

GLUT

3D Gaussian Lookup Table for Continuous Color Transformation

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3D color LUTs

A 3D LUT maps every input color to an output color.

Real-time camera ISP
image signal processing

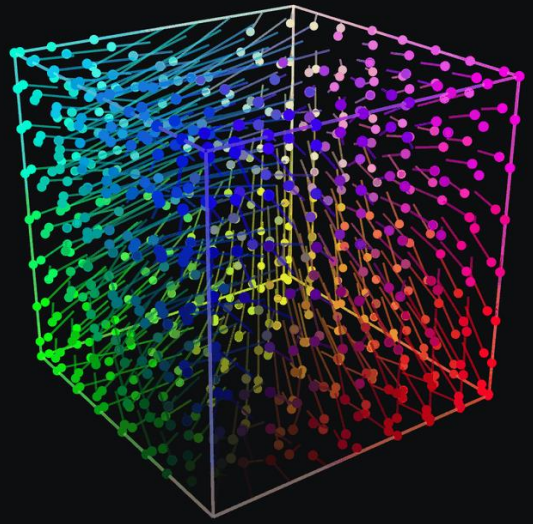
Film color grading
looks for cinema and video

Photo filters
one-tap styles in apps

Representation decides its size, accuracy and editability.



Traditional 3D LUT

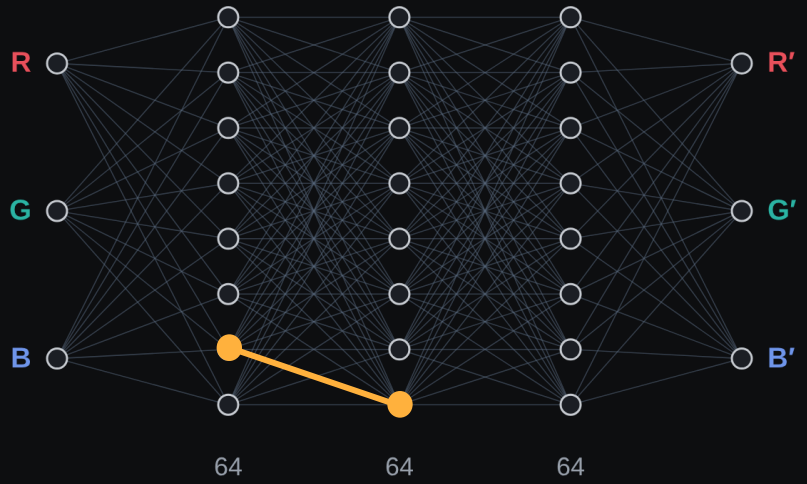


33^3 grid LUT

$33^3 \times 3 = \mathbf{107,811}$ values · **heavy but fast infer**

1. **Sample**
   a regular grid over the RGB cube
2. **Store**
   an output color at every node
3. **Interpolate**
   trilinearly between the 8 nearest nodes for any other color

Implicit neural LUT



NILUT (64×2)

8,771 weights · **compact, continuous**
fast on NPU， blackbox

An example of editing:



Change one weight in the second hidden layer

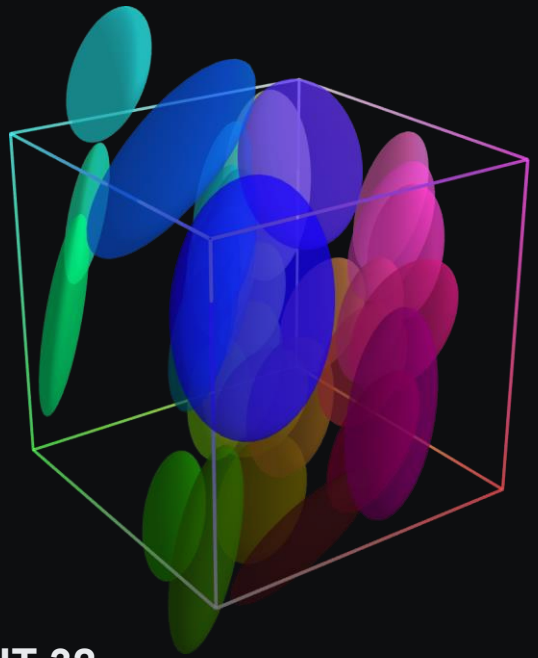
100% of the pixels change color.





