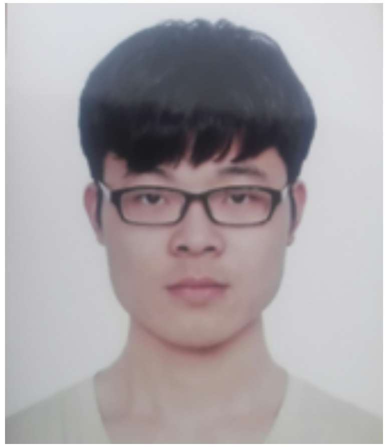
Berkeley UNIVERSITY OF CALIFORNIA

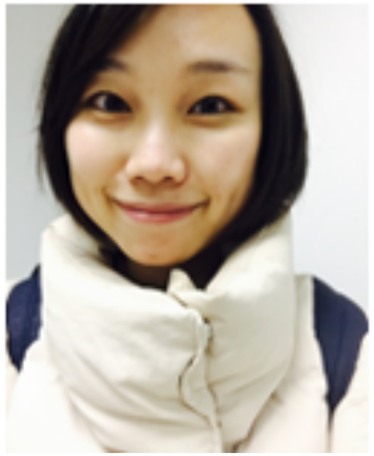
INTERNATIONAL COMPUTER SCIENCE INSTITUTE

北京航空航天大學 BEIHANG UNIVERSITY

Unsupervised Sketch-to-Photo Synthesis



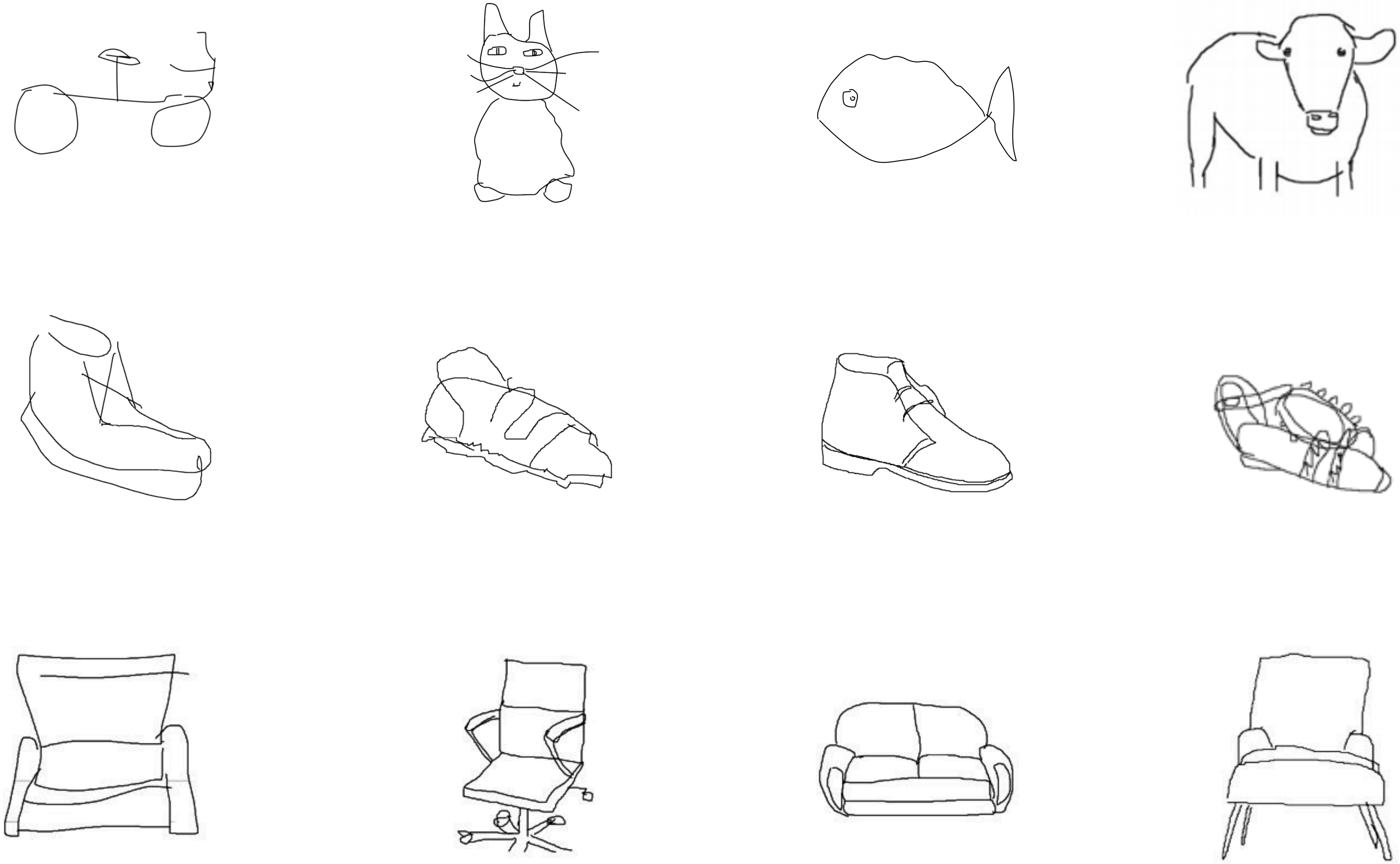
Runtao Liu*

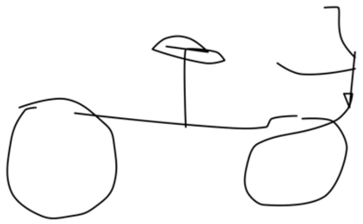


Qian Yu*

Stella Yu

http://sketch.icsi.berkeley.edu/

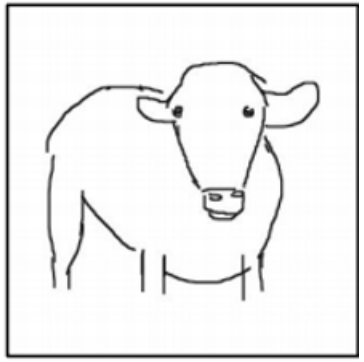




Sketch Recognition

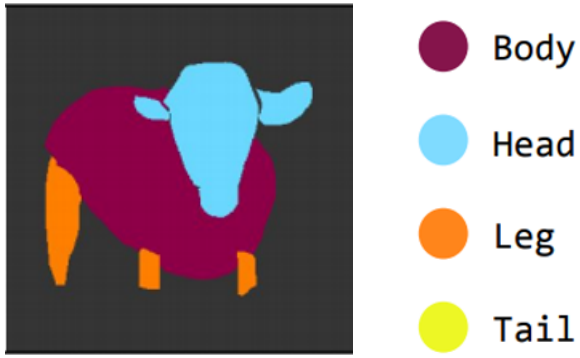
Yu et al., BMVC 2015
Ye et al., ICMR 2016

“ bicycle ”



