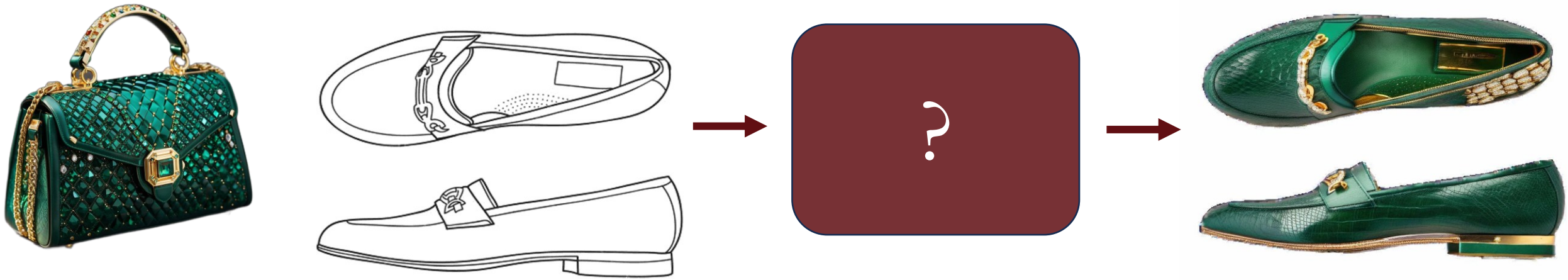
LineArt: A Knowledge-guided Training-free High-quality Appearance Transfer for Design Drawing with Diffusion Model

Xi Wang[1] Hongzhen Li[1] Heng Fang[2] Yichen Peng[3] Haoran Xie[4] Xi Yang[1*] Chuntao Li[1*]
[1]Jilin University [2]KTH Royal Institute of Technology [3]Institute of Science Tokyo
[4]Japan Advanced Institute of Science and Technology (JAIST)

