Prompt-Driven Color Accessibility Evaluation in Diffusion-based Image Generation Models

Xinyao Zhuang[1], Jose Echevarria[2], Kaan Akşit[1]

[1]University College London, [2]Adobe Research

Computational Light Laboratory

https://complightlab.com

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Codebase

1 Problem

Diffusion models generate colorful images, but local textures and structural cues can weaken under color vision deficiency (CVD) simulation. ***Can prompt design alone reliably improve color accessibility, without post-processing [6] or specialized generative models [4]?***

2 Motivation

We systematically evaluate whether pre-trained diffusion models can perform accessibility-aware color transformations through prompt design alone, without explicit post-processing. We focus on protanopia and deuteranopia and introduce ***CVDLoss*** to measure changes in local structure between generated images and their CVD simulations.

3 Our Solution

We compare standard, colorblind-aware, protanopia-aware, and deuteranopia-aware prompts. Our evaluation measures changes in local structure between generated images and their CVD simulations [5].

Prompted image generation
Stable Diffusion 3.5-large / FLUX.2 Klein 4B
8 categories, 640 images

Original image
Reference image I

CVD simulation
Protanopia / Deuteranopia

Perceptual color gradients
OKLab + HyAB for both images [1]

CVDLoss
Normalized gradient discrepancy
Compare prompts to the standard baseline

4 Measuring Color Accessibility

Perceptual gradient metric

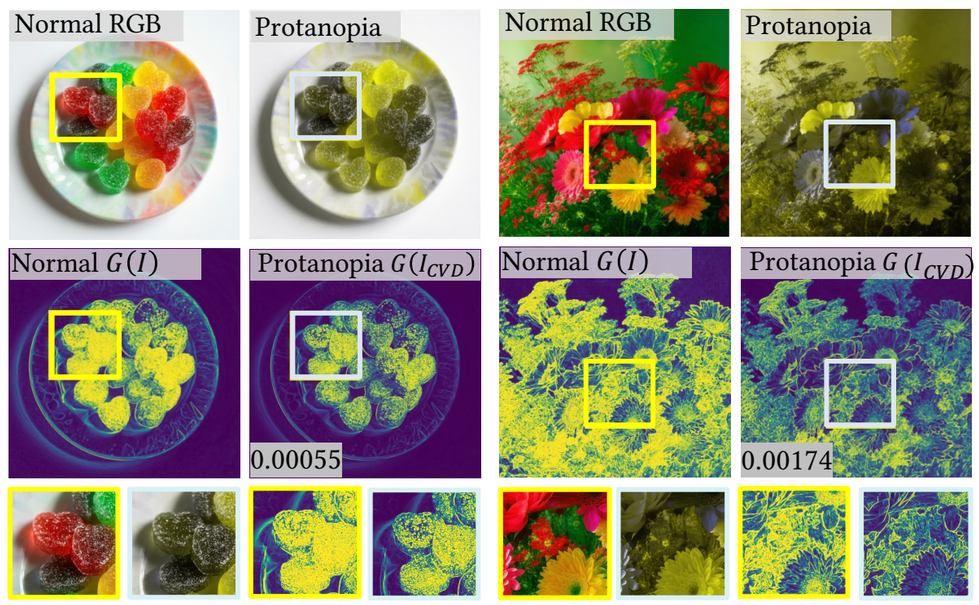
Color conflicts may affect boundaries, textures, and fine details in spatially adjacent regions. We measure these local changes using perceptual 3D color gradients [1], rather than relying only on per-pixel color differences.
For an image I and its CVD simulation, we compute gradient magnitude maps using HyAB color differences in OKLab.

$$\mathrm{CVDLoss}(I, I_{\mathrm{CVD}}) = \frac{\sum_p \left(G(I)_p - G(I_{\mathrm{CVD}})_p\right)^2}{N \cdot \max_p G(I)_p^2}$$

Here, $G(\cdot)$ is the gradient magnitude map, p indexes image pixels, and N is the number of pixels. ***CVDLoss*** measures normalized gradient discrepancies between each image and its corresponding CVD simulation.

Qualitative illustration

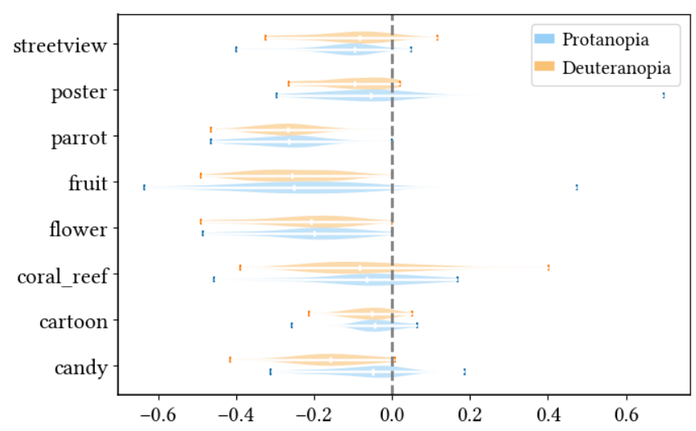
Normal and protanopia views of colorblind-aware generated images, with gradient magnitude maps and local details. Highlighted regions show changes in color gradients and edge structure.



