



JANUS-LORA: A Balanced Low-Rank Adaptation for Continual Learning

A Balanced Low-Rank Adaptation for Continual Learning

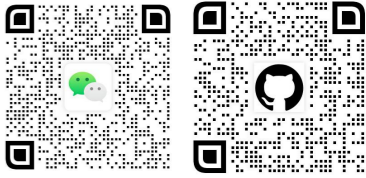
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Github: [zackschen/Janus-LoRA](https://github.com/zackschen/Janus-LoRA)

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1. Derivation -> Diagnosis

Sufficient condition for zero interference

$$\text{Old Outputs Unchanged} \Rightarrow \Delta W X_{\text{past}} = 0$$

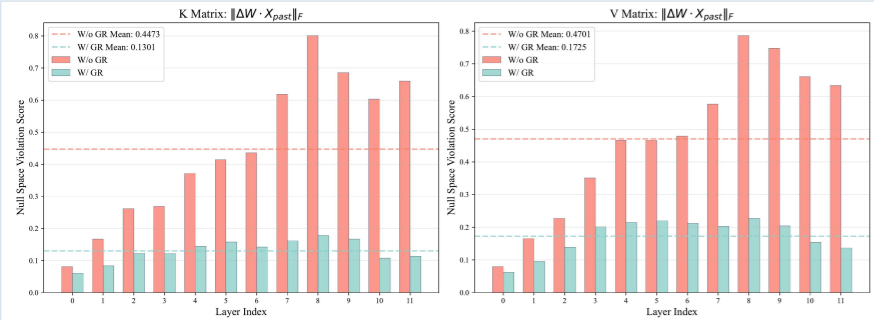
$$\text{Safe Update: } \Delta W_{\text{safe}} = \Delta W_{\text{orig}} (I - V V^T)$$

> Orthogonality is the sufficient condition: updates in the null space avoid changing historical activations.

> But LoRA does not update Delta W directly; it updates A and B independently.

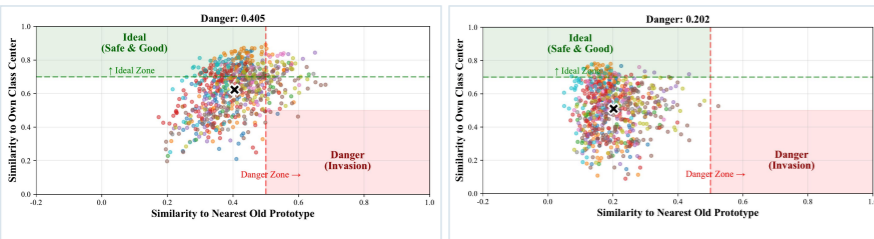
$$\text{LoRA Composite: } \Delta W = B \Delta A + \Delta B A$$

Observed issue 1: Parameter-level misalignment



> W/o GR has high $\|\Delta W X_{\text{past}}\|_F$; GR sharply reduces the violation on K/V matrices.

Observed issue 2: feature-space encroachment



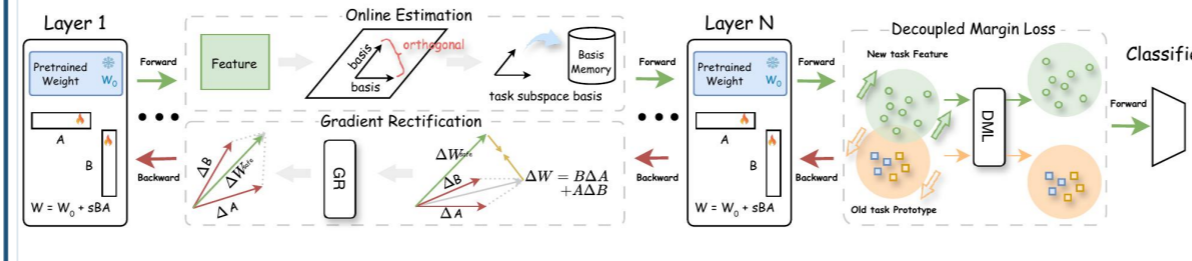
Without DML: danger = 0.405

With DML: danger = 0.202

Main contributions:

- Diagnose forgetting as parameter misalignment + feature encroachment.
- Derive closed-form GR to make LoRA's composite update orthogonal.
- Use DML to preserve plasticity by separating new and old feature regions.

