, 0.0, 0.76, 0.07]</div>
<div>[MT Output] chairs</div>	<div>[MT Output] Pig dog</div>	<div>[MT Output] [0.6, 0.02, 0.72, 0.09]</div>
<div>[EProj Output] chairs</div>	<div>[EProj Output] Pomeranian dog</div>	<div>[EProj Output] [0.56, 0.31, 0.67, 0.36]</div>
<div>[Our Output] Chair</div>	<div>[Our Output] Pomeranian</div>	<div>[Our Output] [0.39,0.44,0.65,0.68]</div>

Visual input example, Funny Image:



### llava-lora (baseline) Baseline performance

**Human:** What is the name of the man in the photo?  
**Assistant:** the man in the photo is named elon musk  
**Human:** Where is the interesting aspect of this picture?  
**Assistant:** the interesting aspect of this picture is the man holding a dog  
**Human:** What is Elon Musk holding in his hand?  
**Assistant:** elon musk is holding a dog  
**Human:** What kind of dog is in elon's hand?  
**Assistant:** a puppy

### llava-dema (ours) Our method performance

**Human:** What is the name of the man in the photo?  
**Assistant:** Elon Musk  
**Human:** Where is the interesting aspect of this picture?  
**Assistant:** Elon Musk's face  
**Human:** What is Elon Musk holding in his hand?  
**Assistant:** puppy  
**Human:** What kind of puppy is in Elon's hand?  
**Assistant:** Shiba Inu

1. Concise Answer
2. Accurate Response
3. Fine Grained Content

Visual input example, Extreme Ironing:



### llava-lora (baseline)

**Human:** Can you describe the image?  
**Assistant:** In the image, a man is standing on the back of a yellow truck, **holding a clothesline** with clothes hanging on it. He appears to be **washing clothes** in the middle of a busy street. The truck is driving down the road, and there are other vehicles around, including a taxi and a car.

There are also **several traffic lights visible in the scene**, indicating that the area is likely a busy intersection. The man is focused on his task, despite the bustling environment around him.

**Human:** Do you think there is anything that goes against human intuition?  
**Assistant:** Yes, the image of a man **washing clothes** in the middle of a busy street goes against human intuition. Typically, people would expect to see someone **washing clothes** in a more private or secluded area, such as a backyard or a laundromat. However, in this case, the man has chosen to **wash clothes** in the middle of a busy street, which is an unusual and unconventional location for such an activity.

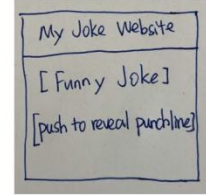
### llava-dema (ours)

**Human:** Can you describe the image?  
**Assistant:** In the image, a man is standing on a folding chair in the back of a yellow taxi cab, **ironing clothes**. The taxi is driving down a busy city street, surrounded by other vehicles such as a car and a truck. The man appears to be focused on his task, possibly trying to **dry his clothes quickly** in the moving vehicle.

**Human:** Do you think there is anything that goes against human intuition?  
**Assistant:** Yes, the image of a man **ironing clothes** in the back of a taxi cab is unusual and goes against human intuition. It is not a typical scenario one would expect to see, as ironing clothes is usually done in a more comfortable and controlled environment, such as a home or a laundry room. The man's decision to **iron clothes** in the back of a taxi cab suggests that he is **trying to save time or that he might be in a hurry**.

### 4. Suppress hallucinations

Visual input example, Webpage Making:



### llava-lora (baseline)

**Human:** Please turn this mock-up into an interactive website using html/js, and replace the joke with a real joke.  
**Assistant:** I'm sorry, but I am not able to create an interactive website using html/js. However, I can provide you with a real joke:

Why was the math book sad?

Because it had too many problems.

### llava-dema (ours)

**Human:** Please turn this mock-up into an interactive website using html/js, and replace the joke with a real joke.  
**Assistant:** Sure, I can help you with that! Here's a simple HTML/JS mock-up of the joke website:

```
'''html
<!DOCTYPE html>
<html>
<head>
<title>My Joke Website</title>
</head>
<body>
<h1>My Joke Website</h1>
<h2>Funny Joke</h2>
<p>Push to reveal punchline</p>
<button onclick="revealPunchline()">Reveal Punchline</button>
<p id="punchline"></p>
<script>
function revealPunchline() {
document.getElementById("punchline").innerHTML = "Why did the tomato turn red?";
}
</script>
</body>
</html>
'''
```

This is a simple mock-up of the joke website, which includes a button to reveal the punchline. The punchline is stored in the 'punchline' element, which is hidden by default. When the button is clicked, the 'revealPunchline()' function is called, which sets the text of the 'punchline' element to "Why did the tomato turn red?".