Sketch Segmentation

Zou et al., ECCV 2018
Sarvadevabhatla et al., MM 2017
Qi et al., CVPR 2015



Sketch based Image Retrieval

Yu et al., CVPR 2016
Hu et al., CVIU 2013
Wang et al., CVPR 2015

Ske  to

Challenge 1: Lack Colors and Details

Photo

Grayscale

Edge Map

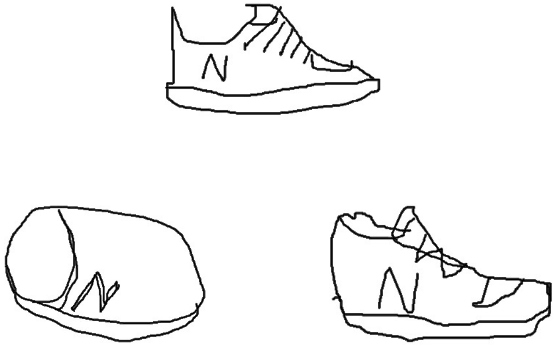
Sketch

more abstract

Challenge 2: Shape Deformation & Style Variations

Photo

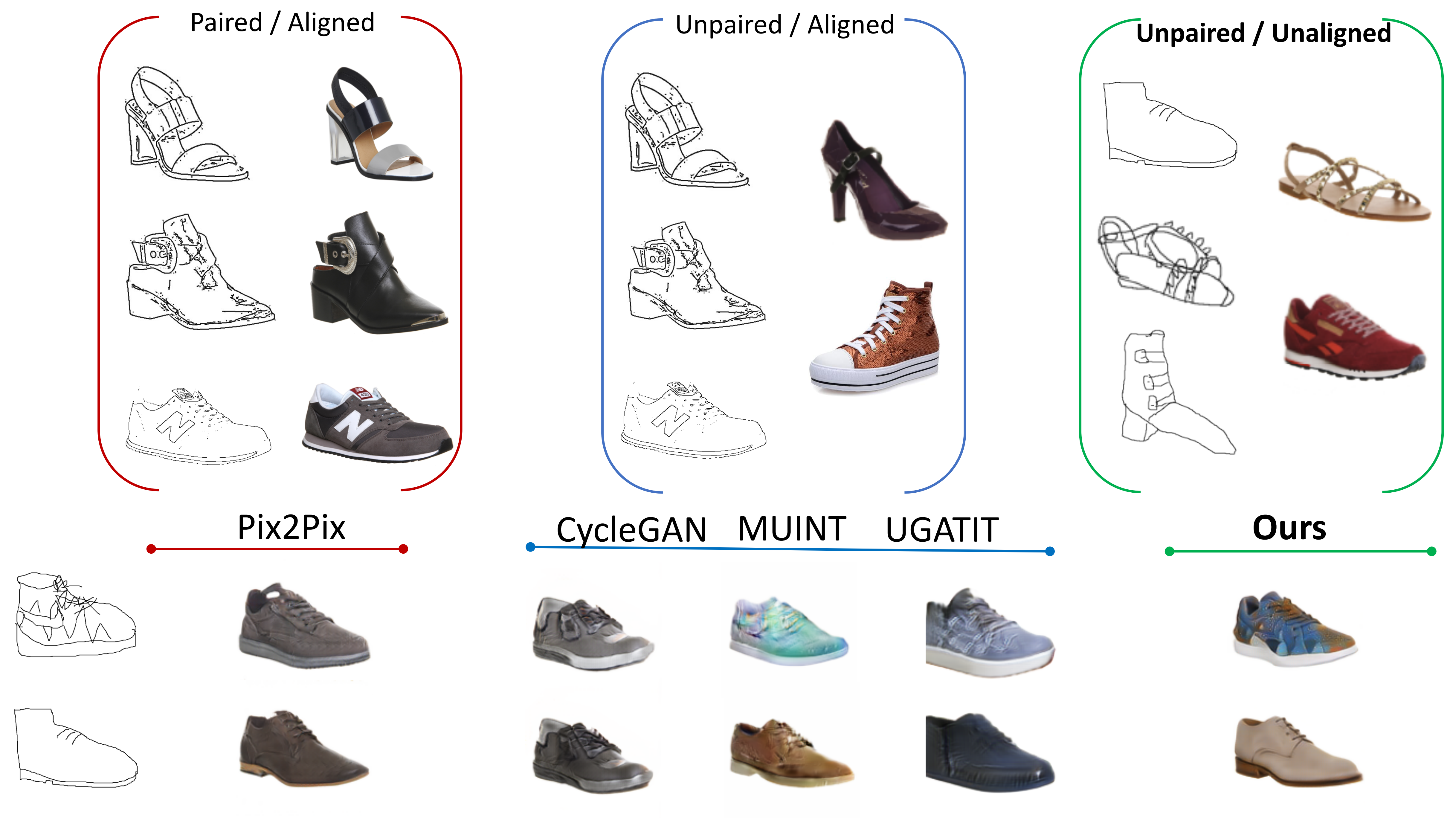
Sketch



Grayscale

Edge Map

more abstract

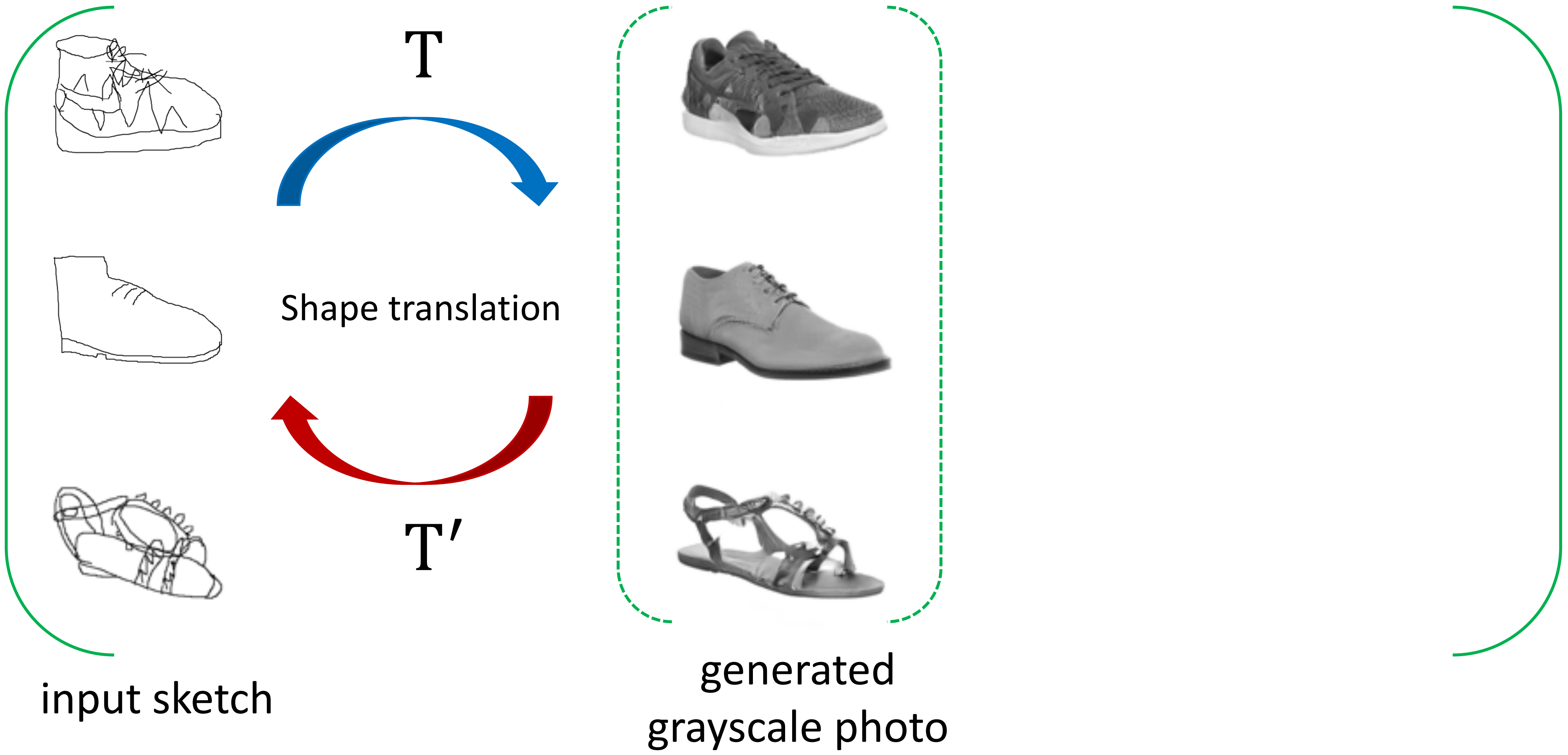

Paired / Aligned
Unpaired / Aligned
Unpaired / Unaligned
Pix2Pix
CycleGAN
MUINT
UGATIT
Ours