2. Method: Resolve Both Failures



Parameter-level stability

> OE estimates the protected historical subspace V online, without old samples.

> GR reverse-engineers Delta W_safe into corrected Delta A and Delta B.

Feature-level plasticity

> DML enforces angular separation from old prototypes so new classes have low-interference feature regions.

$$L_{\text{total}} = L_{\text{task}} + \lambda_{\text{DML}} L_{\text{DML}}$$

OE gives the subspace, GR makes LoRA follow the safe update, DML restores plasticity in feature space.

3. Experiments: What Each Test Proves

1 Prove: the modules are necessary

Experiment: remove/add OE, GR, DML on ImageNet-R

Result: full Janus-LoRA gives best ACC/MAA; OE+GR best BWT.

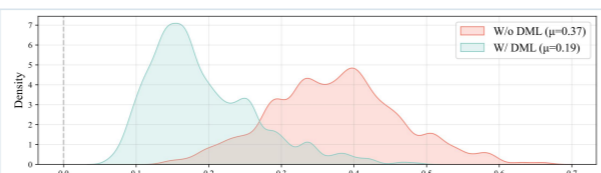
2 Prove: GR fixes update misalignment

Experiment: plug GR into LoRA-DRS and LoRA-GPM

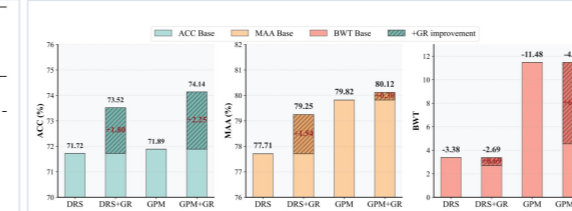
Result: +2.25 ACC and +6.93 BWT on LoRA-GPM.

Variant	ImageNet-R		
	OE	GR	DML
①			
②			✓
③	✓		
④		✓	
⑤	✓	✓	
⑥	✓		✓
⑦	✓	✓	✓

Ablation analysis on the contributions of each module on ImageNet-R



Density distribution between current task samples and historical prototypes



Impact of Integrating Gradient Rectification (GR)

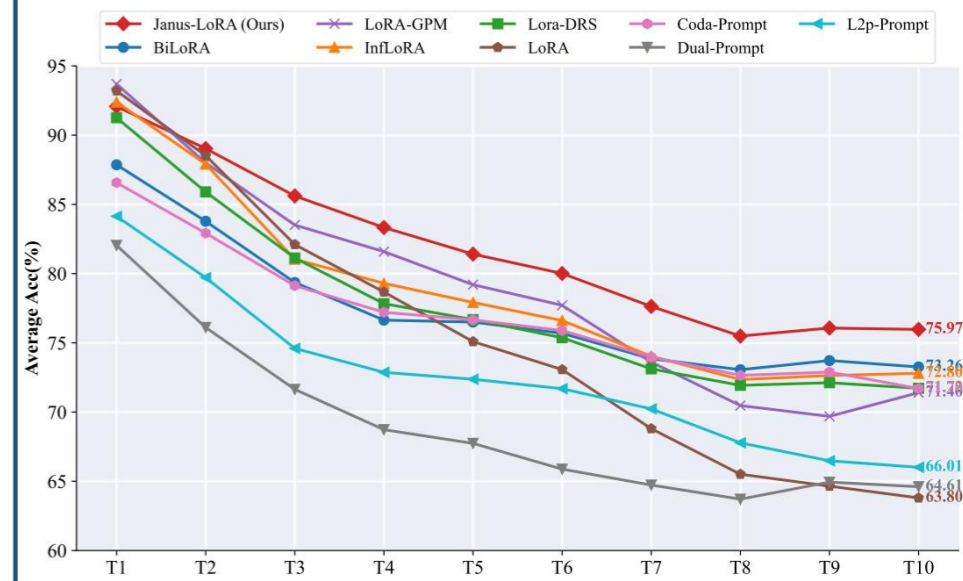
Dataset	Method	ACC ↑	MAA ↑	BWT ↓
ImageNet-R	GPM	38.79 _{0.42}	42.48 _{0.22}	-5.36 _{0.55}
	OE	40.90 _{0.47}	45.93 _{1.15}	-5.98 _{0.90}
CIFAR100	GPM	74.84 _{1.85}	83.30 _{1.78}	-7.70 _{0.32}
	OE	77.31 _{0.63}	84.83 _{0.80}	-6.27 _{2.06}

