

Context-aware Invertible Neural Look-Up-Tables

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Introduction:

What are LUTs? **Look-Up Tables (LUTs)** are a key component for image enhancement. Cameras typically provide multiple options for picture styles, where each style is usually obtained by applying a unique handcrafted LUT. More in detail, a LUT is a predefined mapping function that transforms input values (e.g., colors, intensities) into output values based on stored data. In image and video processing, LUTs are also commonly used to efficiently apply color grading, color enhancement, and other transformations.

Why use LUTs? LUTs are compact and allow for real-time processing with minimal computation. As the transformation function is applied pixel-wisely, LUTs ensure uniform color transformations across frames. These features make LUTs a powerful tool for various tasks and devices.

What is the problem of current LUTs? Although LUTs have lots of advantages, they can still be further improved by current deep-learning techniques. First, to ensure efficiency, LUTs are usually in 32x32x32 or even less resolution, so interpolation is required, leading to inaccuracies in color mapping. Second, traditional LUTs apply global transformations, failing to consider object-specific or region-based color adjustments. Last but not least, LUTs are defined so as to perform well only on many-to-one mappings, which prevents the possibility of applying them to reconstruction problems.

Previous approaches? Conde et al. [1] propose to represent LUTs with a compact MLP model, making the interpolation between several LUTs possible with one single model. However, this model conducts global transformations. Elezabi et al. [2] propose to use the convolutional layers in the model for learning context-aware LUTs. Zehtab et al. [3] use a ResNet-based structure for learning multiple LUTs, the model is possible to represent 512 LUTs with a single model and also make the model invertible. However, all these neural LUTs can only conduct one-to-one or one-to-multiple transformations, which hinders their applications on more flexible transformations between different LUTs.



Figure 1. An example of the workflow of Neural LUT (Image from [1]).

Target and approach:

In this project, our goal is to learn an Invertible Neural LUT, which is capable of conducting multiple-to-multiple transformations between different LUTs.

Project key points:

- Implement the invertible LUT in [3], and test its ability on different image tasks, such as tone mapping, exposure correction, etc.
- Introduce context information to improve its effectiveness in ill-posed problems.

References:

[1] Conde, Marcos V., Javier Vazquez-Corral, Michael S. Brown, and Radu Timofte. "Nilut: Conditional neural implicit 3d lookup tables for image enhancement." In Proceedings of the AAAI Conference on Artificial Intelligence, vol. 38, no. 2, pp. 1371-1379. 2024.

[2] Elezabi, Omar, Marcos V. Conde, Zongwei Wu, and Radu Timofte. "INRetouch: Context Aware Implicit Neural Representation for Photography Retouching." *arXiv preprint arXiv:2412.03848*, 2024.

[3] Zehtab, Vahid, David B. Lindell, Marcus A. Brubaker, and Michael S. Brown. "Efficient Neural Network Encoding for 3D Color Lookup Tables." In Proceedings of the AAAI Conference on Artificial Intelligence, 2025.