Unsupervised Sketch to Photo Synthesis

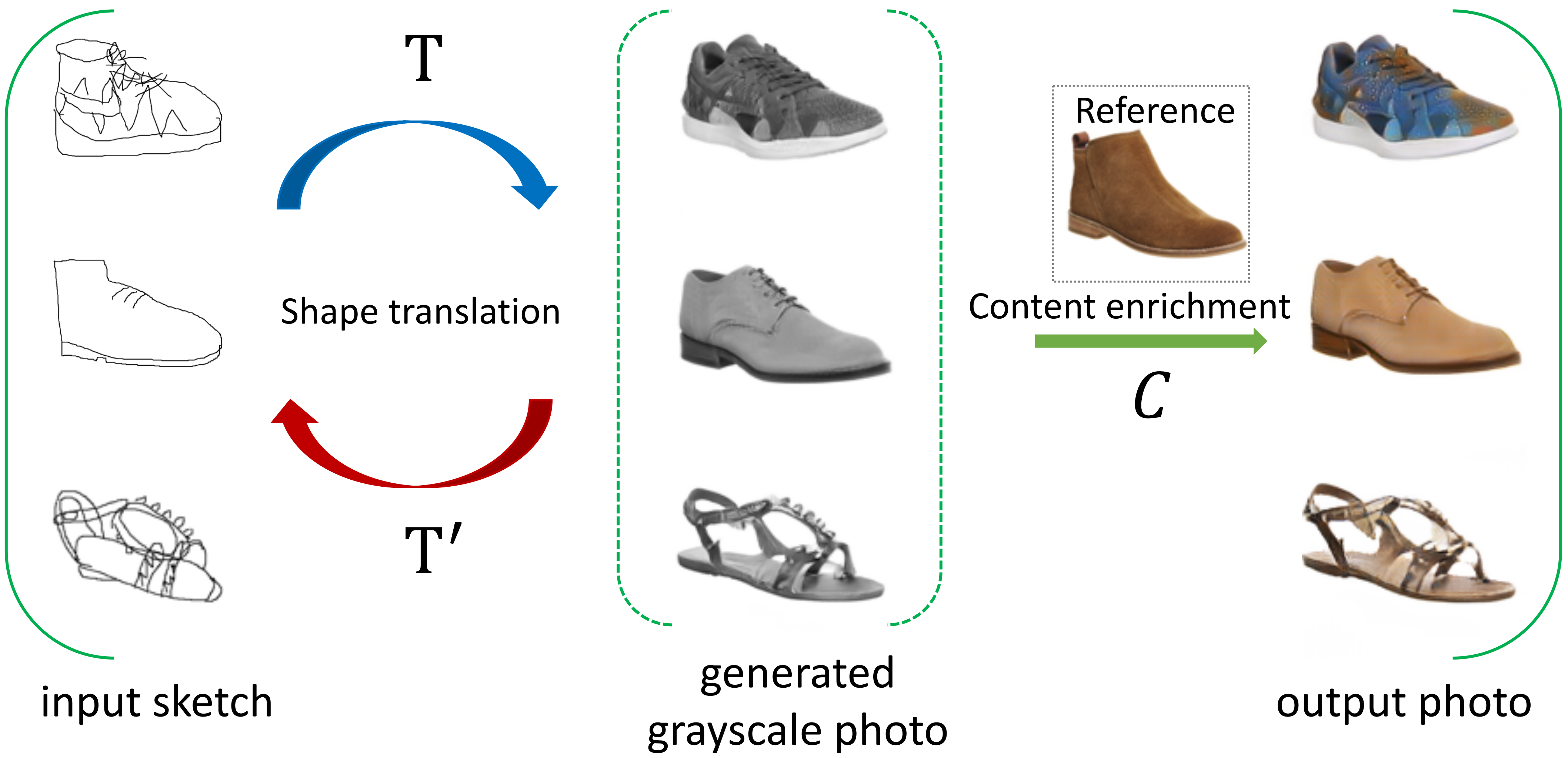
input sketch output photo

Two-Stage Approach via Intermediate Grayscale Image

Stage 1: Shape Translation from Sketch to Grayscale



Stage 2: Content Enrichment from Grayscale to Color



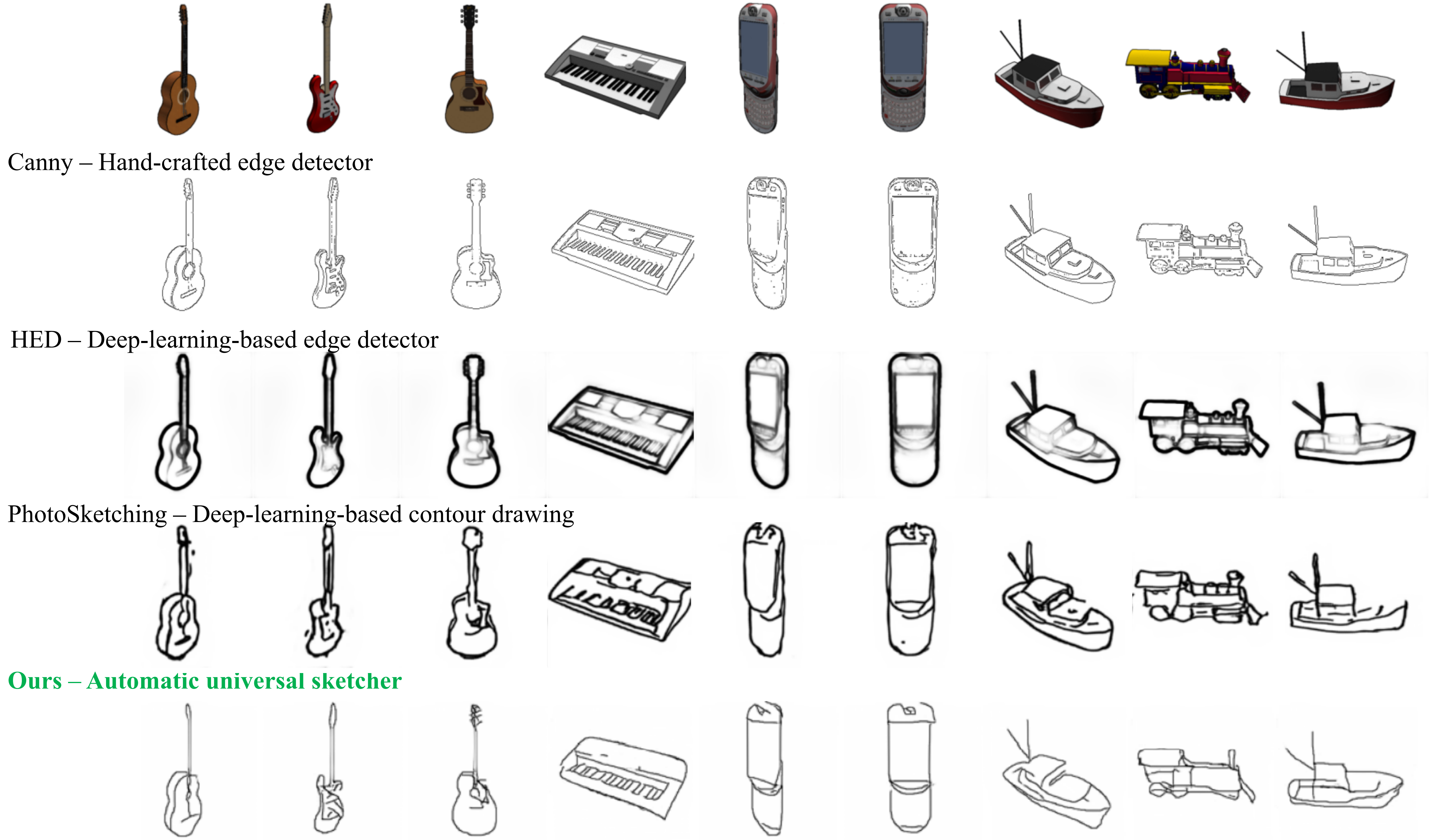

Input Sketch
Synthesized Photo
Synthesized Photo Given A Reference


Pix2Pix
CycleGAN
MUNIT
UGATIT
Our results

Sketch → Photo

Sketch ← Photo

Photo → Sketch

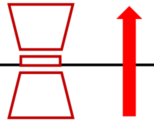

Canny – Hand-crafted edge detector
HED – Deep-learning-based edge detector
PhotoSketching – Deep-learning-based contour drawing
Ours – Automatic universal sketcher

Application: Sketch-based Image Retrieval

Domain	Query	Gallery
Sketch		
Photo		

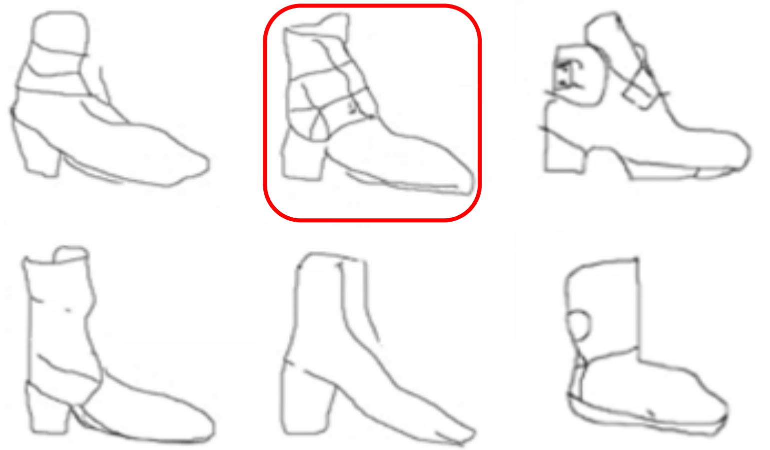
Application: Sketch-based Image Retrieval