Performance comparison between OE and GPM under a single-epoch training

4. Main Results: Evidence Chain

Model	ImageNet-R (T = 5)			ImageNet-R (T = 10)			ImageNet-R (T = 20)		
	ACC ↑	MAA ↑	BWT ↓	ACC ↑	MAA ↑	BWT ↓	ACC ↑	MAA ↑	BWT ↓
Fine-Tuning	69.75 _{0.87}	78.93 _{0.34}	-17.65 _{1.00}	64.24 _{0.95}	74.68 _{0.98}	-21.85 _{0.90}	57.62 _{0.87}	69.86 _{0.34}	-25.43 _{1.11}
L2P	68.02 _{0.42}	73.68 _{0.43}	-7.13 _{0.35}	65.99 _{0.41}	72.70 _{0.53}	-6.95 _{0.29}	60.99 _{0.20}	68.20 _{0.58}	-8.50 _{0.68}
Dual-Prompt	68.48 _{0.19}	72.18 _{0.20}	-4.70 _{0.40}	64.45 _{0.21}	69.23 _{0.32}	-4.45 _{0.57}	64.45 _{0.21}	69.23 _{0.32}	-4.45 _{0.57}
Coda-Prompt	74.05 _{0.41}	78.36 _{0.17}	-4.61 _{0.24}	71.59 _{0.66}	76.72 _{0.57}	-4.48 _{0.47}	65.73 _{0.16}	70.98 _{0.30}	-4.57 _{0.42}
LoRA-DRS	74.51 _{0.66}	80.27 _{0.61}	-4.11 _{0.49}	72.58 _{0.75}	78.34 _{0.70}	-3.72 _{0.65}	67.60 _{0.45}	73.72 _{0.43}	-3.66 _{0.86}
LoRA-GPM	73.96 _{0.72}	81.16 _{0.48}	-10.24 _{0.79}	71.56 _{0.29}	79.34 _{0.47}	-10.95 _{0.58}	64.06 _{0.33}	73.91 _{0.45}	-14.56 _{0.64}
BiLoRA	74.93 _{0.28}	78.59 _{0.48}	-2.74 _{0.15}	73.93 _{0.60}	77.92 _{0.52}	-2.07 _{0.33}	61.70 _{0.24}	68.60 _{0.24}	-5.48 _{0.61}
InfLoRA	76.31 _{0.33}	81.64 _{0.34}	-6.17 _{0.40}	73.90 _{0.69}	80.01 _{0.77}	-6.33 _{0.56}	68.91 _{0.77}	76.24 _{0.65}	-7.74 _{0.46}
Janus-LoRA	77.19 _{0.39}	82.52 _{0.35}	-6.71 _{0.50}	75.78 _{0.16}	81.64 _{0.27}	-6.05 _{0.66}	71.57 _{0.45}	77.11 _{0.35}	-5.77 _{0.66}