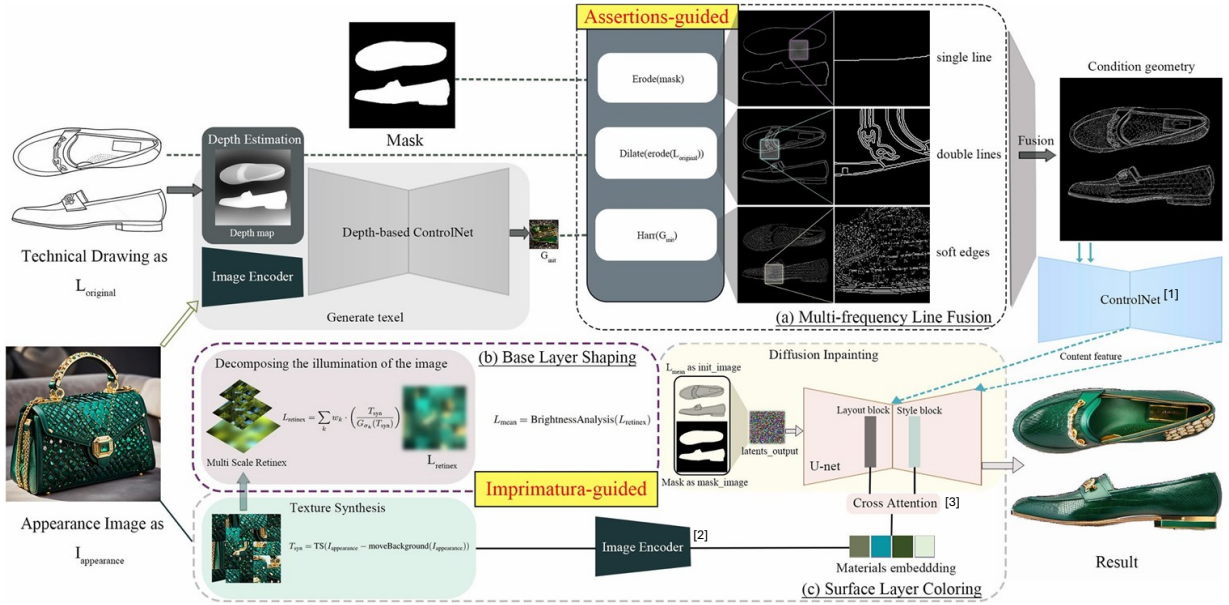
Background



(a) Design task

(a) **Image rendering from line drawings** is vital in design and image generation technologies reduce costs, yet professional line drawings demand preserving complex details. Text prompts struggle with accuracy, and image translation struggles with consistency and **fine-grained control**.

（a） Design task



(b) Our workflow

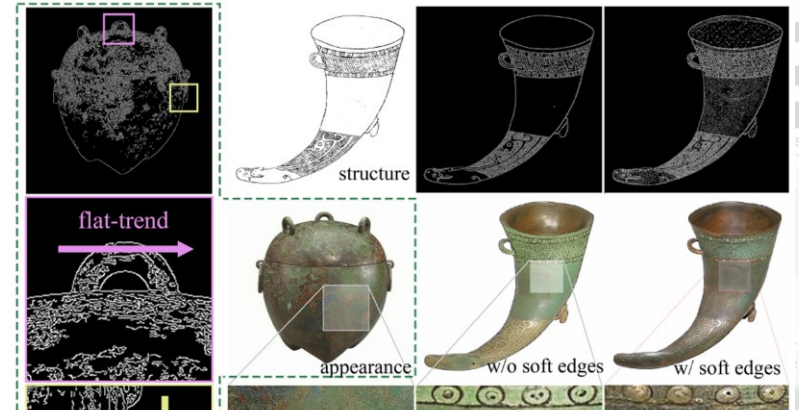
(b) We present **LineArt,** a framework that **transfers complex appearance onto detailed design drawings**, facilitating design and artistic creation. It generates high-fidelity materials while preserving structural accuracy by simulating hierarchical visual cognition and integrating human artistic experience to guide the diffusion process.