Domain	Query	Gallery
Sketch		
Photo		



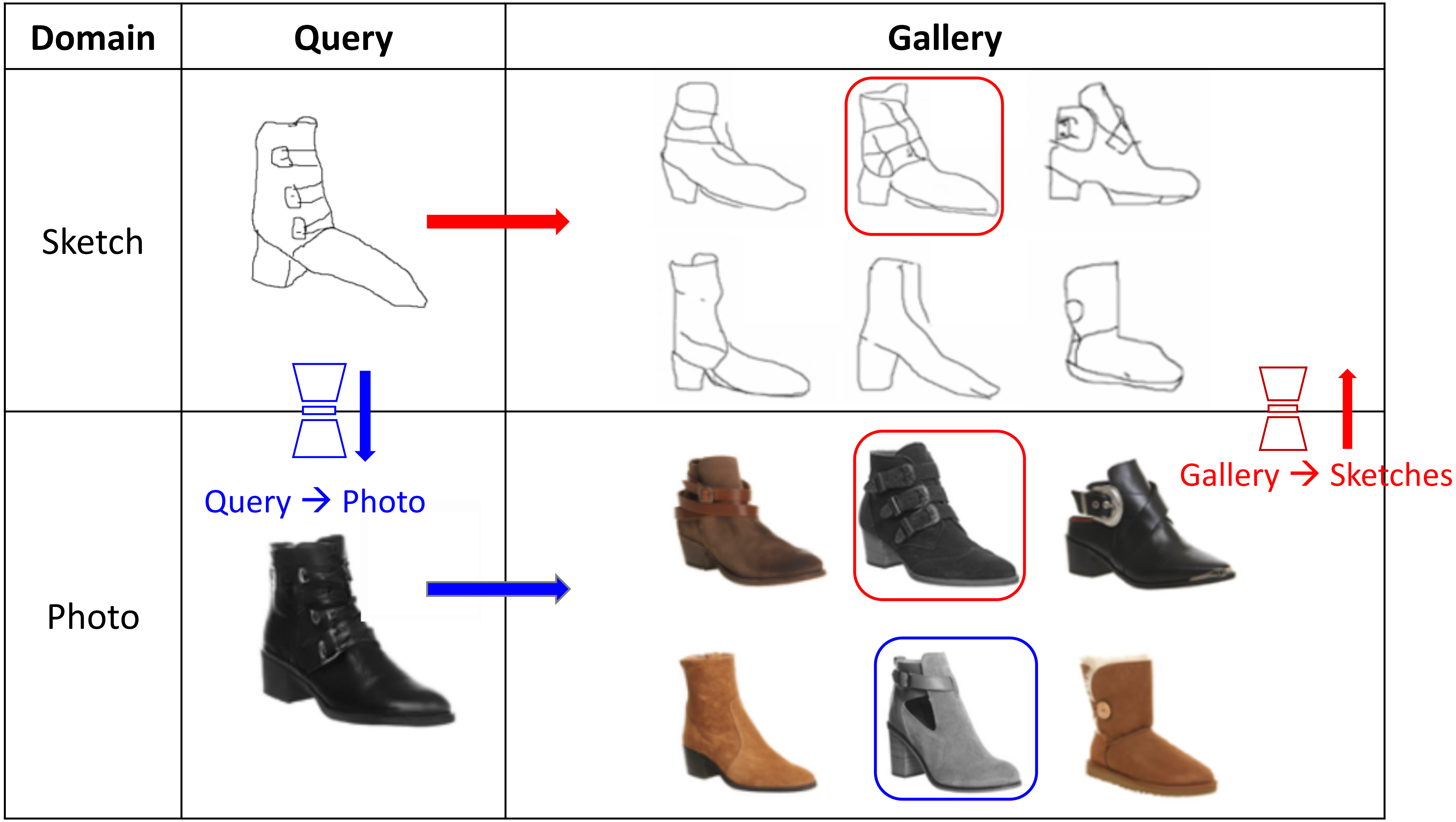
Gallery → Sketches

Application: Sketch-based Image Retrieval

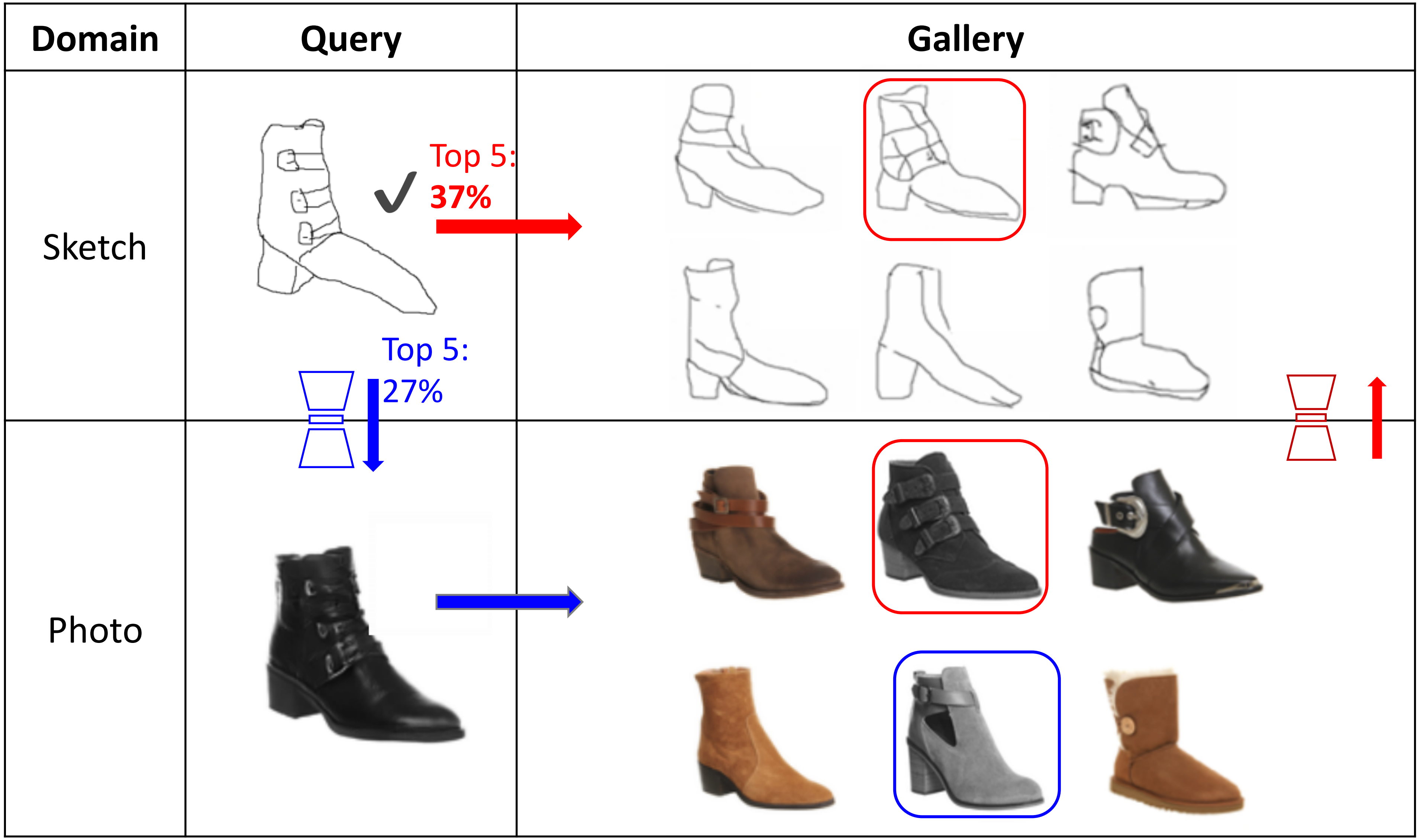
Domain	Query	Gallery
Sketch		
Photo		

Gallery → Sketches

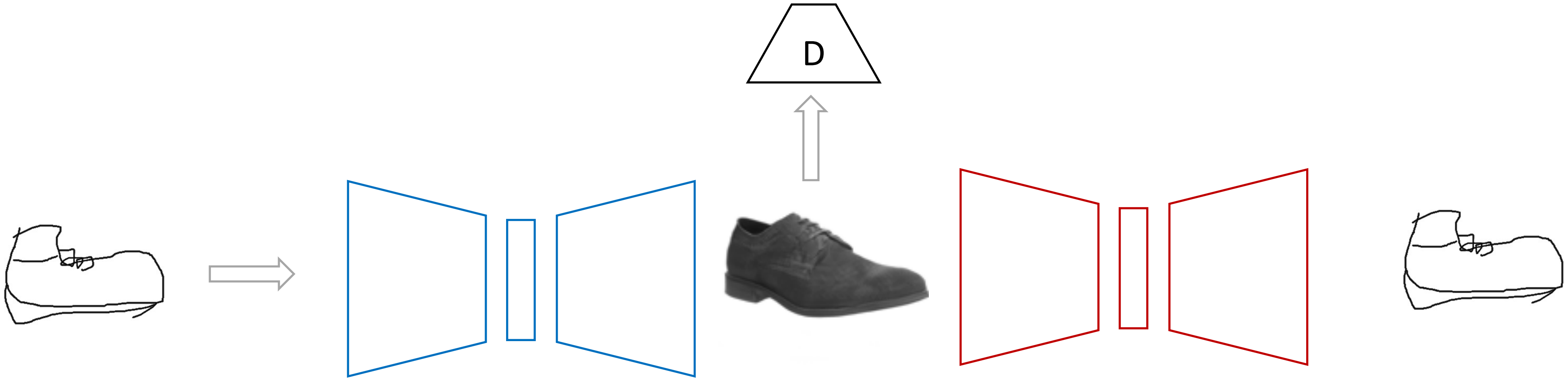
Application: Sketch-based Image Retrieval



