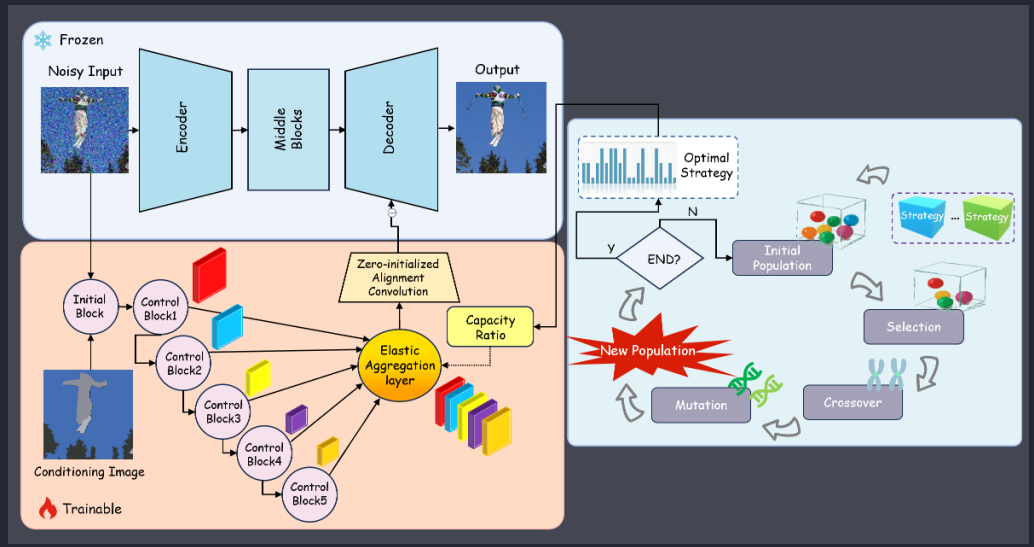
AHFAControl

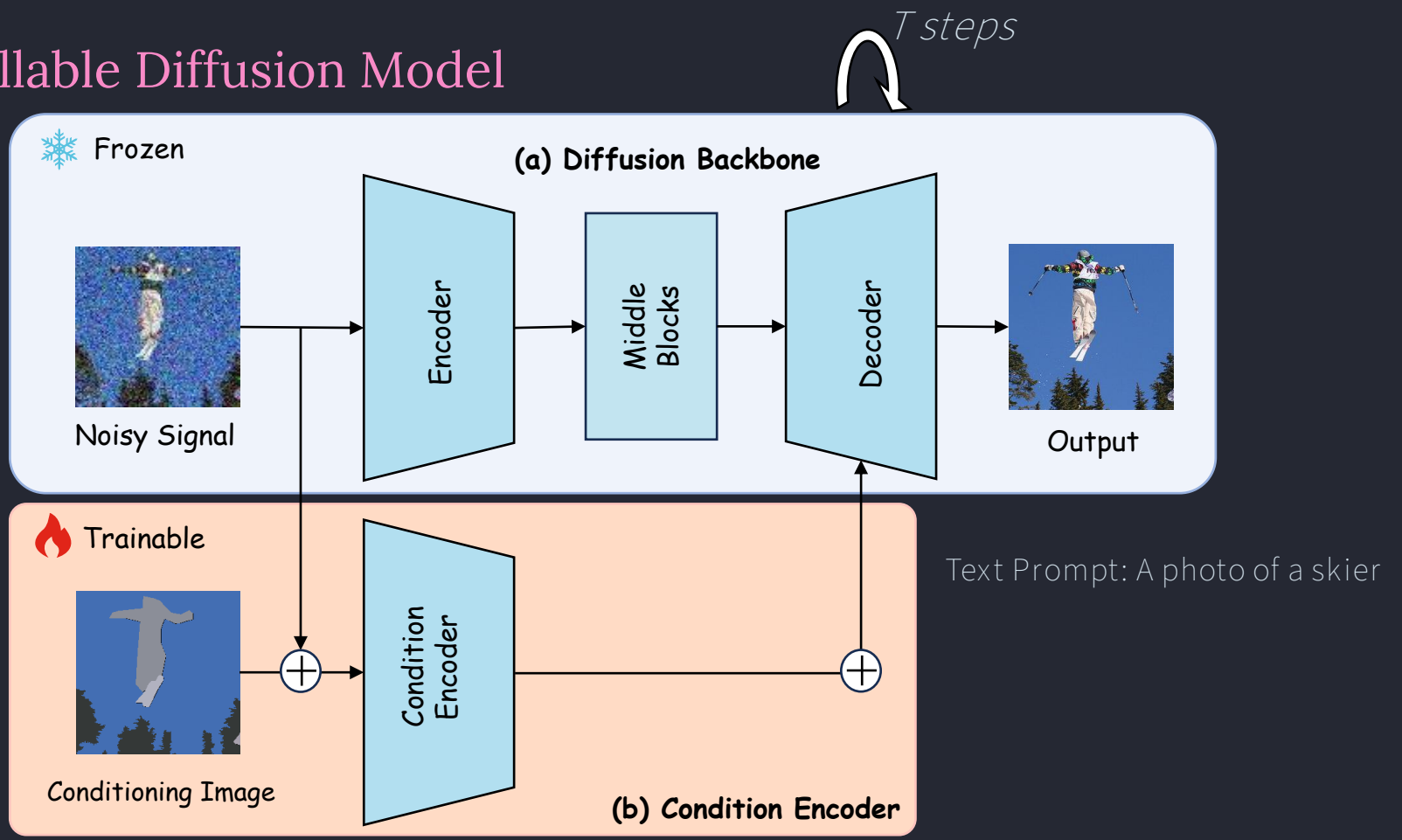
Adaptive Hierarchical Feature Aggregation
for Controllable Diffusion Models