Reference:
[1] Lvmin Zhang, Anyi Rao, and Maneesh Agrawala. Adding conditional control to text-to-image diffusion models. In Proceedings of the IEEE/CVF International Conference on Computer Vision, pages 3836–3847, 2023.
[2] Hu Ye, Jun Zhang, Sibo Liu, Xiao Han, and Wei Yang. Ip-adapter: Text compatible image prompt adapter for text-to image diffusion models. arXiv preprint arXiv:2308.06721, 2023.
[3] Haofan Wang, Qixun Wang, Xu Bai, Zekui Qin, and Anthony Chen. Instantstyle: Free lunch towards style preserving in text-to-image generation. arXiv preprint arXiv:2404.02733, 2024.

(a) Various strokes (b) Le Taureau by Pablo Picasso : Level of Abstraction in Sketching

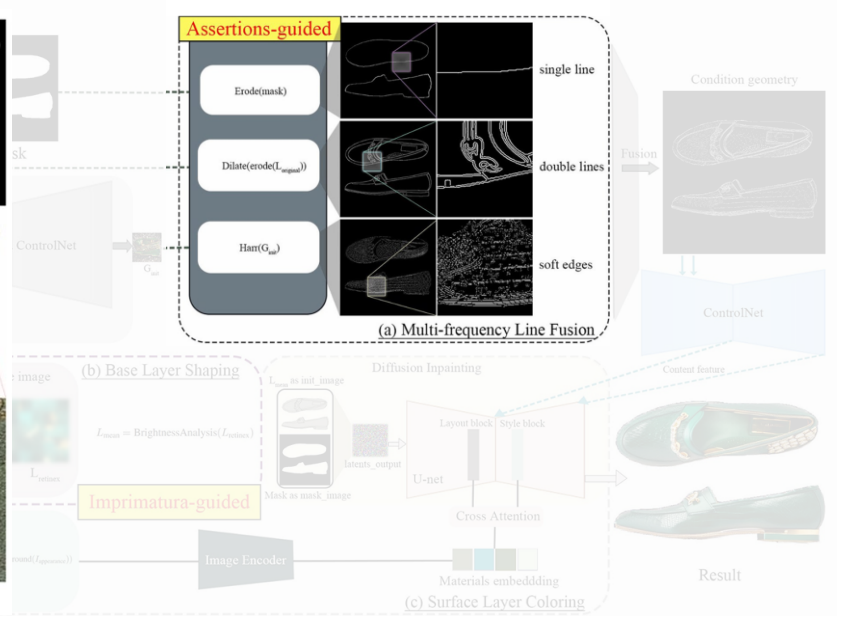
1. Edge 2. Shading-Edge 3. Extended-Edge 4. Line 5. Blob