Application: Sketch-based Image Retrieval

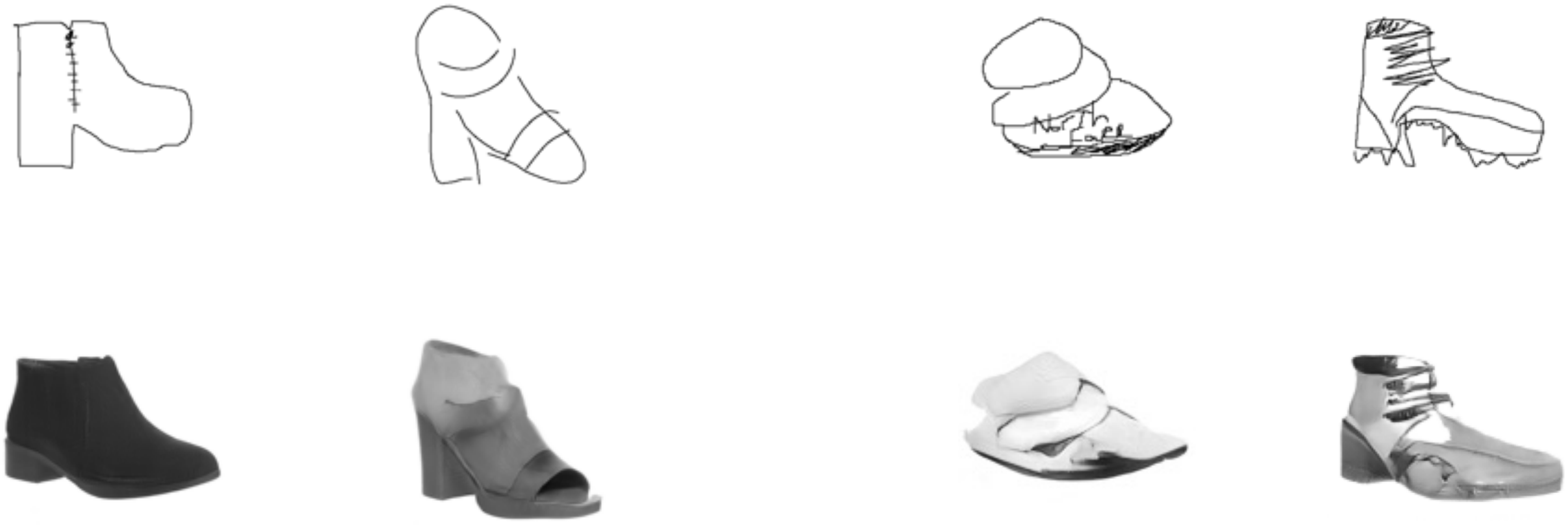


Our Stage 1 Model is Built upon Basic CycleGAN

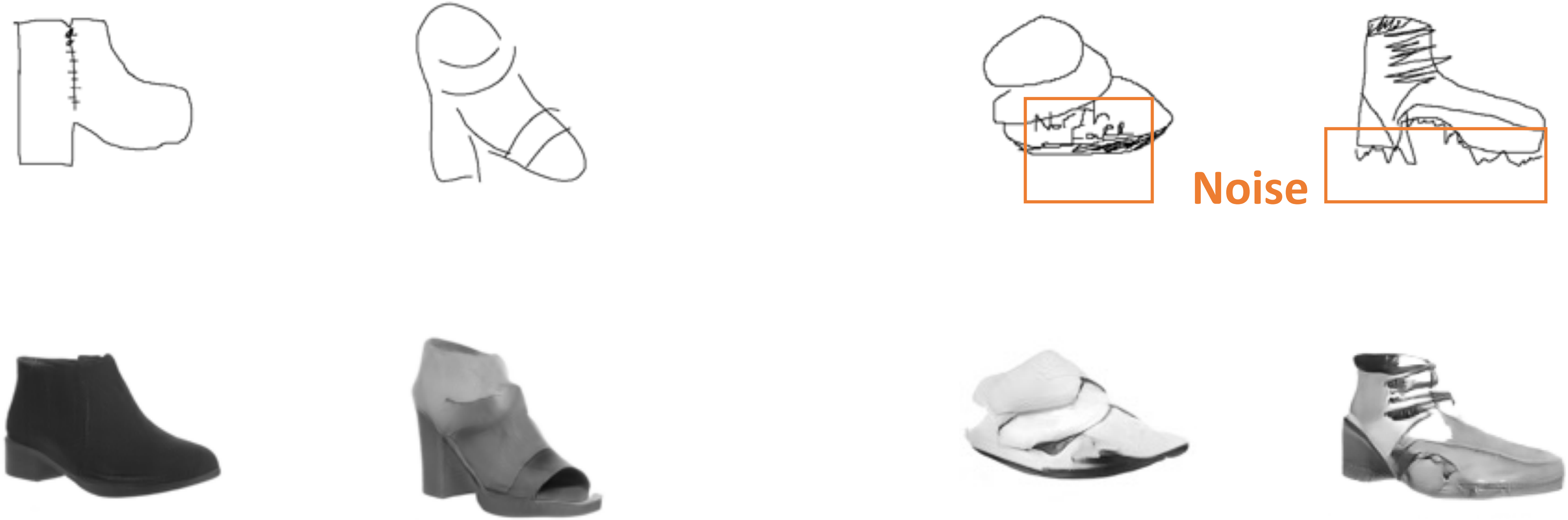


CycleGAN Works Well for Simple Sketches

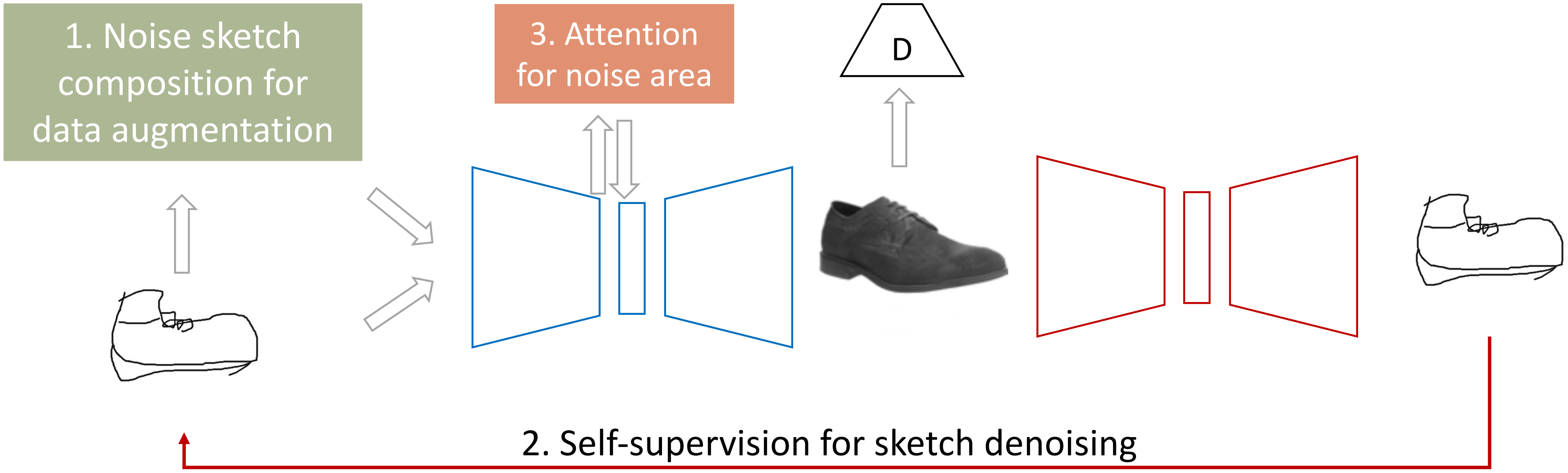
CycleGAN Fails with Complex Stroke Patterns



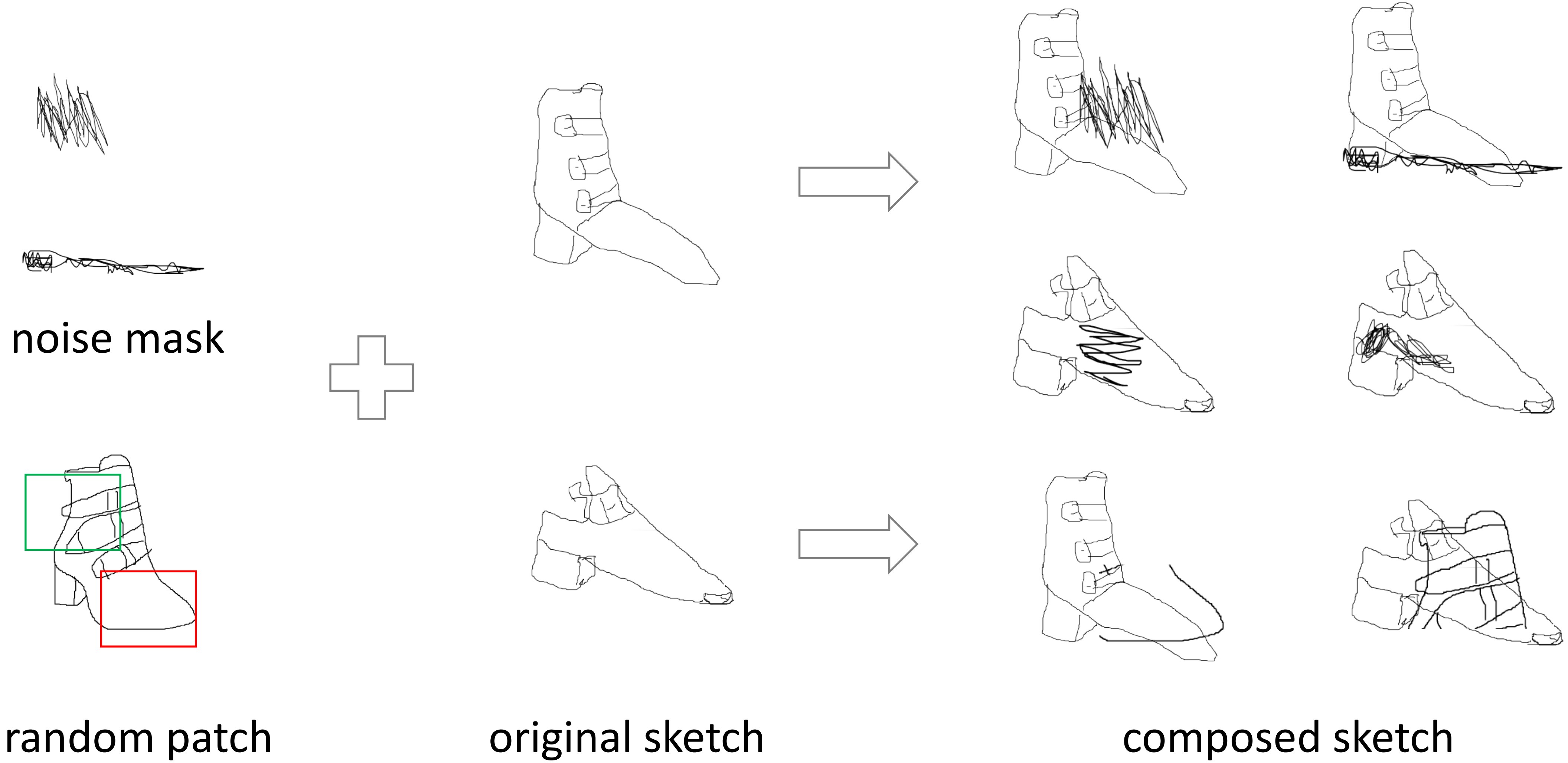
CycleGAN Fails with Noise Sketch



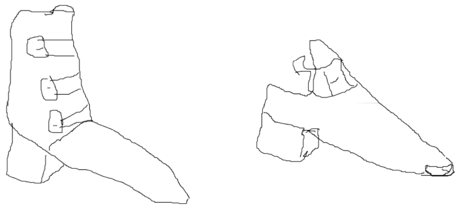
Stage 1: Key Sketch-Specific Technical Novelties



