FlowDrag: 3D-aware Drag-based Image Editing with Mesh-guided Deformation Vector Flow Fields

Gwanhyeong Koo, Sunjae Yoon, Younghwan Lee, Ji Woo Hong, Chang D. Yoo
Korea Advanced Institute of Science and Technology (KAIST)

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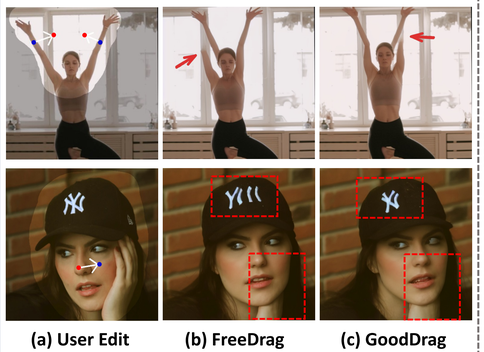
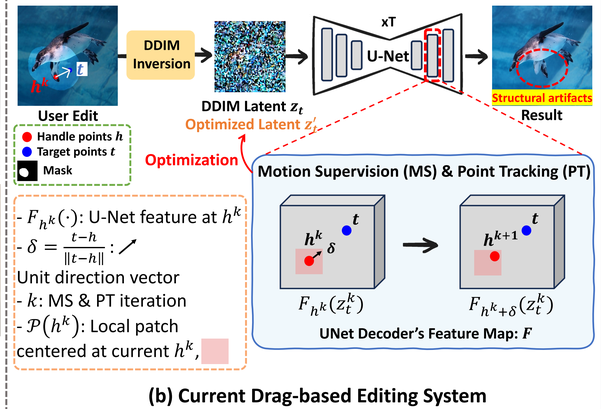
paper project

Problem: Geometric Inconsistency in Drag-based Image Editing



(a) Results of Drag-based Image Editing



(b) Current Drag-based Editing System

Problem: Current drag-based image editing methods often suffer from **geometric inconsistency**, resulting in unnatural deformations or structural artifacts in the edited images.

Causes:

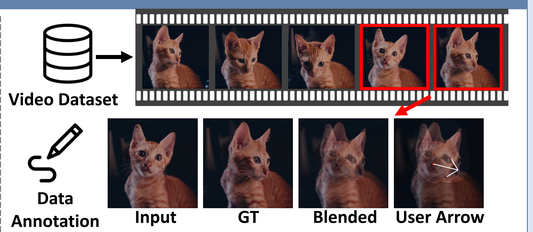
1) Local optimization on few user-defined points: insufficient for capturing global geometry

2) No explicit geometric guidance: no consistent spatial constraints, causing structural artifacts

Observation & VFD Dataset

Findings: When users place drag points that already respect an object's geometry, geometric inconsistencies are greatly reduced.

Challenge: Manually specifying numerous precise points is laborious and often impractical. **How can we derive accurate geometric guidance from just a few user-defined points?**



(a) Labeling Procedure in VFD Dataset

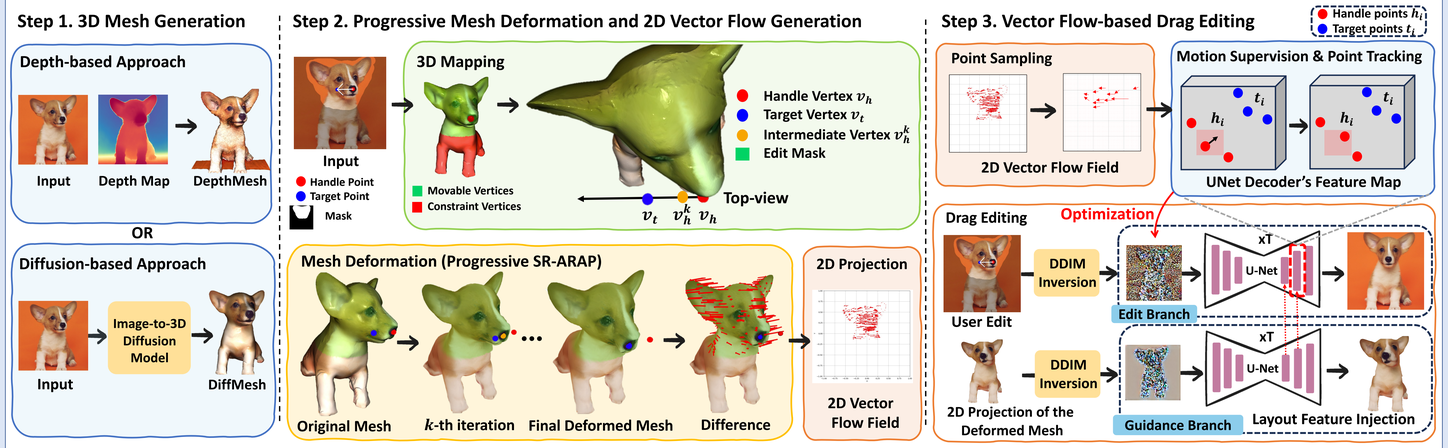
(b) Example from VFG Dataset

Current drag editing benchmarks offer no ground-truth (GT) images, making it impossible to measure edit accuracy objectively.