Rui Hou · Sichuan University, China · ICME 2026

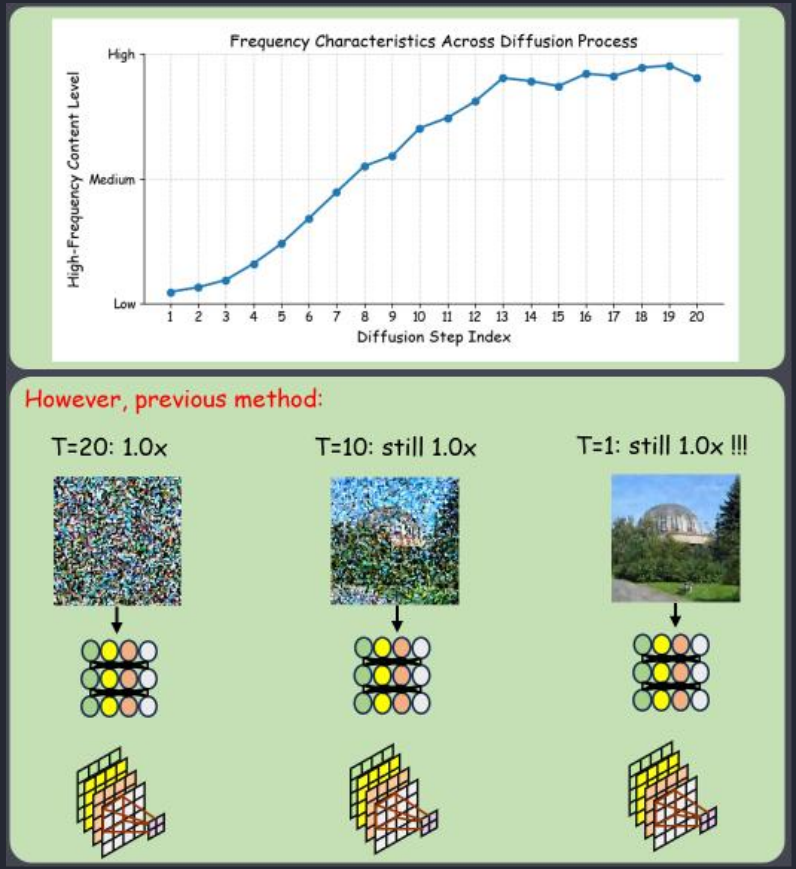
Background

Controllable Diffusion Model



KEY INSIGHT 1

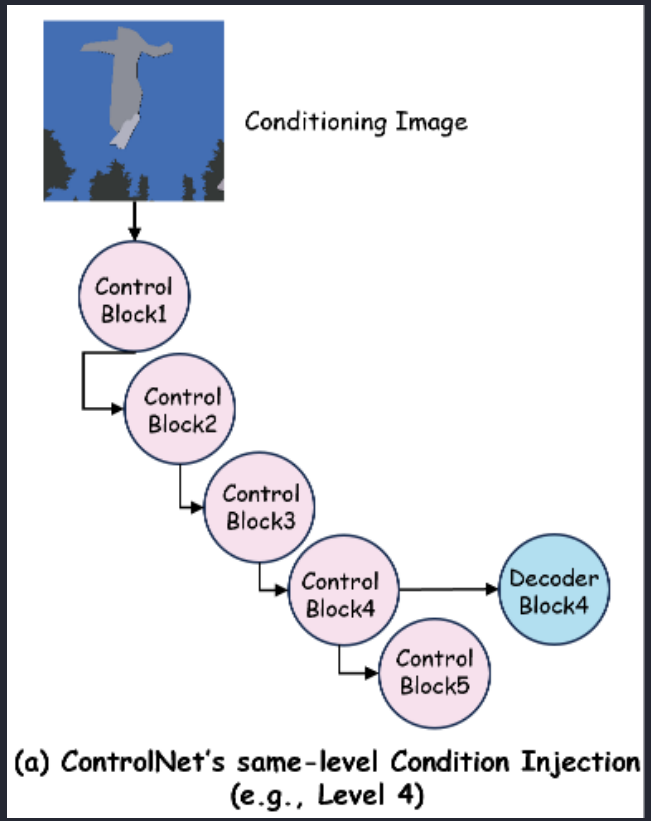
Not All Timesteps Are Equal