Model	CIFAR-100			ImageNet-100			DomainNet		
	ACC ↑	MAA ↑	BWT ↓	ACC ↑	MAA ↑	BWT ↓	ACC ↑	MAA ↑	BWT ↓
Fine-Tuning	83.53 _{1.13}	90.18 _{0.48}	-11.47 _{1.00}	89.10 _{0.31}	92.95 _{0.33}	-6.80 _{0.32}	69.34 _{0.09}	74.83 _{0.03}	-5.14 _{0.20}
L2P	84.52 _{0.04}	88.74 _{0.13}	-4.06 _{2.28}	90.66 _{0.18}	92.87 _{0.29}	-3.02 _{0.10}	71.33 _{0.14}	76.40 _{0.08}	-7.73 _{0.56}
Dual-Prompt	83.09 _{0.49}	88.80 _{0.39}	-4.02 _{0.32}	89.08 _{0.37}	91.79 _{0.52}	-3.58 _{0.13}	71.70 _{0.11}	77.30 _{0.07}	-5.74 _{0.44}
Coda-Prompt	85.36 _{0.30}	90.15 _{0.16}	-4.41 _{0.47}	91.63 _{0.38}	93.93 _{0.25}	-3.12 _{0.23}	73.14 _{0.04}	78.64 _{0.04}	-5.50 _{0.29}
LoRA-DRS	84.02 _{0.85}	89.23 _{0.68}	-2.16 _{0.33}	92.42 _{0.21}	94.11 _{0.11}	-2.03 _{0.24}	73.40 _{0.04}	79.36 _{0.05}	-4.80 _{0.16}
LoRA-GPM	86.01 _{0.15}	91.31 _{0.14}	-5.56 _{0.06}	91.53 _{0.59}	94.00 _{0.37}	-3.58 _{0.30}	69.24 _{0.19}	74.84 _{0.18}	-5.55 _{0.39}
BiLoRA	86.48 _{0.77}	91.00 _{0.44}	-3.32 _{0.51}	91.74 _{0.29}	93.65 _{0.10}	-2.80 _{0.25}	67.32 _{0.11}	73.03 _{0.14}	-4.91 _{0.36}
InfLoRA	86.69 _{0.28}	91.61 _{0.23}	-4.61 _{0.27}	91.84 _{0.32}	93.94 _{0.30}	-2.37 _{0.05}	72.94 _{0.06}	78.98 _{0.07}	-7.38 _{0.11}
Janus-LoRA	88.68 _{0.25}	92.58 _{0.20}	-5.29 _{0.33}	92.47 _{0.17}	94.32 _{0.14}	-3.24 _{0.46}	73.82 _{0.09}	79.67 _{0.05}	-7.74 _{0.17}



Backbone	Method	ACC ↑	MAA ↑	BWT ↓
SAM	Fine-Tuning	47.66	55.70	-40.37
	L2P	66.01	73.21	-7.75
	Dual-Prompt	61.19	67.77	-5.27
	Coda-Prompt	61.92	70.88	-19.01
	LoRA-DRS	68.12	75.73	-4.78
	LoRA-GPM	58.44	66.40	-26.85
	BiLoRA	65.66	70.95	-2.65
DINO	InfLoRA	69.64	77.21	-5.90
	Janus-LoRA	70.22	77.90	-6.47
	LoRA-GPM	56.79	70.50	-24.36
DINO	L2P	62.48	69.26	-5.37
	Dual-Prompt	59.60	66.97	-5.56
	Coda-Prompt	64.22	72.43	-6.81
	LoRA-DRS	64.39	72.07	-4.36
	LoRA-GPM	62.15	73.34	-16.56
	BiLoRA	65.84	72.33	-3.91
	InfLoRA	67.83	75.98	-7.79
Janus-LoRA	68.20	76.15	-5.73	