Noise Sketch Composition

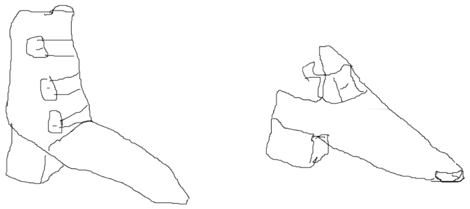


Self-Supervised Objective

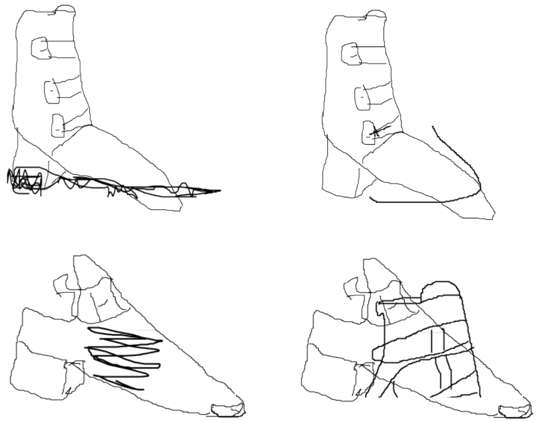


input sketch

Cycle-consistency

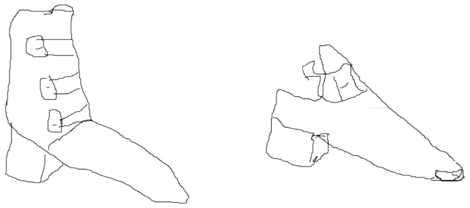


target



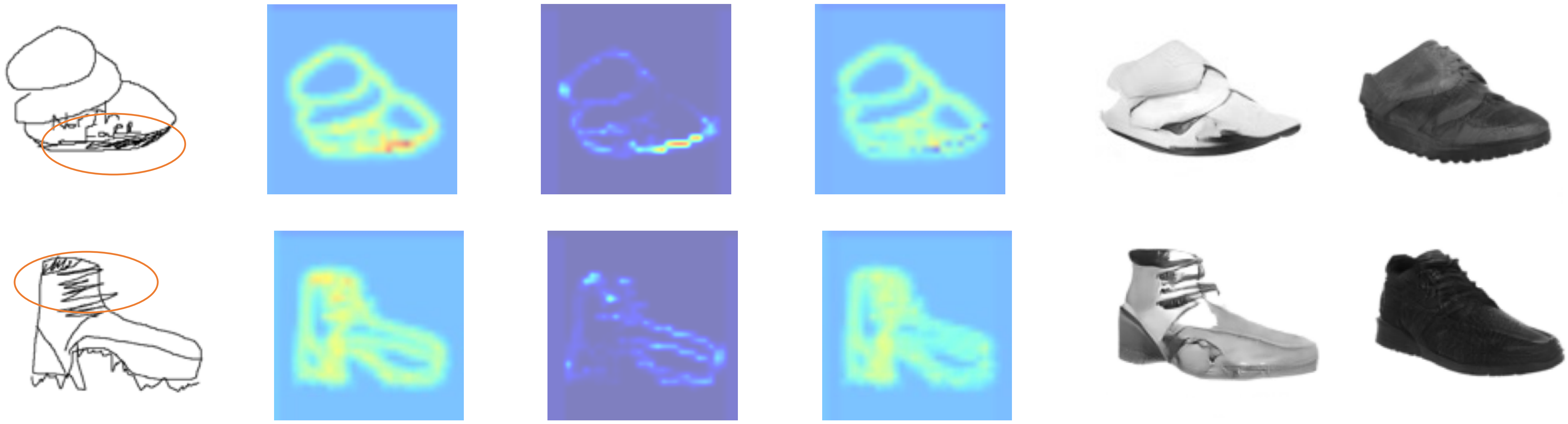
composed sketch

Self-supervised Denoising



target

Attention - Ignore Distractions



Feature map **before** re-weight

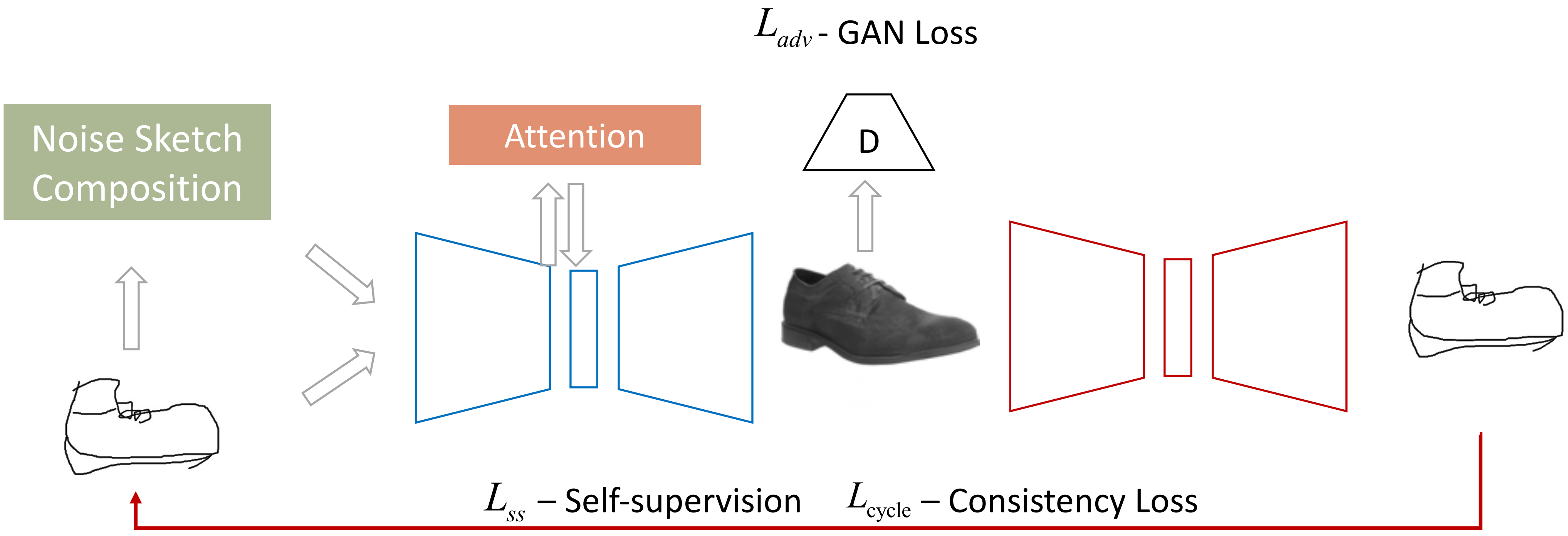
Attention mask

Feature map **after** re-weight

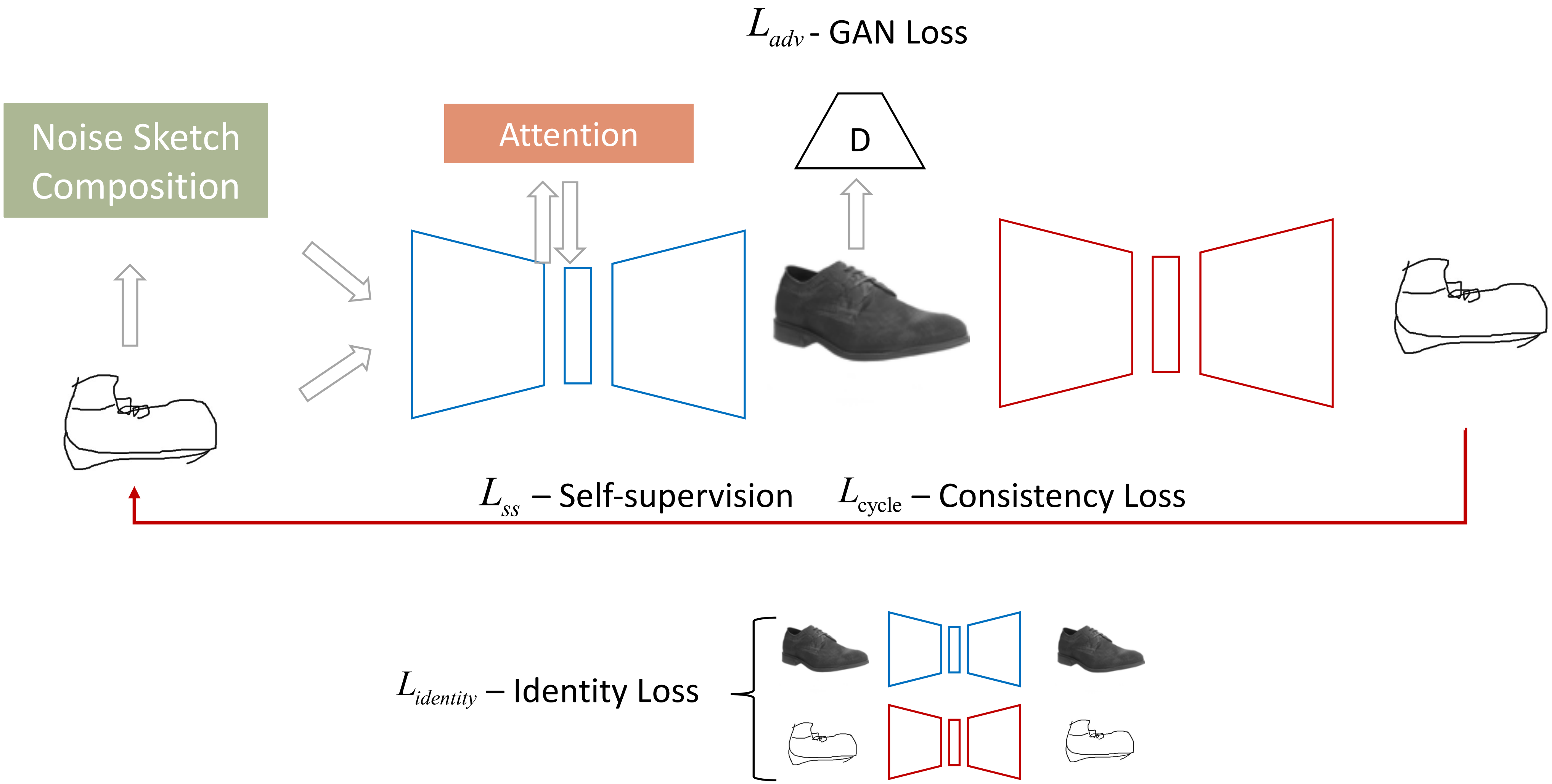
Without attention

With attention

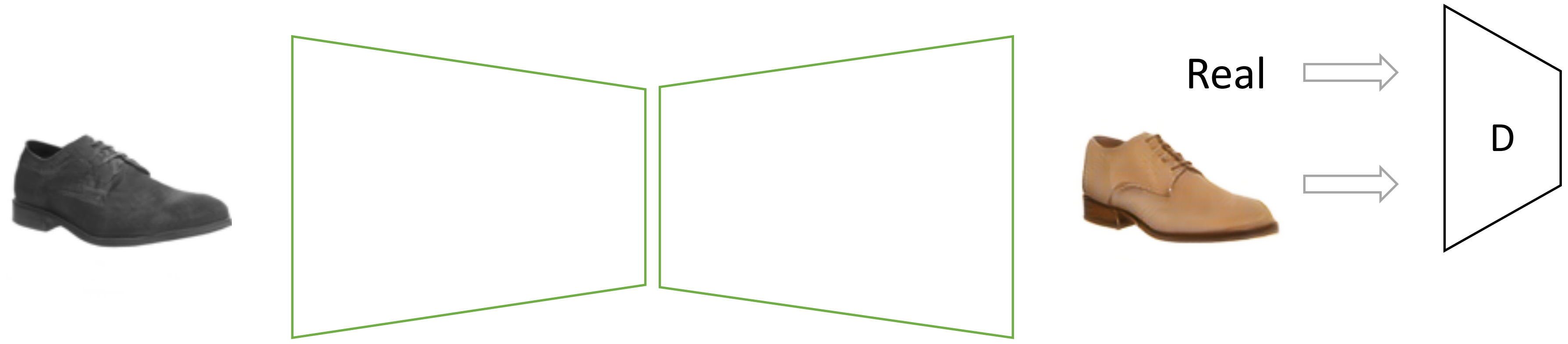
Stage 1: Shape Translation