→ Timestep-adaptive control is essential

KEY INSIGHT 2

Structural Loss



Previous methods: Single-level injection

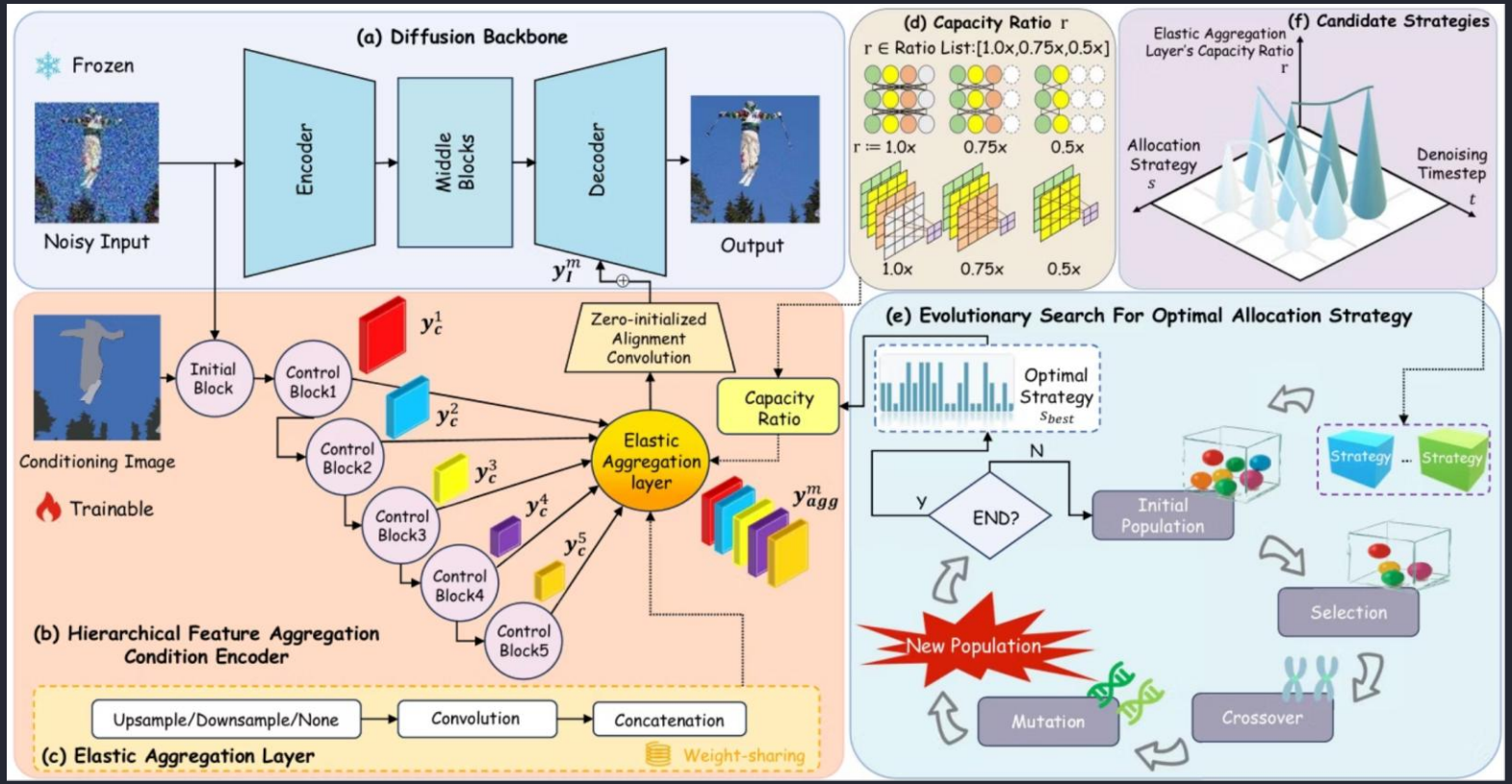
low-level details
&
high-level semantics