bright = color changed

GLUT: 3D Gaussian LUT



GLUT-32

716 parameters (22×32+12) · **more compact**

continuous, interpretable, easy to edit

per Gaussian

μ_i	center	3
Σ_i	covariance (Cholesky)	6
o_i	opacity	1
M_i, b_i	local color transform	12

per GLUT

G, g	global color transform	12

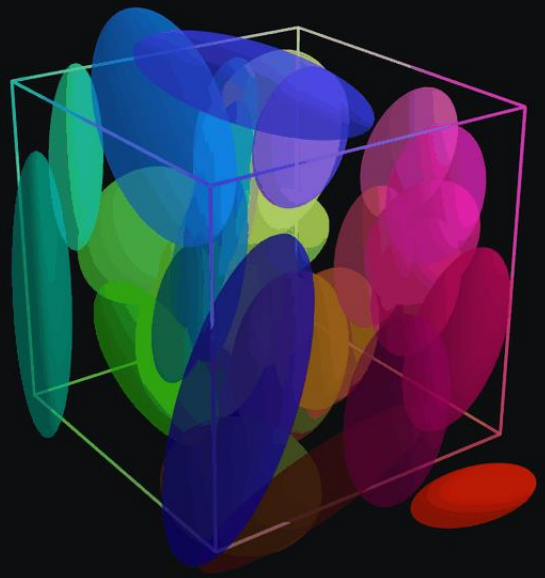
weight

$$w_i(x) = \frac{o_i \mathcal{N}(x; \mu_i, \Sigma_i)}{\sum_j o_j \mathcal{N}(x; \mu_j, \Sigma_j)}$$

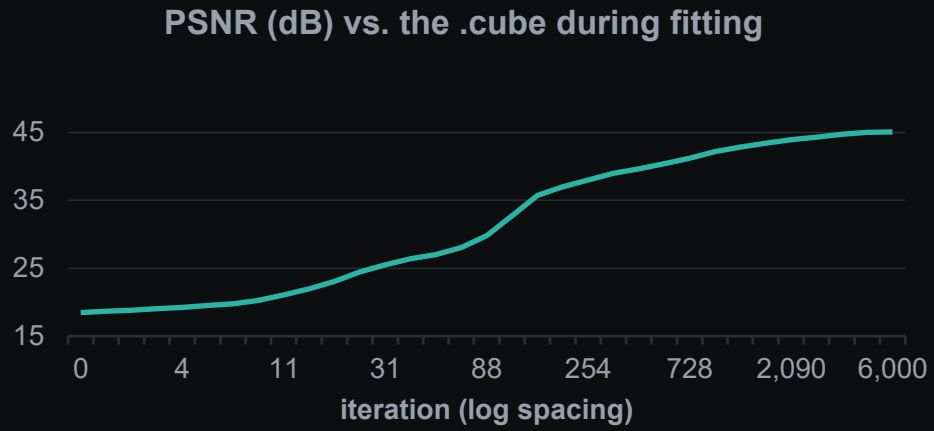
color transform

$$f(x) = \sum_{i=1}^{N} w_i(x) \underbrace{(M_i x + b_i)}_{\text{Local}} + \underbrace{Gx + g}_{\text{Global}}$$

Fitting a GLUT



iteration 6,000 PSNR 45.1 dB



$$\mathcal{L} = \mathcal{L}_1 + \lambda_{hc}\mathcal{L}_{hc} + \lambda_s\mathcal{L}_s$$