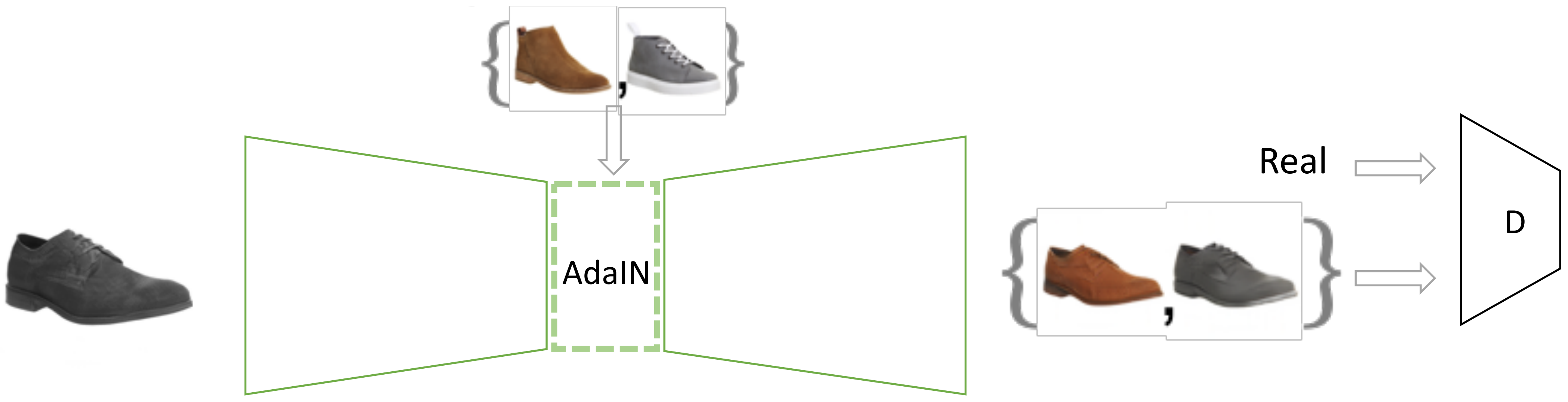
Stage 1: Shape Translation



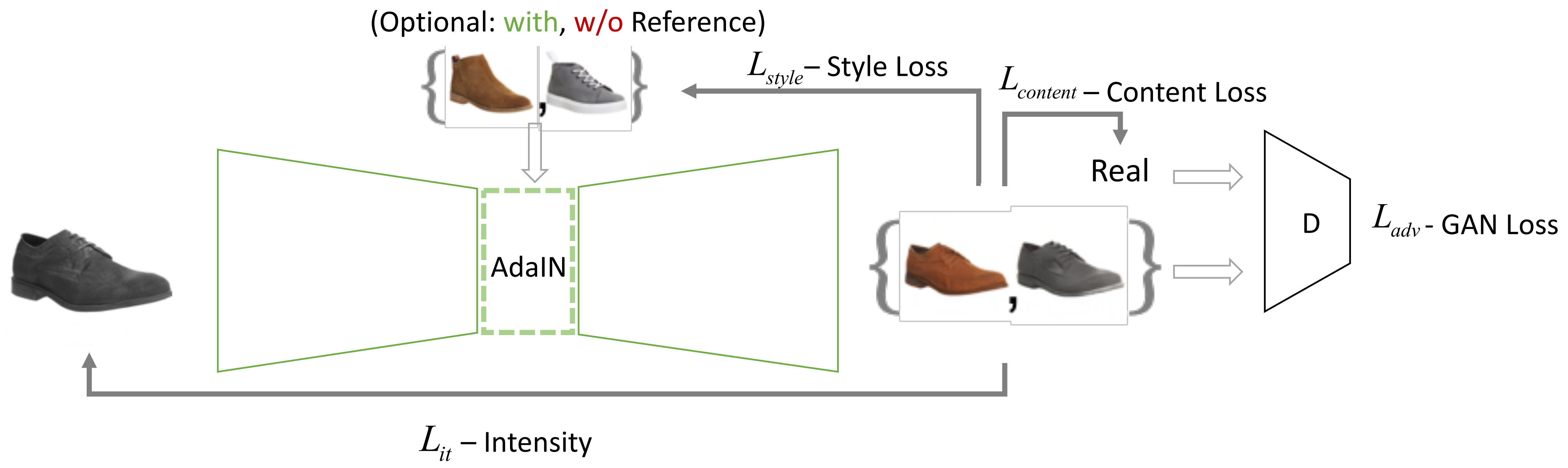
Stage 2: Content Enrichment without Reference



Stage 2: Content Enrichment with Reference



Stage 2: Content Enrichment with Optional Reference



Ours Are More Photo-Realistic, Sketch-Faithful, Diverse

	ShoeV2			ChairV2		
Model	FID ↓	Quality ↑	LPIPS ↑	FID ↓	Quality ↑	LPIPS ↑
Pix2Pix*	65.09	27.0	0.071	177.79	13.0	0.096
CycleGAN	79.35	12.0	0.0	124.96	20.0	0.0
MUNIT	92.21	14.5	**0.248**	168.81	6.5	**0.264**
UGATIT	76.89	21.5	0.0	107.24	19.5	0.0
Ours	**48.73**	**50.0**	0.146	**100.51**	**50.0**	0.156