Are Lost!

Can we prevent?

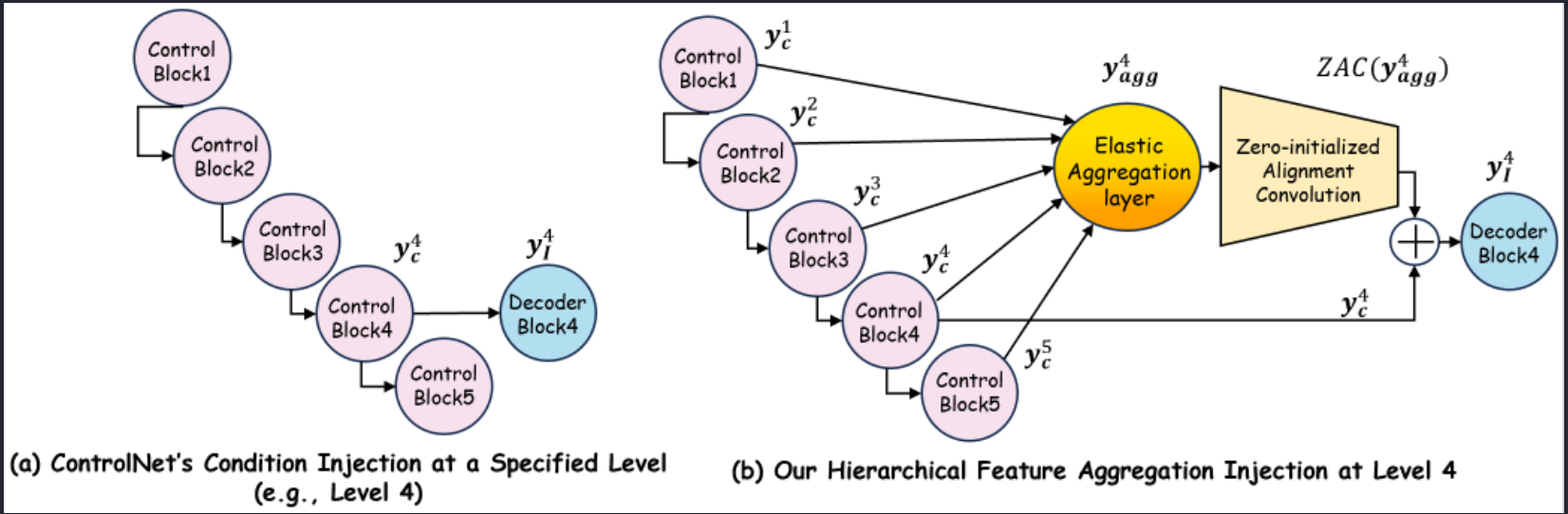
FRAMEWORK

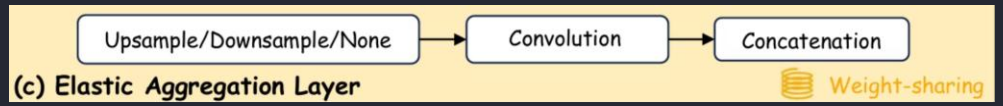
AHFAControl: System Overview