(c) Assertions in visual representations



(a.1)Frequency analysis

(a.2)Impact of Soft Edges on Result Roughness



Insight1:

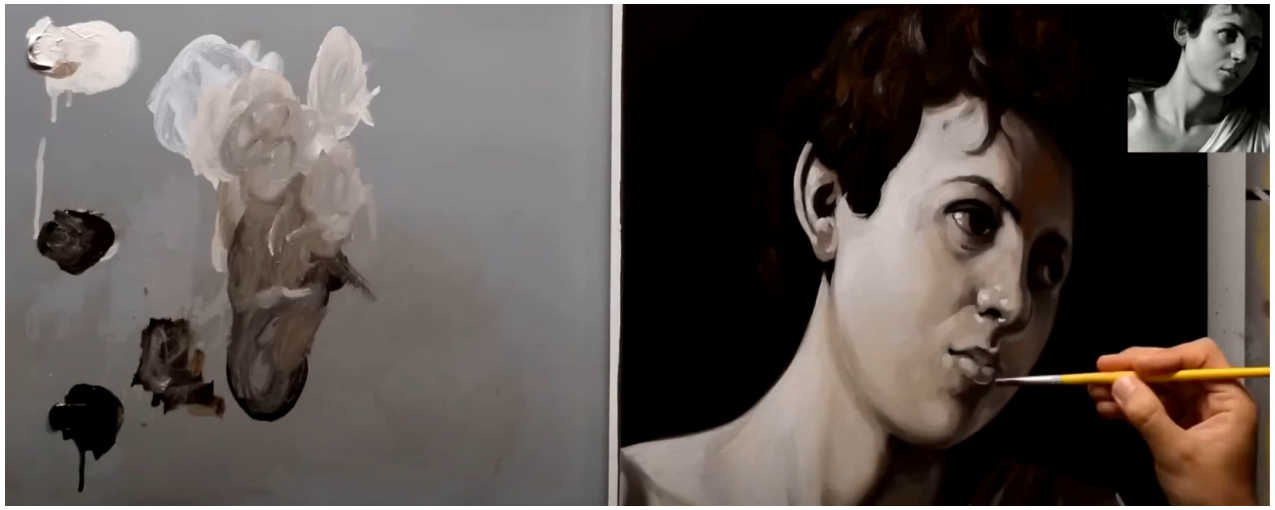
The key lines that determine the three-dimensional structure and surface division of an object should be regarded as a closed and continuous *single line*.

