SlimFlow: Training Smaller One-Step Diffusion Models with Rectified Flow

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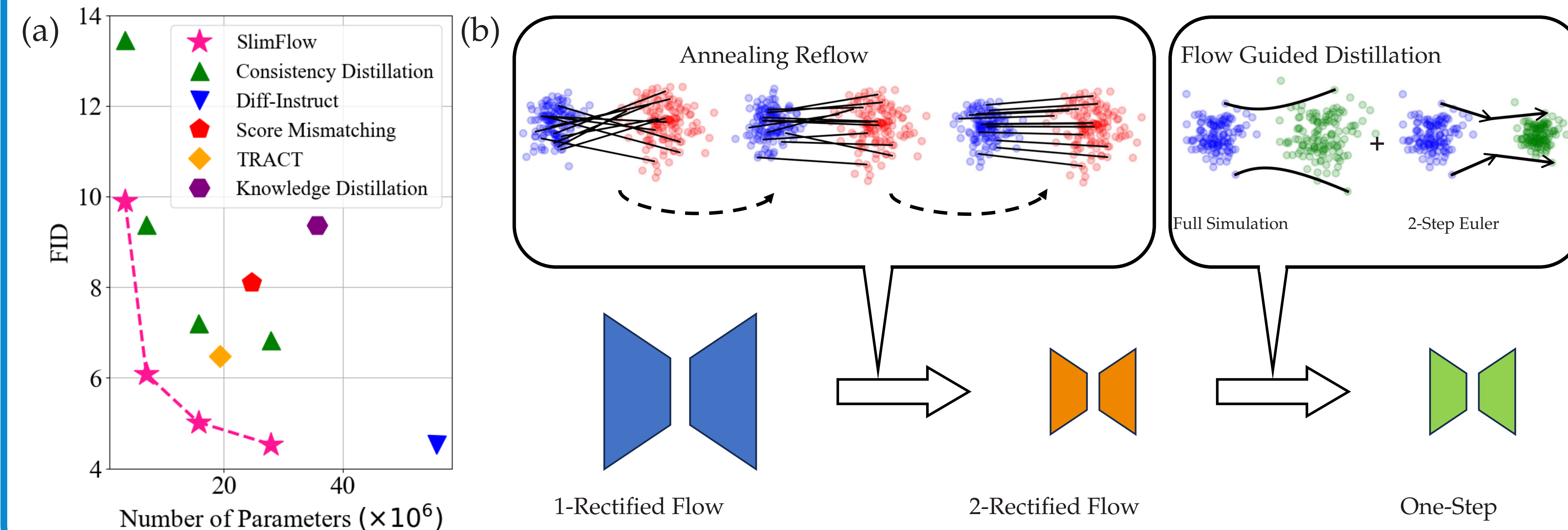
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Background