CORE INNOVATION

Hierarchical Feature Aggregation

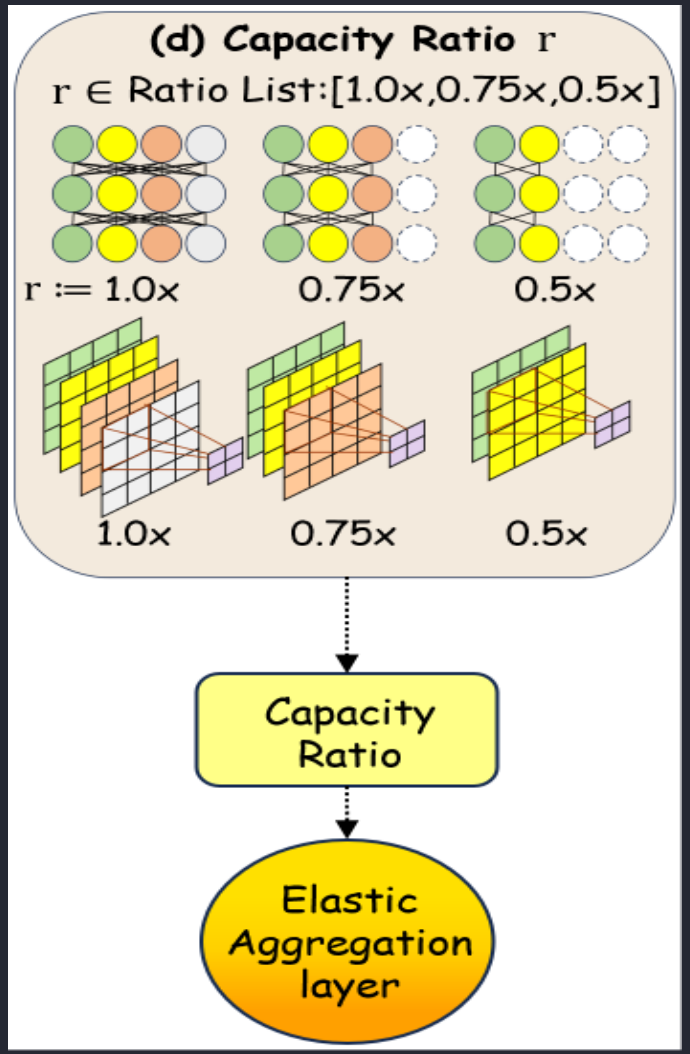




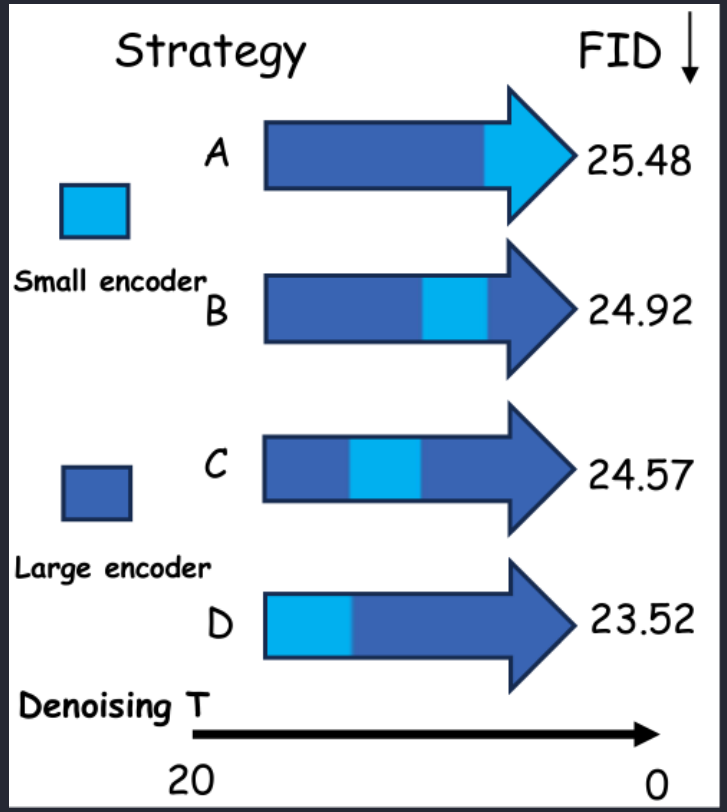
CORE INNOVATION