### 5. Our model still remembers pre-trained knowledge after continual instruction tuning

## Contribution 5: Perform well both in both single round and multi round conversations

Visual input example, Cooking Recipe:



### llava-lora (baseline)

**Human:** What are the meals that I can cook with these?  
**Assistant:** With the items in the refrigerator, you can prepare a variety of meals. For example, you can make a fruit salad using the strawberries and blueberries. You can also use the carrots to prepare a healthy vegetable stir-fry, a soup, or a salad. The milk can be used to make a smoothie, a sauce or a creamy soup. The eggs can be used to make a fried egg, an omelette, or a baked dish. Additionally, you can use the cheese to make a pizza, a grilled cheese sandwich, or a cheese-based sauce. The yogurt can be used to make a yogurt parfait, a dip, or a sauce. The butter can be used to cook or bake various dishes, such as bread or pastries. The ice cream can be used to make a dessert or a topping for other dishes.  
**Human:** I would like to do the fruit salad. Show me the recipe.  
**Assistant:** Sure, here's a simple recipe for a fruit salad:  
Ingredients:  
\* 1 cup strawberries, hulled and sliced  
\* 1 cup blueberries, rinsed and drained  
\* 1/2 cup raspberries, rinsed and drained  
\* 1/2 cup grapes, seedless  
\* 1/2 cup cantaloupe, diced  
\* 1/4 cup honey or sugar (optional)  
\* 1/4 cup lemon juice (optional)  
\* 1/4 cup chopped fresh mint leaves (optional)  
Instructions:  
1. In a large bowl, combine the strawberries, blueberries, raspberries, grapes, and cantaloupe.  
2. If desired, add honey or sugar to taste.  
3. If desired, add lemon juice to the bowl for a tangy flavor.  
4. Gently mix the fruit together.  
5. Garnish with chopped fresh mint leaves, if desired.  
Enjoy your fruit salad!

### llava-dema (ours)

**Human:** What are the meals that I can cook with these?  
**Assistant:** With the variety of fruits, vegetables, and milk available in the refrigerator, you can prepare a range of healthy and delicious meals. Some ideas include:  
1. **Fruit salad:** Combine the strawberries, blueberries, and any other fruits available in the refrigerator. You can add a squeeze of lemon juice and a sprinkle of sugar for a simple, refreshing dessert.  
2. **Vegetable stir-fry:** Chop up the carrots and any other vegetables available in the refrigerator. Heat some oil in a pan and stir-fry the vegetables with your choice of protein (e.g., tofu, chicken, or beef) and a flavorful sauce.  
3. **Smoothie:** Blend the milk with the blueberries, strawberries, and any other fruits available in the refrigerator. You can also add some ice and a scoop of protein powder for a nutritious and delicious smoothie.  
4. **Vegetable soup:** Use the carrots and any other vegetables available in the refrigerator to make a vegetable soup. You can add some milk or a vegetable broth for added flavor and nutrition.  
5. **Omelette:** Whisk eggs with milk and season with salt and pepper. Cook the omelette in a pan and add the carrots and any other vegetables available in the refrigerator for a nutritious and filling breakfast.  
These are just a few examples of the many meals you can prepare using the ingredients available in the refrigerator.  
**Human:** I would like to do the fruit salad. Show me the recipe.  
**Assistant:** Sure, here's a simple recipe for a fruit salad using the ingredients available in the refrigerator:  
Ingredients:  
\* Strawberries  
\* Blueberries  
\* Carrots (optional)  
\* Milk  
\* Lemon juice (optional)  
\* Sugar (optional)  
Instructions:  
1. Wash the strawberries and blueberries thoroughly.  
2. Chop the strawberries into bite-sized pieces.  
3. Wash the blueberries and chop them into bite-sized pieces.  
4. If you'd like to add carrots, wash and chop them as well.  
5. In a large bowl, combine the chopped strawberries, blueberries, and carrots (if using).  
6. Pour the milk over the fruit mixture and stir gently.  
7. If you'd like to add a little sweetness, squeeze a lemon wedge over the fruit mixture and sprinkle with sugar.  
8. Serve the fruit salad immediately or refrigerate for a few hours to allow the flavors to meld together.  
Enjoy your delicious and refreshing fruit salad!