This work aims to develop small, efficient one-step diffusion models based on the powerful rectified flow framework, by exploring joint compression of inference steps and model size. Compared with the original framework, squeezing the model size brings two new challenges:
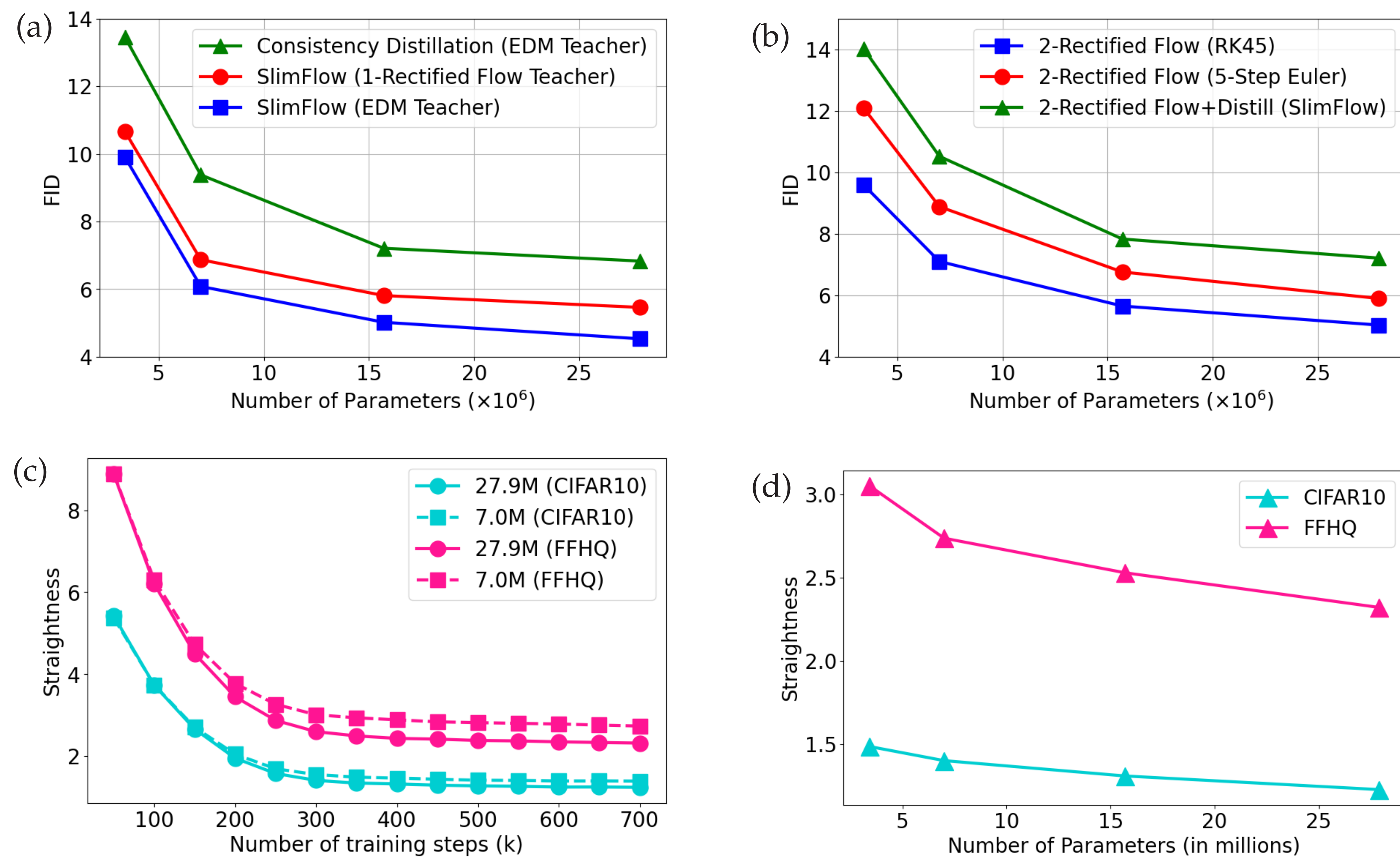
- the initialization mismatch between large teachers and small students during reflow;
- the underperformance of naive distillation on small student models.

To address these challenges, we propose SlimFlow, comprising two stages: Annealing Reflow and Flow-Guided Distillation. We

Overview of Method

(a) Comparison of different one-step diffusion models on the CIFAR10 dataset. (b) To get powerful one-step diffusion model, our SlimFlow framework designs two stages: **Annealing Reflow** provides a warm-start for the small 2-Rectified Flow model by gradually shifting from training with random pairs to teacher pairs; **Flow Guided Distillation** enhances the one-step small model by distillation from 2-Rectified Flow with both off-line generated data using precise ODE solver and online generated data using 2-step Euler solver.

Results

(a) Comparison of models trained with different methods on CIFAR10.

(b) Comparison between 2-rectified flow and the distilled one-step generator on CIFAR10.

(c) Straightness of 2-rectified flows with different sizes during Annealing Reflow.

(d) Final straightness of 2-rectified flows with different numbers of parameters.

Quantitative Results

Dataset	Method	#Params	NFE (↓)	FID (↓)	MACs (↓)	FLOPs (↓)
FFHQ 64×64	EDM	55.7M	79	2.47	82.7G	167.9G
	DDIM	55.7M	10	18.30	82.7G	167.9G
	AMED-Solver	55.7M	5	12.54	82.7G	167.9G
	BOOT	66.9M	1	9.00	25.3G	52.1G
	SlimFlow (EDM teacher)	27.9M	1	7.21	26.3G	53.8G
	SlimFlow (EDM teacher)	15.7M	1	7.70	14.8G	30.4G
ImageNet 64×64	EDM	295.9M	79	2.37	103.4G	219.4G
	DDIM	295.9M	10	16.72	103.4G	219.4G
	AMED-Solver	295.9M	5	13.75	103.4G	219.4G
	DSNO	329.2M	1	7.83		
	Progressive Distillation	295.9M	1	15.39	103.4G	219.4G
	Diff-Instruct	295.9M	1	5.57	103.4G	219.4G
	TRACT	295.9M	1	7.43	103.4G	219.4G
	DMD	295.9M	1	2.62	103.4G	219.4G
	Consistency Distillation	295.9M	1	6.20	103.4G	219.4G
	Consistency Training	295.9M	1	13.00	103.4G	219.4G
	BOOT	226.5M	1	16.30	78.2G	157.4G
	SlimFlow (EDM teacher)	80.7M	1	12.34	31.0G	67.8G

References

[1] Xingchao Liu and et al. Flow straight and fast: Learning to generate and transfer data with rectified flow. *ICLR*, 2022.

[2] Qiang Liu. Rectified flow: A marginal preserving approach to optimal transport. *arXiv*, 2022.

More Information

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