“Elastic” Mechanism & Capacity Ratio For Timestep-Adaptation

Weight Sharing



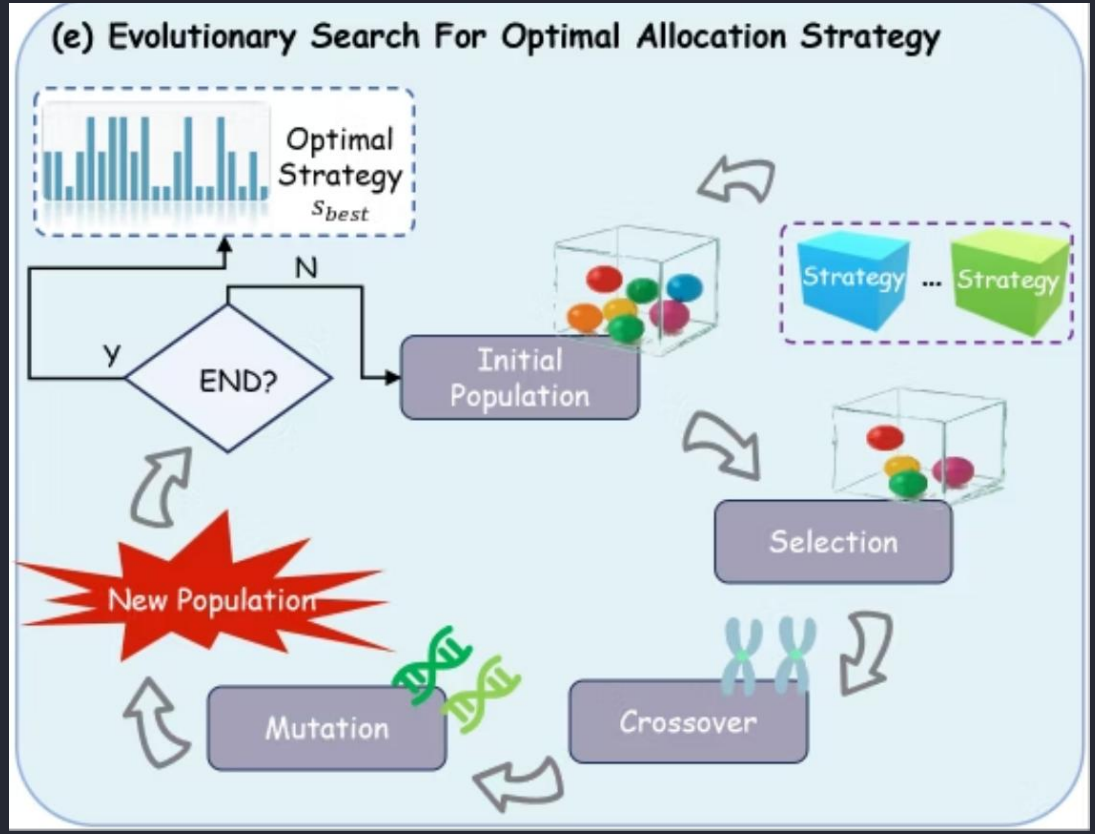
Why not **manually** design “ratio-to-timestep” ?



