KaRF: Weakly-Supervised Kolmogorov-Arnold Networks-based Radiance Fields for Local Color Editing

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NEURAL INFORMATION PROCESSING SYSTEMS

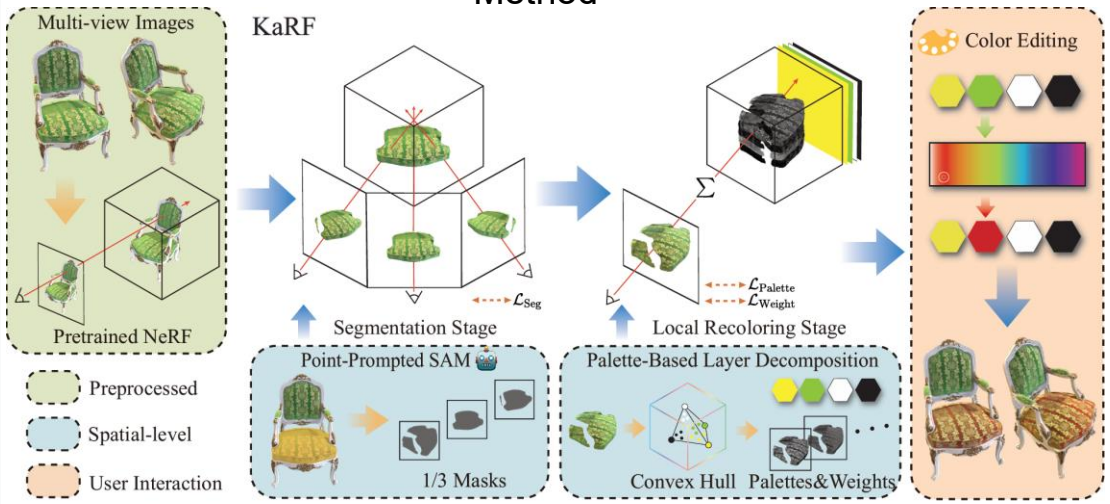
Motivation

Recent advancements have suggested that neural radiance fields (NeRFs) show great potential in color editing within the 3D domain. However, most existing NeRF-based editing methods continue to face significant challenges in local region editing, which usually lead to imprecise local object boundaries, difficulties in maintaining multi-view consistency, and over-reliance on annotated data. To address these limitations, in this paper, we propose a novel weakly-supervised method called KaRF for local color editing, which facilitates high-fidelity and realistic appearance edits in arbitrary regions of 3D scenes. At the core of the proposed KaRF approach is a unified two-stage Kolmogorov-Arnold Networks-based radiance fields framework, comprising a segmentation stage followed by a local recoloring stage. This architecture seamlessly integrates geometric priors from NeRF to achieve weakly-supervised learning, leading to superior performance. More specifically, we propose a residual adaptive gating KAN structure, which integrates KAN with residual connections, adaptive parameters, and gating mechanisms to effectively enhance segmentation accuracy and refine specific editing effects. Additionally, we propose a palette-adaptive reconstruction loss, which can enhance the accuracy of additive mixing results. Extensive experiments demonstrate that the proposed KaRF algorithm significantly outperforms many state-of-the-art methods both qualitatively and quantitatively.

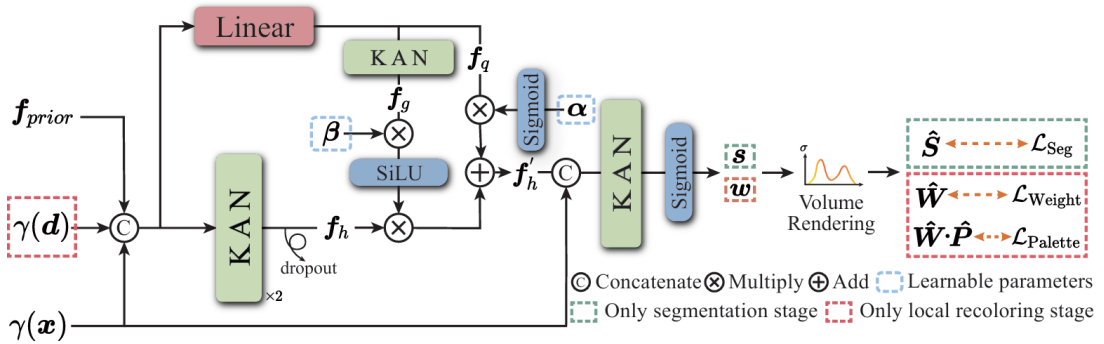
Contributions

- We propose the KaRF framework for local color editing, which enables users to selectively recolor arbitrary regions while requiring minimal guiding information.
- We propose a novel residual adaptive gating KAN structure and a palette-adaptive reconstruction loss to achieve precise segmentation and local recoloring.
- Extensive experiments demonstrate that the proposed KaRF algorithm significantly outperforms many state-of-the-art methods both qualitatively and quantitatively.

Method

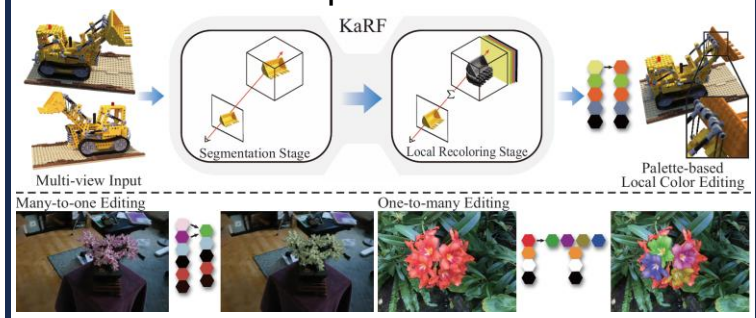


The process consists of two stages:
(1)KAN-based segmentation radiance fields generate consistent masks from sparse point prompts.
(2)Layer decomposition and KAN-based recoloring radiance fields reconstruct palettes and weights, enabling interactive color editing via palette manipulation.

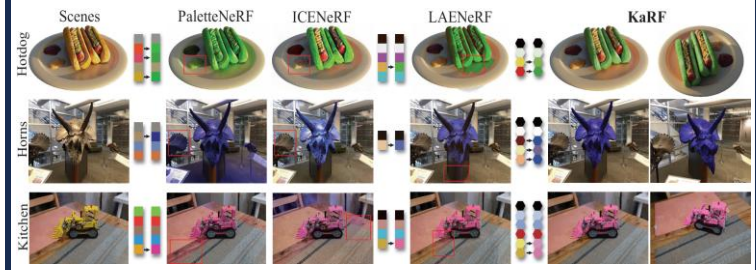


Segmentation Radiance Fields: Takes 3D position and prior features to predict per-point class probabilities.
Recoloring Radiance Fields: Incorporates viewing direction, 3D position and prior features to output per-point weights for a learnable color palette.

Experiments



KaRF, a novel weakly-supervised method for local color editing of neural radiance fields.



Qualitative comparison with NeRF local color editing methods.