Artist-friendly Editing of Measured Pseudo-Spectral Assets

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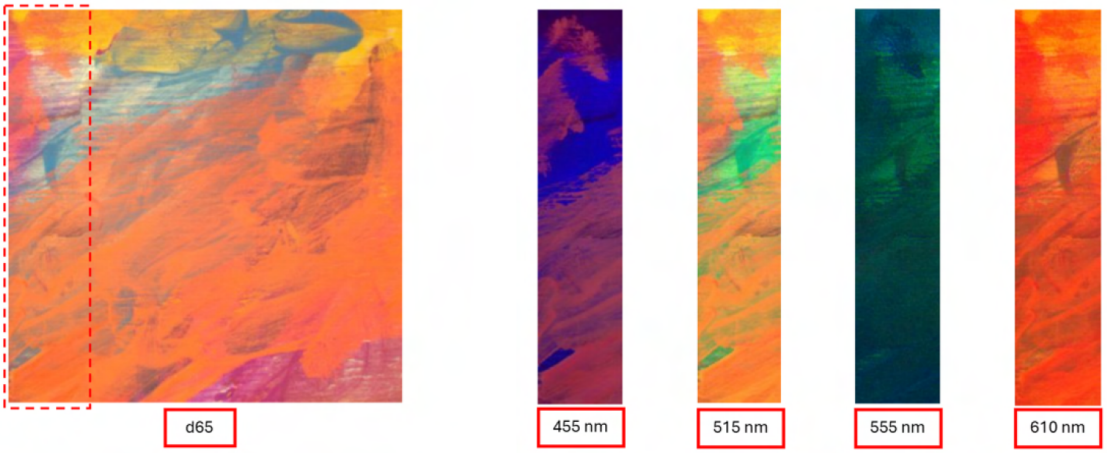


Figure 1: Left: photograph of a painting made with fluorescent paints and observed under a daylight illuminant (D65). In recent work, we captured the complex color effects produced by such fluorescent materials when lit under different illuminants. Right: a vertical band of the captured material may then be relit under complex lighting – here peaky illuminants centered at different wavelengths. Our goal in this project is to grant editing abilities on such measured fluorescent material textures as well as measured illuminants.

Context

In Computer Graphics, there are two main classes of rendering engines. RGB rendering is the most common and is based on RGB colors emitted by light sources, reflected by objects according to their materials, and absorbed by sensors. This is clearly an approximation of physical light transport, since the properties of interest should not be colors but spectra; only at the very end of the rendering process should spectra be converted to colors. The other main class of rendering engine is thus spectral: it is not only much more costly in terms of computation and memory resources, but also makes asset capture (i.e., textures, environments) much more tedious. Yet it remains the solution of choice when it comes to produce physically-realistic (even predictive) images: it properly accounts for a variety of complex effects such as metamerism, iridescence, fluorescence, etc.

Goals

We have recently devised optical measurement methods using simple camera and spectral filters to capture complex spectral lighting and materials. In particular, we were able to measure fluorescence material textures,

as shown in Figure 1. We termed our approach 'pseudo-spectral' since it approximates spectral assets through a small number of coefficients that are directly measured.

However, we need to provide methods tailored to artists for the *editing* of such pseudo-spectral assets to make them useful in practice. For fluorescent materials, this means separating the fluorescent component from the more common reflectance component, both being combined in measurements. For light sources, one needs to either capture UV irradiance, or estimate it given limited measurements, in order to take full advantage of fluorescence effects in renderings. In both cases, we are particularly interested in editing assets with spatial or angular variations (i.e., textures), where artistic control becomes particularly challenging.

Methodology

We will first consider lighting measurements. Capturing UV irradiance requires specific modified camera where UV filtering has been discarded (e.g., see [TS15]), which we did not have when we performed our measurements. Our approach will then be to augment measured lighting with UV content under artistic control, while preserving plausibility of results. The same method should be applicable to existing environment maps that capture omnidirectional lighting in RGB.

We will then turn to the editing of fluorescence using our material measurements. In practive, we captured reduced reradiation matrices, which approximate full reradiation using a few coefficients through the pseudo-spectral approach. Such reduced matrices can be in principle decomposed into reduced reflectance matrix and a (potentially normalized) reduced fluorescence matrix [BFB25]. Alternatively, the full reradiation matrices may be reconstructed through optimisation [ILW23], in which case the decomposition becomes trivial (reflectance is on the diagonal). We will study and compare both approaches, and try to take into account uncertainties with dedicated optimization methods (e.g., [EGL97]).

Expected skills

Experience in python programming is required to perform basic editing and comparisons, in GLSL shader programming for rendering and editing in context. A basic knowledge of matrix algebra and optics is required.

References

[BFB25] Laurent Belcour, Alban Fichet, and Pascal Barla. A Fluorescent Material Model for Non-Spectral Editing & Rendering. In *SIGGRAPH Conference Papers 2025 -: Special Interest Group on Computer Graphics and Interactive Techniques Conference Conference Papers*, pages 1–9, Vancouver BC, Canada, August 2025. ACM.

[EGL97] Laurent El Ghaoui and Hervé Lebret. Robust solutions to least-squares problems with uncertain data. *SIAM Journal on Matrix Analysis and Applications*, 18(4):1035–1064, 1997.

[ILW23] Tomáš Iser, Loïc Lachiver, and Alexander Wilkie. Affordable method for measuring fluorescence using gaussian distributions and bounded mese. *Opt. Express*, 31(15):24347–24362, Jul 2023.

[TS15] Jolyon Troscianko and Martin Stevens. Image calibration and analysis toolbox – a free software suite for objectively measuring reflectance, colour and pattern. *Methods in Ecology and Evolution*, 6(11):1320–1331, 2015.