Manual Design is infeasible.

SEARCH STRATEGY

Finding the Optimal Strategy : Evolutionary Search



Fitness Function
= Image Quality + Control Precision

QUANTITATIVE RESULTS

SOTA Performance Across Benchmarks

Conditional Datasets	Controllable Diffusion Models	Metrics		
		FID↓[a]	*mIoU*↑[b]*/HDD*↓	*CLIP Score*↑
COCO2017 (Canny Edge)	ControlNet [6]	25.13	18.52	0.290
	T2I-Adapter [5]	30.70	15.09[c]	0.292
	Uni-ControlNet [21]	24.25	15.94	0.293
	ControlNet-XS [8]	23.08	15.22	0.296
	CtrLoRA [20]	23.20	16.13	0.304
	AHFAControl	**22.65**	**13.04**	**0.316**
ADE20k (Seg. Mask)	GLIGEN [7]	23.79	0.21	0.249
	T2I-Adapter [5]	24.65	0.18	0.249
	ControlNet [6]	21.33	0.28	0.253
	ControlNet++ [9]	19.89	0.34	0.264
	FlexControl [15]	14.80	0.38	0.284
	AHFAControl	**11.86**	**0.50**	**0.299**

22.65

Best FID

0.50

Highest mIoU

10.4%

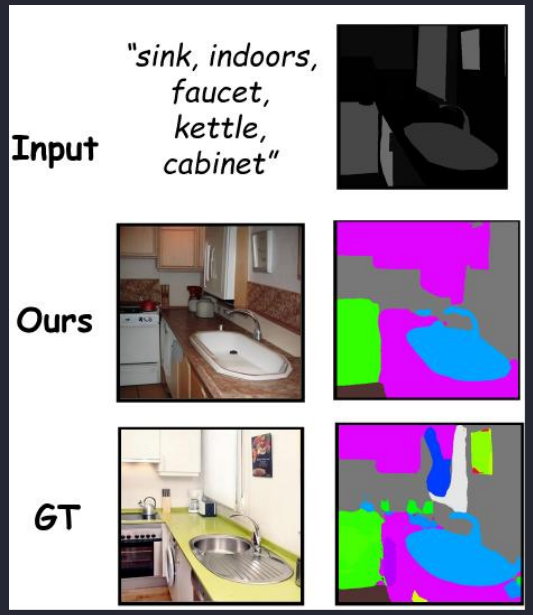
GFLOPs Saved

Better quality. Less computation.