Insight2:

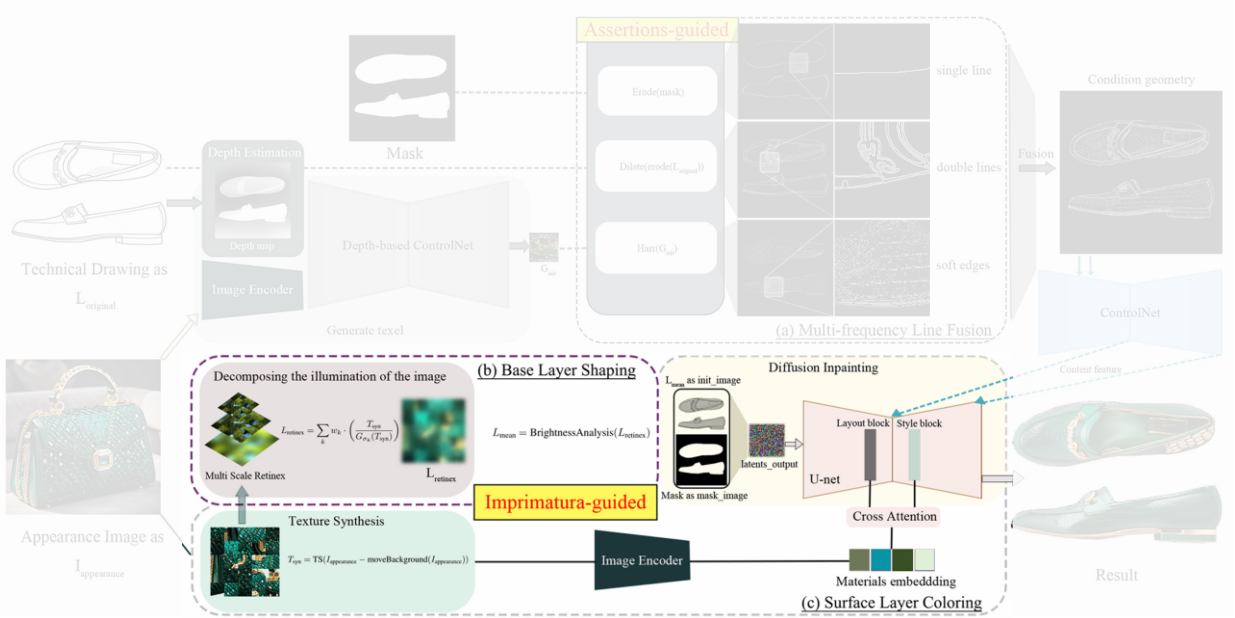
Texture and details in line drawings should be presented with significant visual representation of *double lines*.

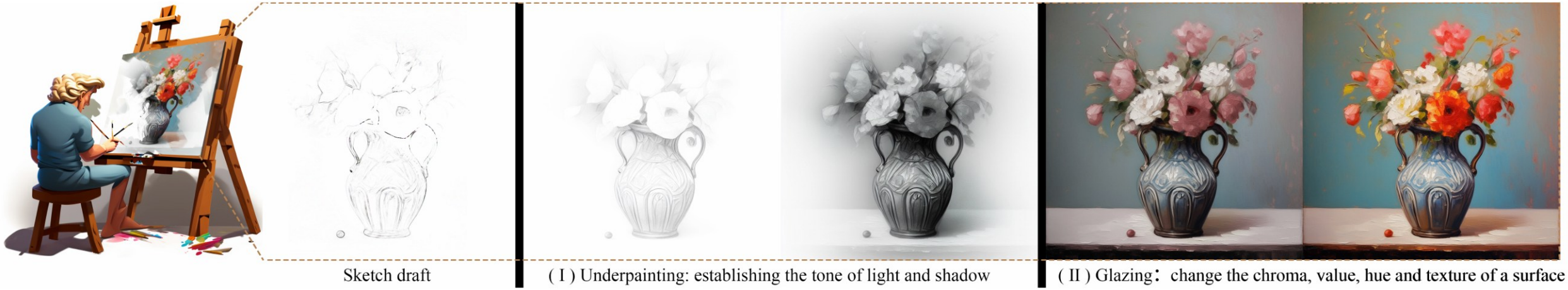
Insight3:

Soft edges (a collection of points and lines) not only imply spatial gradient relationships, but the description of details can also show material characteristics.