Quality: User study on forced choice per photo quality w.r.t. sketch

1. Trained on ShoeV2, Generalize to Other Datasets

2. Trained on ShoeV2, Test on Other Categories

Training

shoe

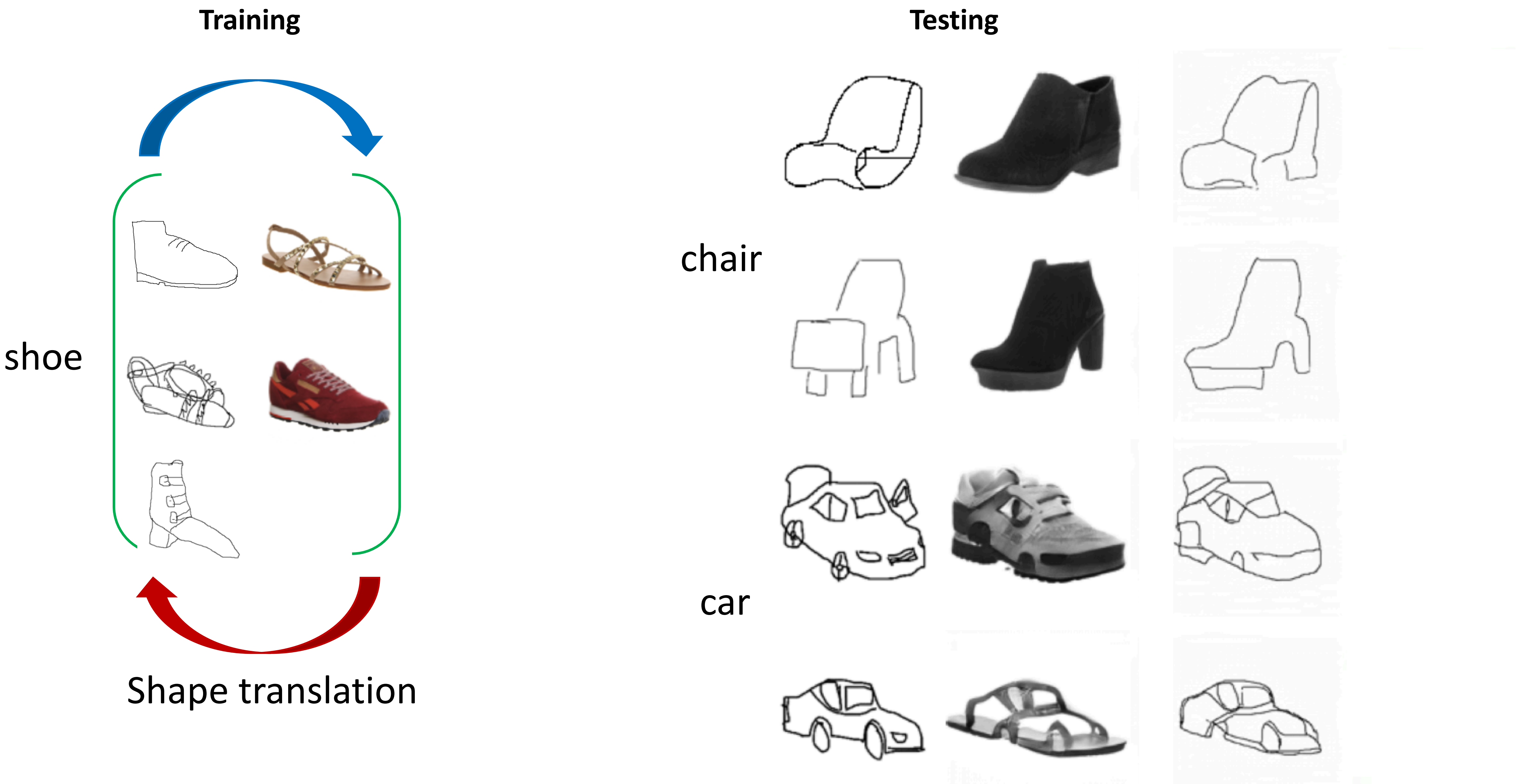
Shape translation

Testing

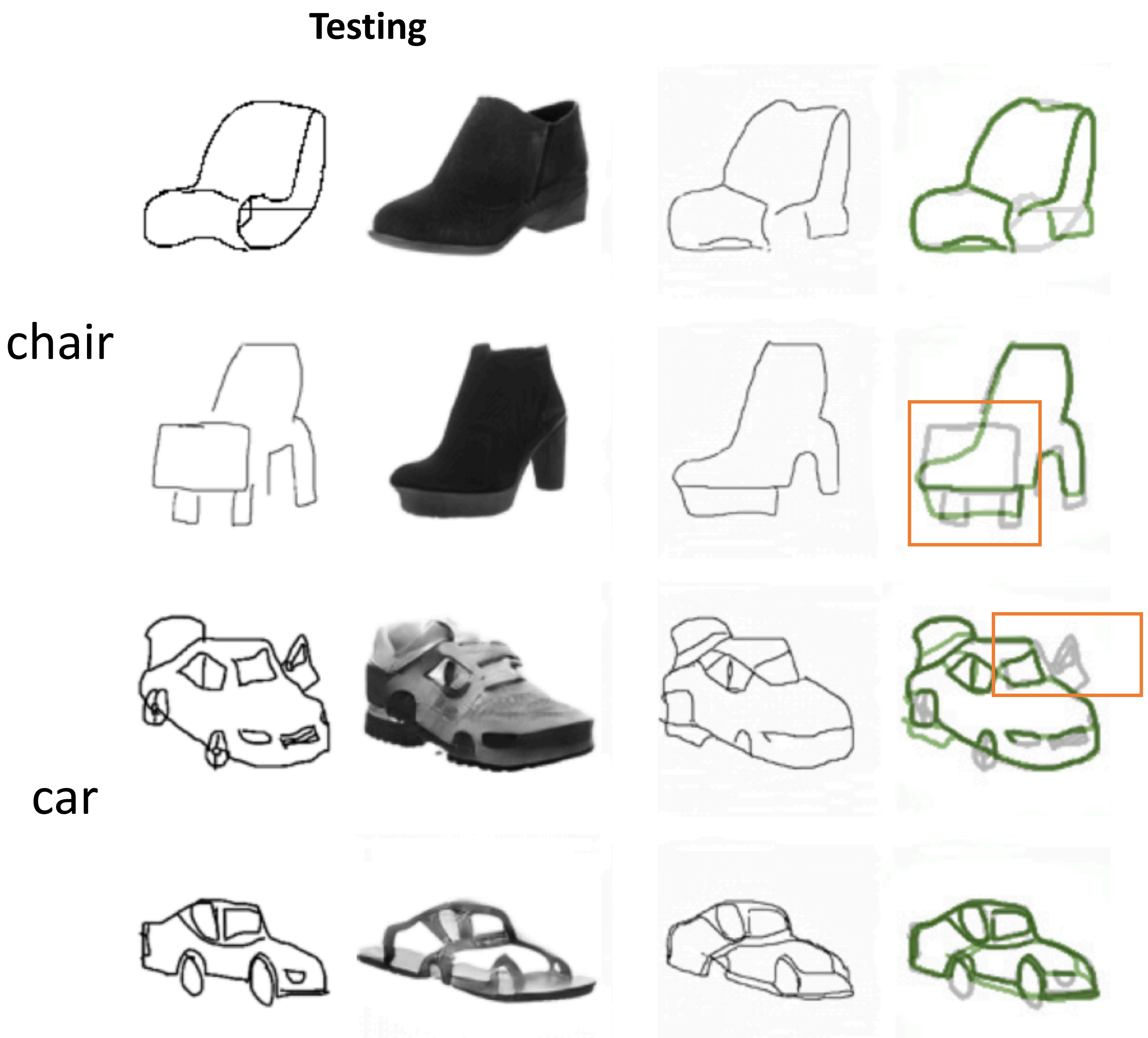
chair

car

2. Trained on ShoeV2, Test on Other Categories

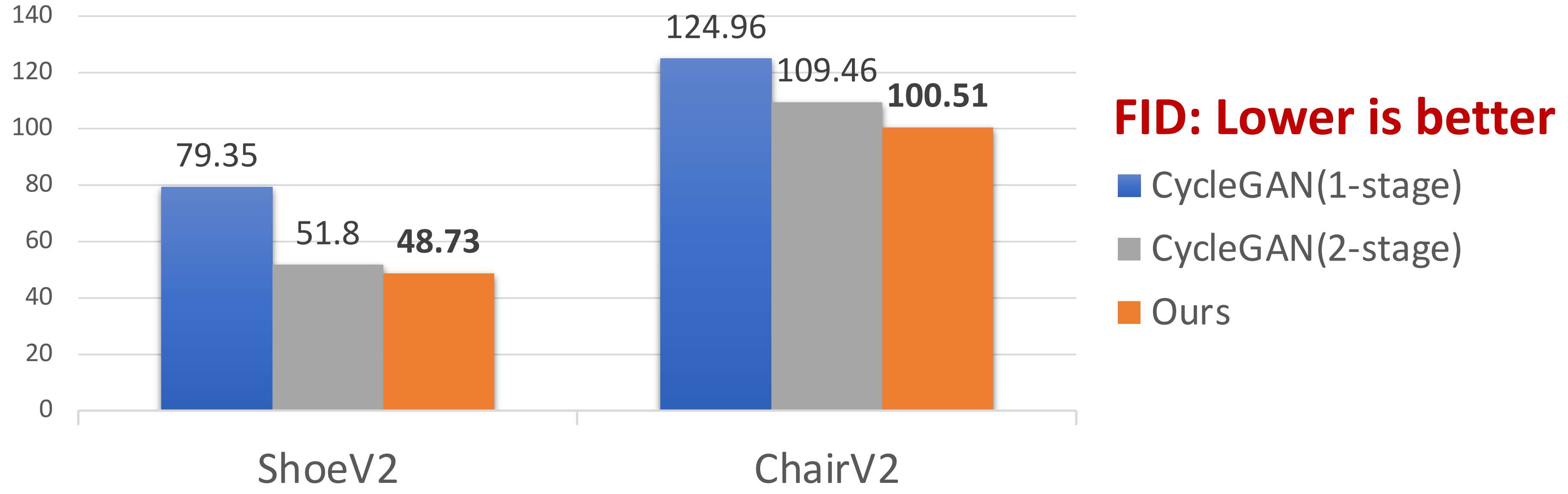


2. Trained on ShoeV2, Test on Other Categories



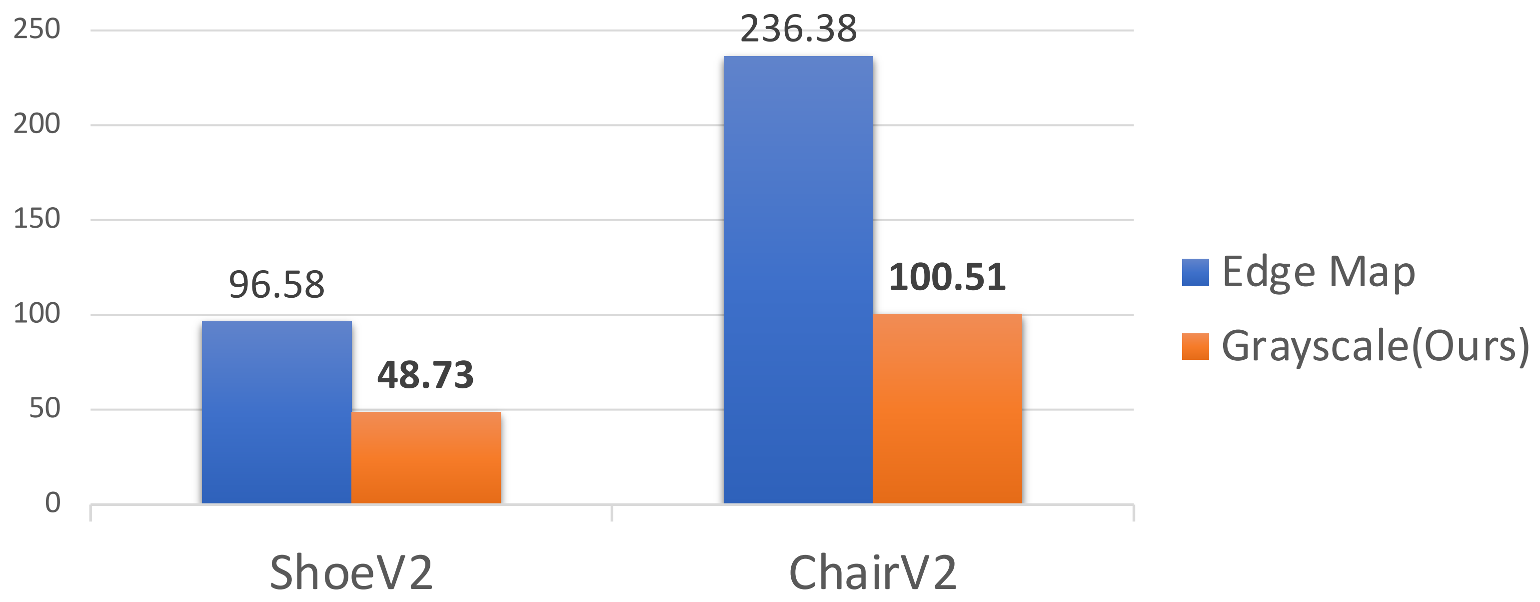
Ablation Study: Three Insights

	Alternative	Our Choice
Architecture Choice	One-Stage	Two-Stage ✓



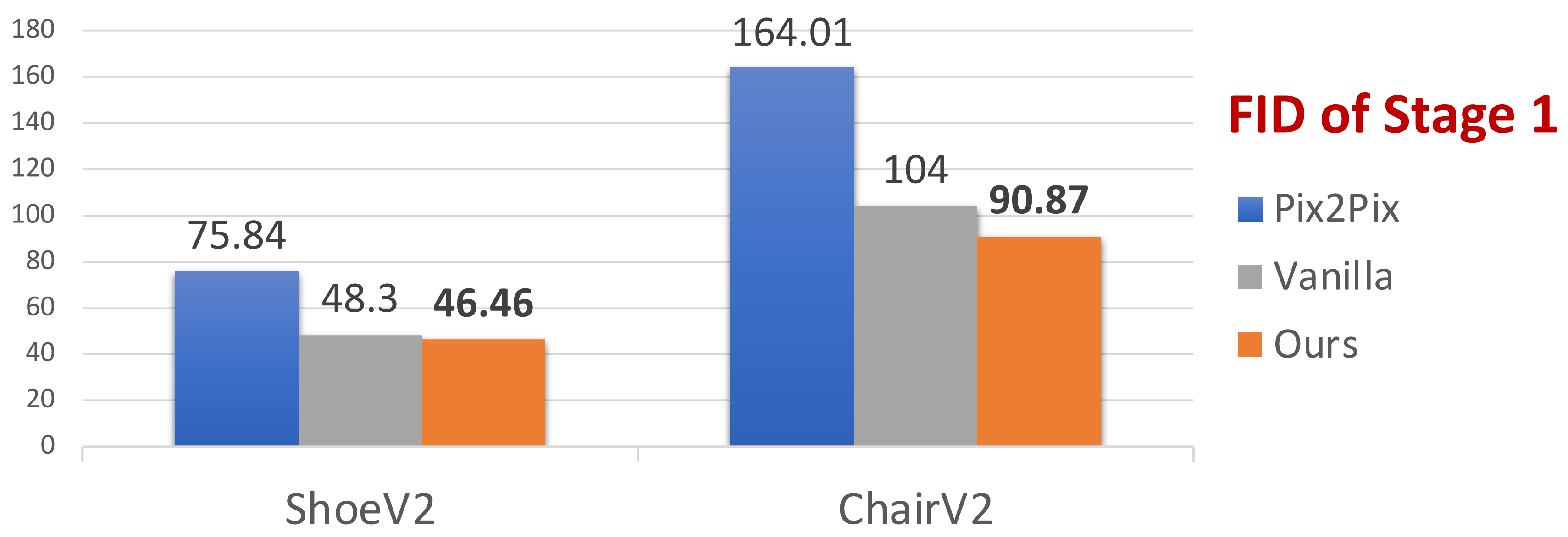
Ablation Study: Three Insights

	Alternative	**Our Choice**
Architecture Choice	One-Stage	Two-Stage ✓
Intermediate Synthesis Goal	Edge-Map	Grayscale ✓



Ablation Study: Three Insights

	Alternative	Our Choice
Architecture Choice	One-Stage	Two-Stage ✓
Intermediate Synthesis Goal	Edge-Map	Grayscale ✓
Training Setting	Paired	Unpaired ✓



Code / Model / Demo

http://sketch.icsi.berkeley.edu/