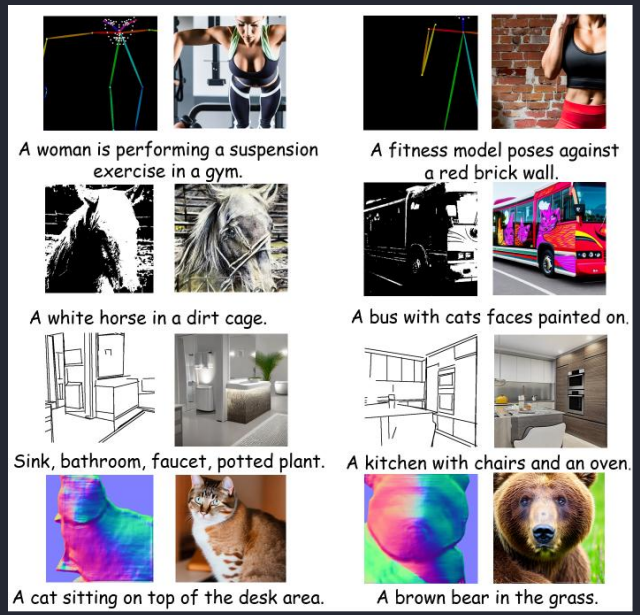
VISUAL RESULTS

Sharper Edges, Cleaner Boundaries

Edge Control



Segmentation Control



Other Types

Ablation Study

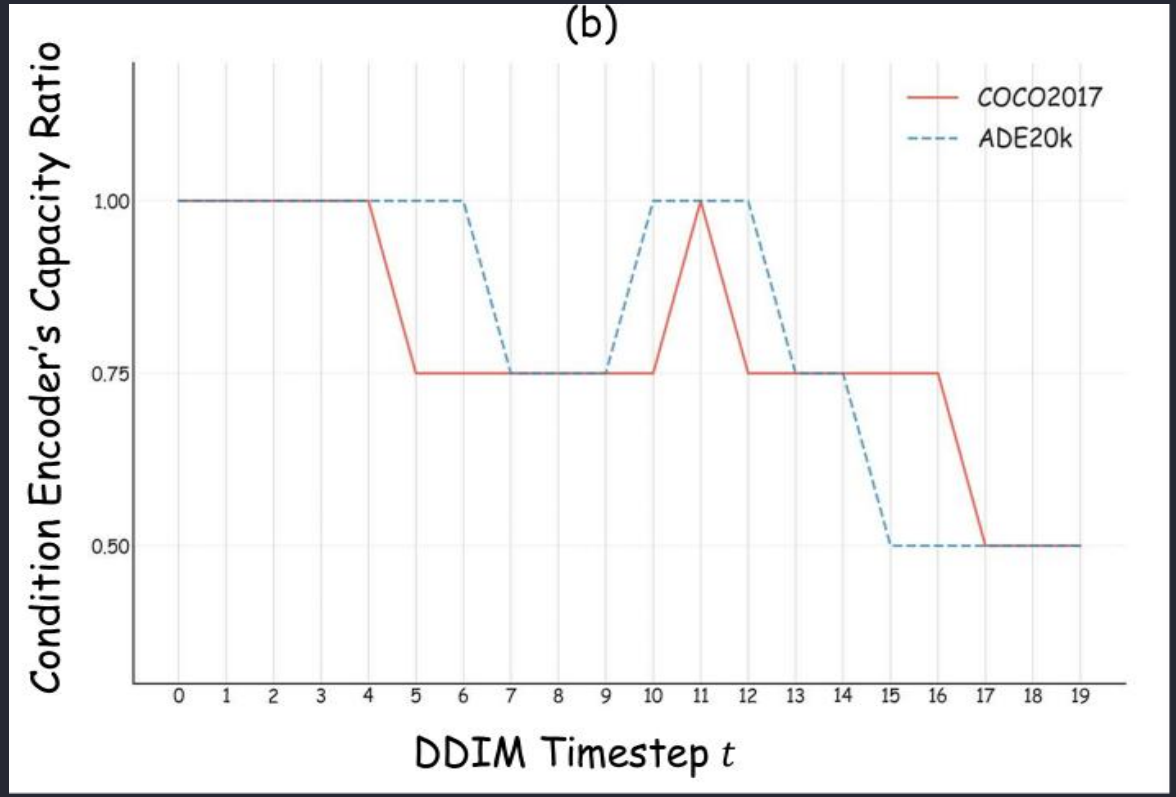
THE EFFECT OF EVOLUTIONARY SEARCH

Allocation Strategies	Metrics			
	FID[a]↓	*GFLOPs*↓	*Sampling Time*↓	*mIoU*↑ / *HDD*↓
All $r := 1.0\times$	24.80	73.59	2.7998	0.45 / 14.54
All $r := 0.75\times$	24.32	62.67	2.7603	0.47 / 13.81
All $r := 0.5\times$	23.63	**51.75**	**2.7294**	0.44 / 13.80
Random	24.01	60.49	2.7448	0.47 / 13.57
Manually-Designed	25.22	59.94	2.7407	0.45 / 14.17
After Search	**22.65**	65.95	2.7692	**0.50 / 13.04**

THE EFFECT OF HIERARCHICAL FEATURE AGGREGATION

Aggregation $\mathbf{y_{agg}}^m$	Same-Level Features $\mathbf{y_c}^m$	*FID*[a]↓	*mIoU*↑ / *HDD*↓
×	✓	25.13	0.28 / 18.52
✓	×	26.95	0.34 / 14.58
✓	✓	**24.80**	**0.45 / 14.54**

Results of Evolutionary Search



Thank you! Open for questions.

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