Video from https://youtu.be/dUOZ4g4h0II?si=-hyaesfotvLV6_nj

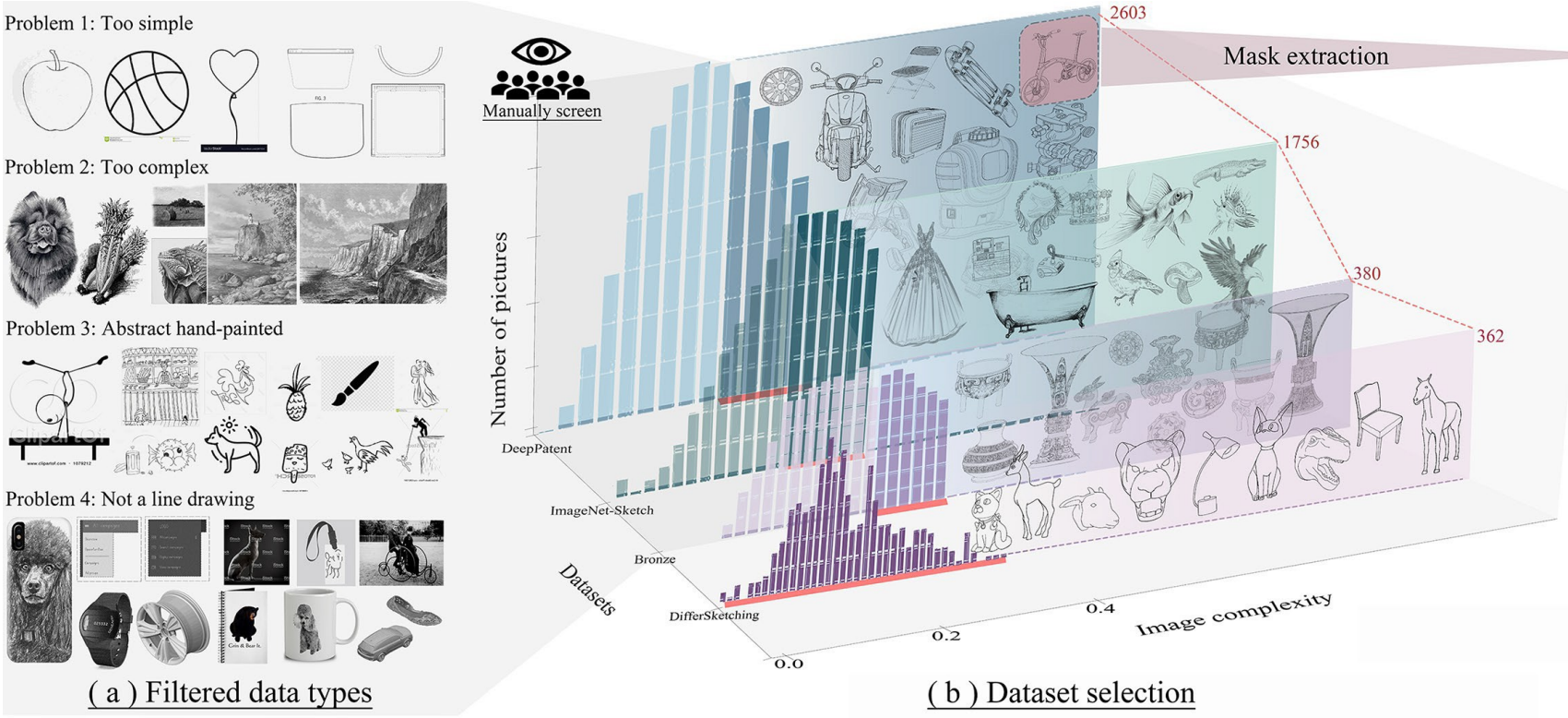




Sketch draft

(I) Underpainting: establishing the tone of light and shadow

(II) Glazing： change the chroma, value, hue and texture of a surface



(a) Filtered data types (b) Dataset selection (c) Data collection

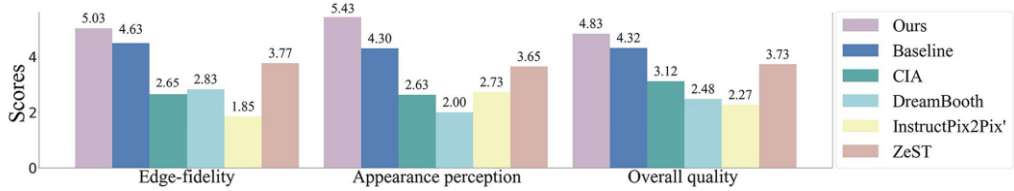
(a) shows the types of data we filtered out.
(b) shows an overview of the data after the initial screening based on image complexity and manual removal of noise data.
(c) shows the data preprocessing of the selected data, including the automatic processing process of mask and three rounds of manual verification.
After (b)(c), we obtained 5101 line drawings from four design datasets: Bronze, DifferSketching[1], ImageNet-Sketch[2], DeepPatent[3] .

Reference:
[1] Chufeng Xiao, Wanchao Su, Jing Liao, Zhouhui Lian, Yi Zhe Song, and HongboFu. Differsketching: How differently do people sketch 3d objects? ACMTransactionsonGraphics (TOG), 41(6):1–16, 2022.
[2] Haohan Wang, Songwei Ge, Zachary Lipton, and Eric P Xing. Learning robust global representations by penalizing local predictive power. Advances in Neural Information Processing Systems, 32, 2019.
[3] Michal Kucer, Diane Oyen, Juan Castorena, and Jian Wu. Deeppatent: Large scale patent drawing recognition and retrieval. In Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision, pages 2309–2318, 2022.