Our Solution: VFD (Video Frame Drag) Dataset
We construct 250 input/GT pairs from adjacent frames in DAVIS and Pexels[1] videos, **with human annotators labeling matching points as drag directions**, providing reliable references for geometry-aware evaluation.

[1]Pexels: copyright-free videos at (https://www.pexels.com/)

Proposed Method



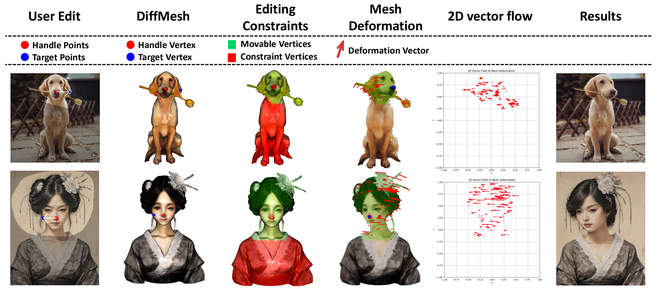
We propose FlowDrag, a Geometry-aware 3-Step Drag Editing Pipeline.

1. 3D Mesh Generation: build *DepthMesh* (fast) or *DiffMesh* (complete) from the input image.

2. Progressive Mesh Deformation: apply SR-ARAP on the mesh then project vertex displacements into a dense **2D vector flow**.

3. Vector Flow-based Drag Editing: **leverage the flow and mesh projection to guide motion supervision & point tracking.**

Experiments

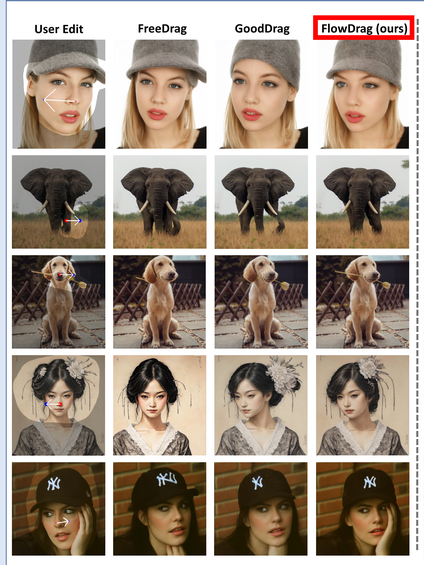


(a) Visualization of the Mesh-Guided Editing Process

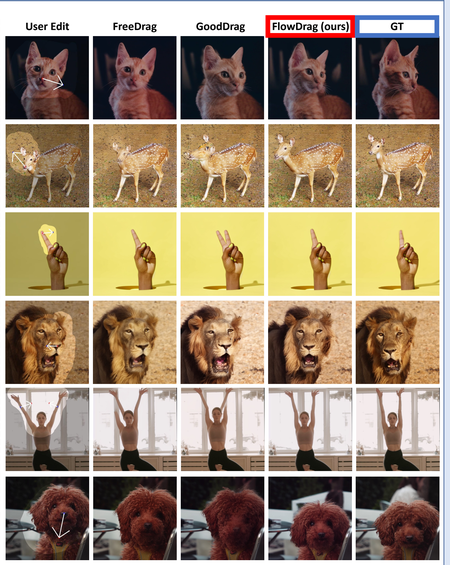
Method	PSNR↑	1−LPIPS↑	MD↓
VFD-Bench			
DiffEditor (Mou et al., 2024)	16.23	0.67	43.35
DragDiffusion (Shi et al., 2024)	17.55	0.76	38.42
DragNoise (Liu et al., 2024)	16.58	0.71	40.52
FreeDrag (Ling et al., 2023)	17.38	0.72	42.78
GoodDrag (Zhang et al., 2024)	18.14	0.79	35.31
FlowDrag (Ours)	**18.55**	**0.82**	**28.23**

(b) Performance of Recent Drag-based Editing Methods on the VFD-Bench dataset

Results



(a) Drag Editing Results on DragBench



(b) Drag Editing Results on VFD-Bench