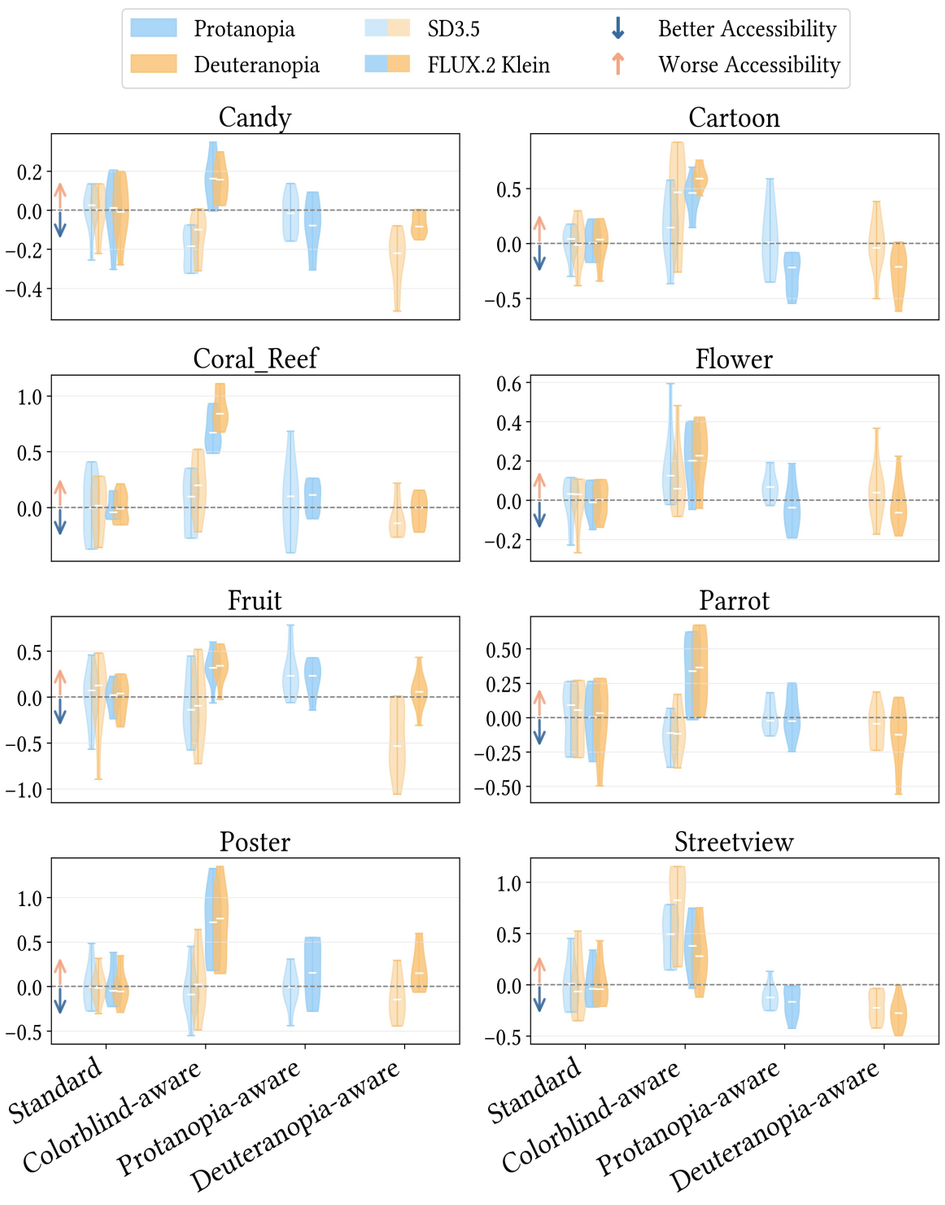
5 Evaluation and Results

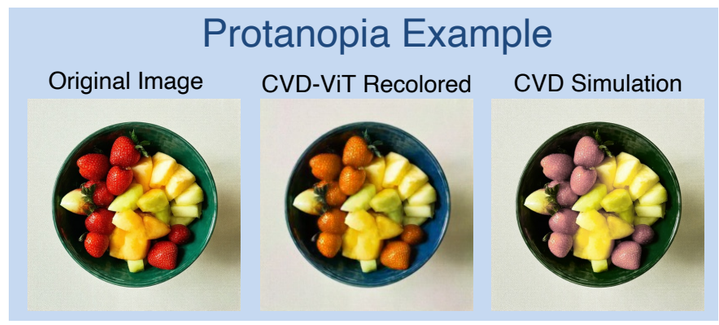
Synthetic validation

We use CVD-ViT [2] to recolor standard-prompt images for protanopia and deuteranopia. We subtract original $log_{10}(\mathrm{CVDLoss})$from recolored $log_{10}(\mathrm{CVDLoss})$. Mostly negative shifts support the metric's response to explicit accessibility-oriented transformations.



Negative shifts indicate reduced *CVDLoss*.





Prompt-based evaluation

We subtract the standard-prompt mean of $log_{10}(\mathrm{CVDLoss})$. Negative values indicate reduced discrepancy under CVD simulation.

The same prompt can reduce ***CVDLoss*** in one category and increase it in another. Deficiency-targeted prompts do not consistently improve the corresponding condition. Both models show this variability: **prompt-only interventions do not yield predictable perceptual–structural improvements.**

Implication

Consistent with Hayashi et al. [3], these findings motivate methods that incorporate CVD simulation or accessibility objectives during training or post-processing.

6 References

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[6] M. Ribeiro and A. J. P. Gomes. 2019. Recoloring Algorithms for Colorblind People: A Survey. ACM Comput. Surv.

Contact: Xinyao.zhuang.24@ucl.ac.uk