error in RGB

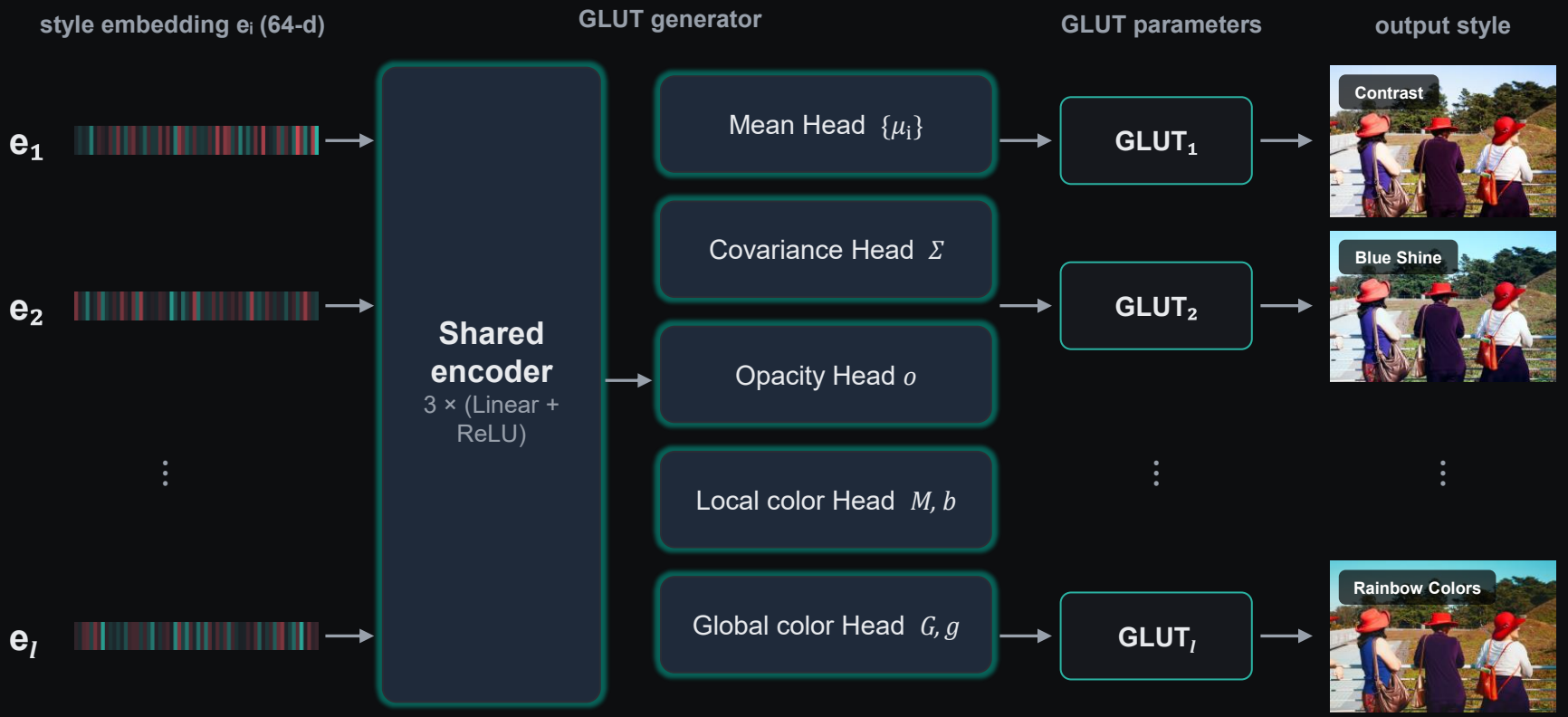
hue-chroma in CIELab

Opacity sparsity

GLUT vs. implicit neural LUT



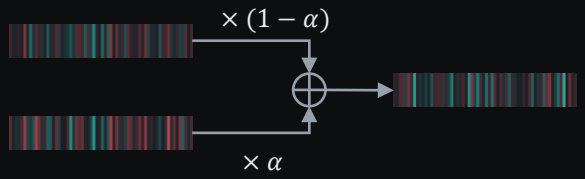
CGLUT: one model for multiple styles



Style blending

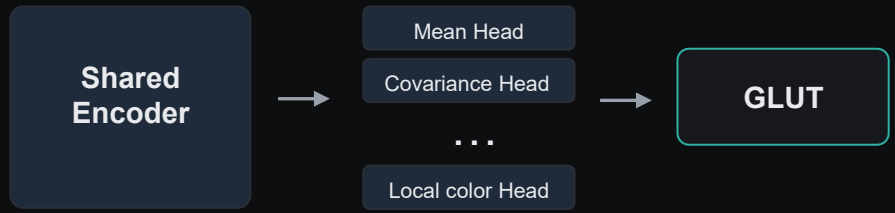
Blending happens on the embedding, not on the images.