(a) Qualitative experiment

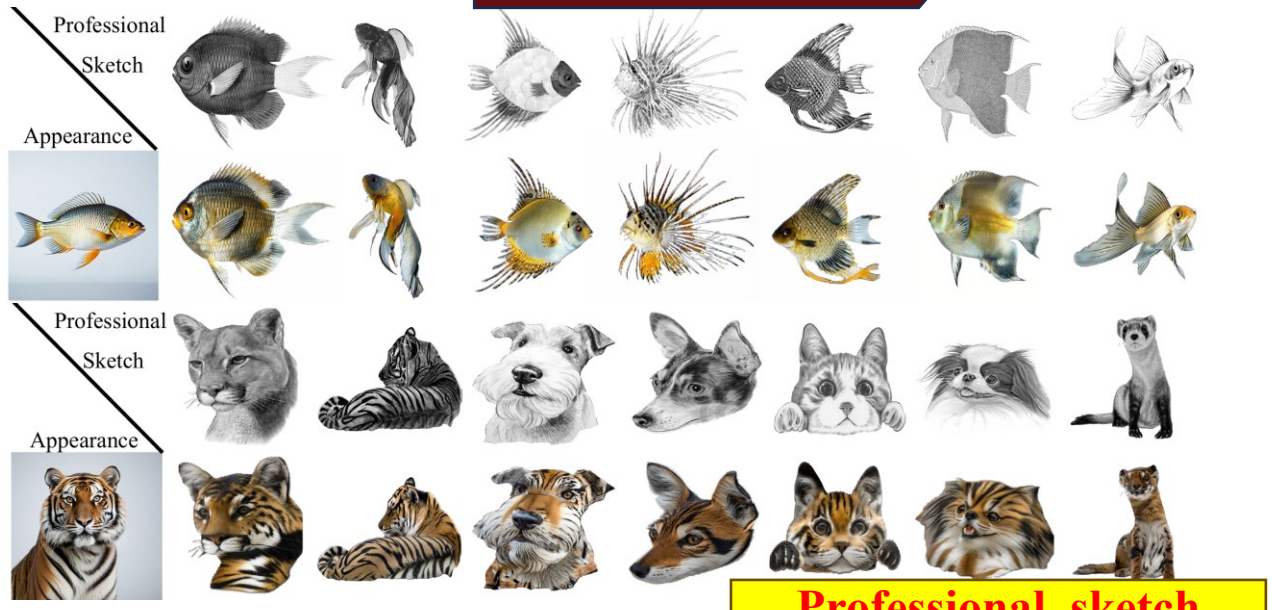
Dataset	Method	Overall quality FID↓	LPIPS↓	CLIP↑	Appearance perception PSNR↑	CH↓	GLCM↓	Edge-fidelity SSIM↑	CD↓
Bronze IC:0.2576-0.2903	**Ours**	**86.31**	**0.25**	**0.86**	25.20	**0.20**	**2.42**	**0.83**	**2.38**
	Baseline [93, 95]	88.26	0.35	0.84	24.48	0.23	29.23	0.81	2.72
	CIA [1]	140.18	0.47	0.75	20.93	0.68	2.45	0.73	263.97
	ZeST [16]	113.79	0.41	0.78	25.87	0.21	5.71	0.72	6.32
	DreamBooth [69]	113.36	0.38	0.81	**27.15**	0.25	11.23	0.77	9.76
	InstructPix2Pix' [9, 93]	223.72	0.48	0.74	24.15	0.29	36.72	0.79	15.51
DifferSketching IC:0.0461-0.2165	**Ours**	211.37	**0.23**	**0.83**	19.25	**0.62**	**1.24**	**0.96**	**2.48**
	Baseline [93, 95]	218.83	0.24	0.81	19.11	0.69	30.75	0.95	3.94
	CIA [1]	237.38	0.47	0.68	**20.16**	0.64	1.61	0.91	241.15
	ZeST [16]	242.88	0.25	0.78	19.24	0.68	2.26	0.94	15.35
	DreamBooth [69]	**202.52**	0.24	0.77	18.88	0.76	37.48	0.95	30.93
	InstructPix2Pix' [9, 93]	235.87	0.29	0.76	19.15	0.74	30.71	0.94	10.32
ImageNet_Sketch IC:0.2500-0.2650	**Ours**	**100.71**	**0.20**	**0.86**	**20.93**	**0.33**	**3.19**	**0.88**	**5.89**
	Baseline [93, 95]	111.04	0.23	0.85	19.85	0.36	28.37	0.85	7.10
	CIA [1]	205.18	0.47	0.66	20.92	0.50	16.03	0.80	240.64
	ZeST [16]	167.78	0.29	0.79	20.22	0.37	28.65	0.83	12.98
	DreamBooth [69]	198.66	0.32	0.77	18.88	0.39	34.79	0.85	33.94
	InstructPix2Pix' [9, 93]	127.03	0.25	0.82	19.15	0.40	28.62	0.84	14.00
DeepPatent IC:0.2715-0.2790	**Ours**	**107.23**	**0.30**	**0.84**	**28.86**	**0.25**	**3.42**	**0.83**	**8.12**
	Baseline [93, 95]	130.32	0.39	0.77	20.31	0.38	20.25	0.80	14.49
	CIA [1]	250.19	0.58	0.65	21.39	0.47	13.34	0.72	224.91
	ZeST [16]	182.03	0.48	0.73	20.22	0.37	26.61	0.76	27.56
	DreamBooth [69]	159.45	0.44	0.73	19.74	0.35	31.53	0.77	46.55
	InstructPix2Pix' [9, 93]	179.62	0.44	0.75	20.29	0.42	24.94	0.78	28.03

(b) Quantitative experiment



(c) User study


Design task
Input
Material
Input
Material
Input
Material
Input
Material


Professional
Sketch
Appearance
Professional
Sketch
Appearance
Professional sketch


User hand
drawing
Appearance
hand-drawn

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