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Light Optimization for Visual Quality and Conservation of Artwork

Gil P. Baguio[1], Rugved Kore[2], Dr. Jeffrey Mundinger[2], Dr. Dorukalp Durmus[2]

[1]Eager Street Academy; [2]Department of Architectural Engineering, Penn State University

Abstract

Lighting can affect both the visual quality of an artwork and can cause damage through photochemical action. Optimizing light source spectrum for surface reflectance factor of the artwork can minimize light absorption, therefore reduce irreversible damage of delicate materials. This study utilized absorption minimization method and computational color science tools to reduce light absorption and energy consumption by lighting without affecting the color quality of artifact.

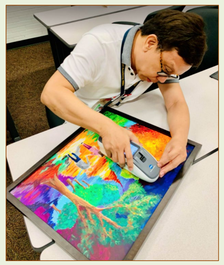
Introduction

- Optimizing light source spectrum can aid in conservation of art collections by reducing damage caused by optical radiation while preserving color fidelity (Durmus et al. 2020).
- Computational simulations have shown that optimizing test spectra can reduce light absorption between 18% and 48%, without causing perceptible color or hue shifts in the paintings (Durmus et al. 2018).
- The goal of this research study is to find the optimal lighting conditions for visual quality and conservation of an artwork by using computational color science tools.
- The study developed a computational tool using python programming to extract meaningful and useful information from large amount of data collected.

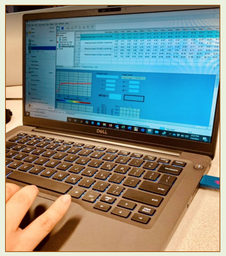
Methods

- Equipment
  - painting
  - spectrophotometer
  - Augment-reality (AR) RGB projector
- Computational
  - input data
    - # reflectance factor
    - # color matching functions
    - # light source spectra
  - brute-force search
  - python programming

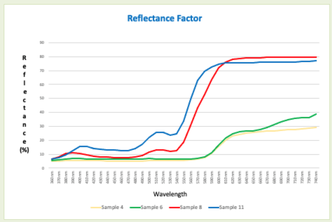
Processes



Measuring Light Absorption using Spectrophotometer

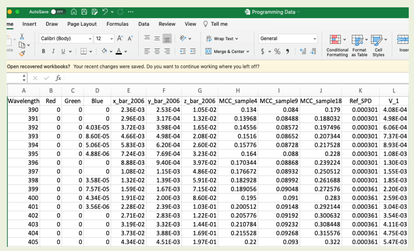


Uploading Data from Spectrophotometer

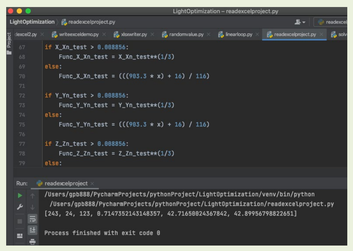


Calculating & Analyzing Reflectance

Light Optimization Set-up

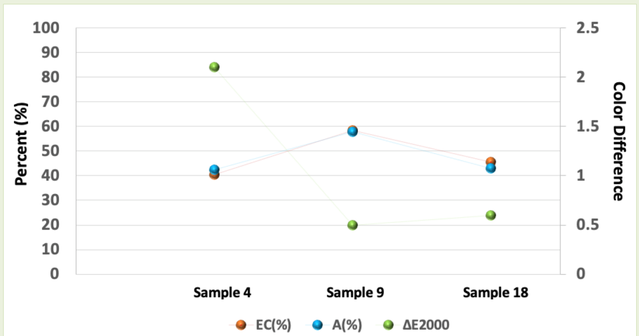


Input Data



Coding Data using Python Programming

Results



Samples	Red	Green	Blue	ΔE_{2000}	EC(5)	A(%)
Sample 4	81	151	8	2.1	40.42	42.56
Sample 9	253	115	112	0.5	58.54	57.8
Sample 18	255	87	35	0.6	45.55	42.89

Optimal solutions for three samples had:

a) a color difference, $\Delta E_{2000} < 2.1$;
b) light absorption, A < 43%-58%; and
c) energy consumption, EC < 41%-59% compared to reference illuminant.

Conclusion

RGB projector spectra was optimized to halve the damage on the artifact and energy consumed by lighting without causing large color shifts on the artwork. Absorption-minimization method has the potential to prolong works of art while maintaining perceived visual quality.

Future Work

The pilot study can be continued to perform a large sample set (e.g., more color samples from the painting) and use multi-objective genetic algorithm (MOGA) optimization to reduce computational time and power.

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References

D. Durmus, D. Abdalla, A. Duis and W, Davis (2020) Spectral Optimization to Minimize Light Absorbed by Artwork, LEUKOS, 16:1, 45-54, DOI: 10.1080/15502724.2018.1533852

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