① mix the embeddings



$$e(\alpha) = (1-\alpha)e_A + \alpha e_B$$

② generate GLUT parameters





Speed and Compression Ratio

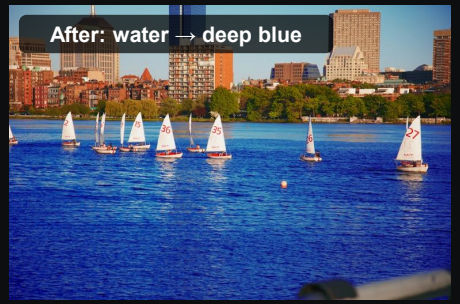
Type	Method	FPS (CPU) ↑			FPS (GPU) ↑			Comp. ratio (%) ↓	
		512^2	HD	4K	512^2	HD	4K	75-LUT	225-LUT
Single Style	NILUT (64×2)	11.42	1.82	0.47	1,538	239	47	0.55	4.32
	NILUT (128×2)	5.87	0.83	0.20	822	111	28	1.96	15.70
	GLUT-32	14.05	1.96	0.49	6,170	891	**226**	**0.10**	**0.75**
Multiple Style	CNILUT (128×3)	0.34	0.01	–	1.86	0.03	–	0.05	0.16
	CNILUT (256×3)	0.30	–	–	1.83	0.03	–	0.17	0.52
	ENNELUT (L2)	4.92	0.66	0.18	406	39	10	0.02	0.07
	CGLUT-32 (Small)	1.01	0.14	0.04	1,147	545	**194**	**0.07**	**0.20**

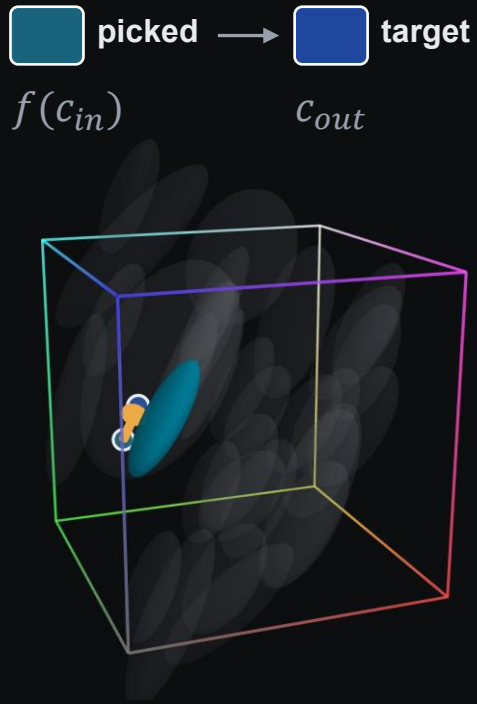
"–" denotes FPS lower than 0.01.

- **~ 200 FPS** at 4K UHD on GPU
- **0.10%** compression ratio for 64^3 LUTs

GLUT editing







the K top-weighted Gaussian (K = 1)

$$\boldsymbol{\delta} = \boldsymbol{c}_{out} - f(\boldsymbol{c}_{in})$$

$$\alpha_k = \frac{w_k(\boldsymbol{c}_{in})}{\sum_{j \in top-K} w_j(\boldsymbol{c}_{in})}$$

$$\boldsymbol{b}_k \leftarrow \boldsymbol{b}_k + s\alpha_k\boldsymbol{\delta}$$

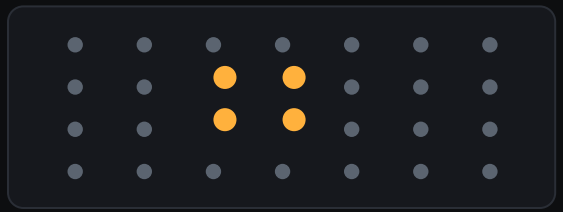
When K=1, it only modify:
one bias term (3 values)

LUT editing on different representations



Grid LUT

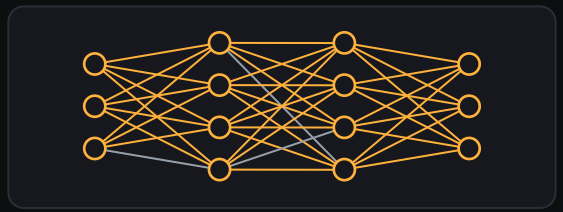




shift 64 nodes (192 values)
Blotchy and still not reach the target

NILUT





7,615 of 8,771 weights change
require retraining

GLUT





Change 1 bias (3 values)
closed form, without training

GLUT: 3D Gaussian Lookup Table

for Continuous Color Transformation

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Code, models, and demos:
github.com/CVC-Color/glut

Questions? **dxue@cvc.uab.cat** or an issue on GitHub

scan for the project page