Luminance-Preserving and Temporally Stable Daltonization

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Daltonization: Improving Images for People with Color Vision Deficiencies (CVDs)

Normal vision perspective

CVD perspective before daltonization

CVD perspective after daltonization
Dichromacy

Protanopia Dichromacy

Missing L Cone Sensitivity

Spectral Sensitivity of the LMS Cones
CVD Simulation

Normal vision

Protanopia

Deuteranopia

Tritanopia

[Viénot et al. 99]
Daltonization

Normal vision perspective

Protanopia CVD perspective

+ Our Daltonization

(~0.2 ms / frame – RTX 4090)
Luminance Preservation

Original

CVD

CVD + Farup [2020]

CVD + Ours

Luminance difference compared to original

0.0

0.15
Daltonization without Temporal Stability

Normal vision perspective

CVD perspective

+ Daltonization

(Machado and Oliveira [2010])
Our approach: Temporal Stability

Normal vision perspective

CVD perspective + Daltonization (Ours)
RGB Cube in YCbCr

- Color transform to *linear* YCbCr
  - Linear luminance
  - Separates luminance and chrominance

- Transformed RGB cube
  - Generates an RGB parallelepiped
Luminance planes

• Equiluminance planes crossing the RGB parallelepiped
  • Luminance polygons
Per-polygon color mapping

• Final Daltonization
  • Luminance-preserving transformation
**Daltonization: Optimized color mapping**

**Goal:** Map all colors onto the **Dichromat’s line of visibility**

1. **Initial projection:**
   Project colors to the dichromat’s line of visibility

2. **Linear remapping:**
   Inside available gamut + preserving grey point

3. **Red-green differentiating remapping**

4. **Interpolation:**
   Preserving colors close to the dichromacy line

5. **Weighted histogram equalization**
   Increase the use of available colors
Remapped colors result

Original Image

Remapped Color Image
(Ours)
Color back-projection

Original Image

Presented Image

After back-projection (Ours)
(No change in how a dichromat sees the image)
Color back-projection
**Evaluation**

**Normal vision perspective**

**CVD perspective (Protanopia)**
Real-time implementation

Follow the QR code to find our paper and supplemental material: (https://research.nvidia.com/publication/2023-05_daltonization)

3840x2160 image: ~0.2 ms / frame
Thank You

https://research.nvidia.com/publication/2023-05_daltonization