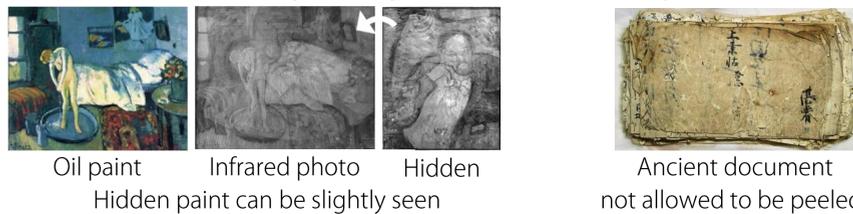


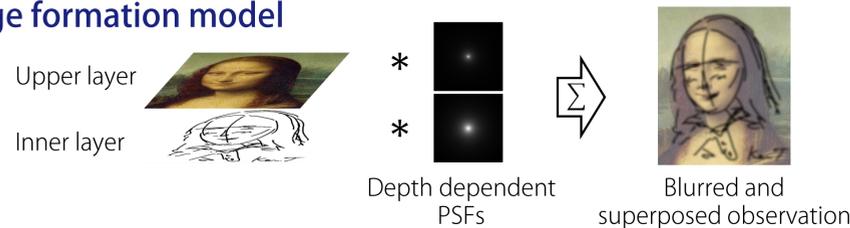
Objective

Visualize clear inner layers e.g. hidden paints, signature, etc.



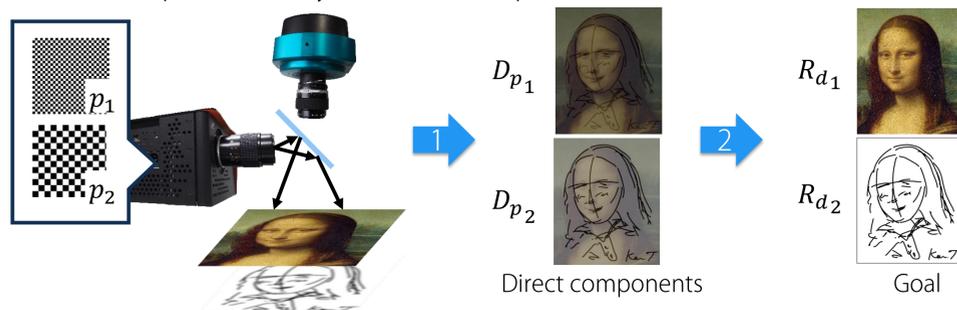
Overview

Image formation model



Multi-frequency illumination

1. Project multiple pitches of patterns and extract each direct component^[1]
2. Decompose each layer's direct component



[A1] Direct component model

$$D_{p_n} = \alpha(p_n, d_1) R_{d_1} + \alpha(p_n, d_2) R_{d_2}$$

Detail **A1**

[A2] Solve a linear system

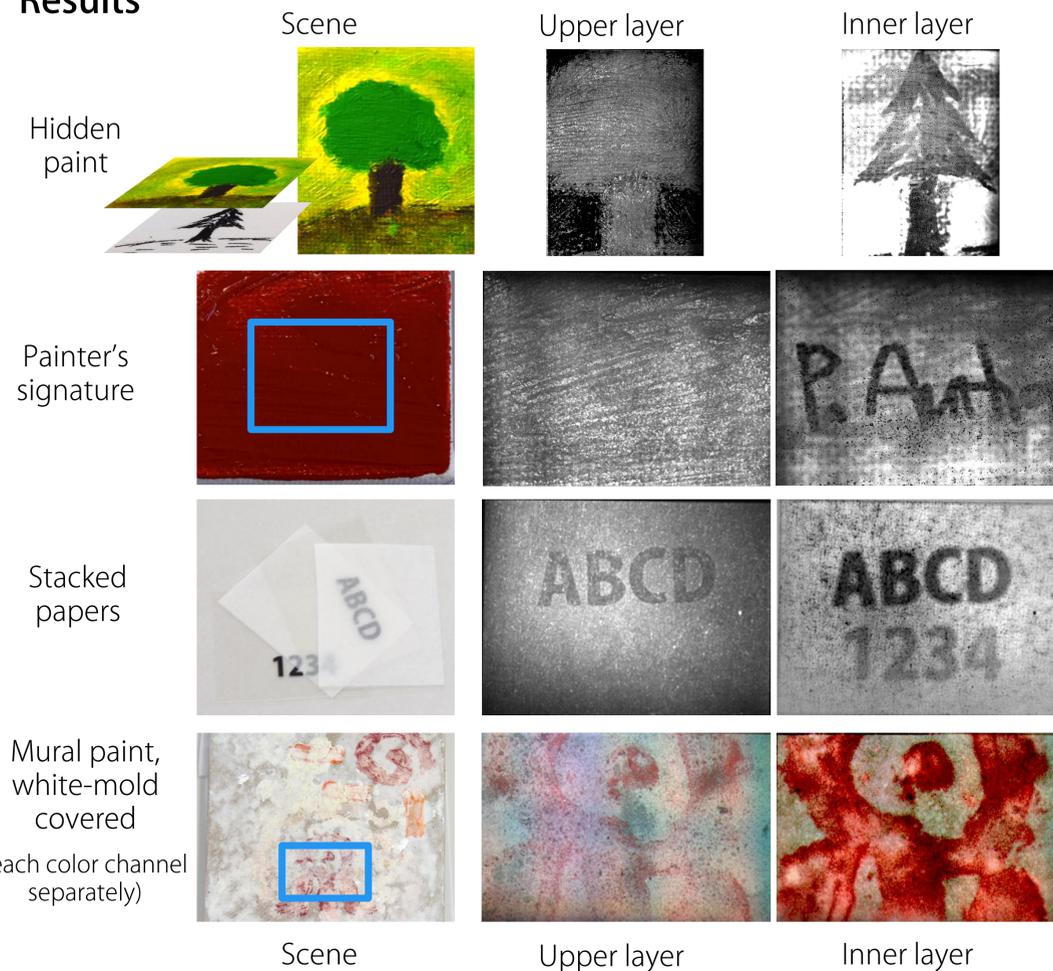
$$\begin{bmatrix} D_{p_1} \\ D_{p_2} \end{bmatrix} = \begin{bmatrix} \alpha(p_1, d_1) & \alpha(p_1, d_2) \\ \alpha(p_2, d_1) & \alpha(p_2, d_2) \end{bmatrix} \begin{bmatrix} R_{d_1} \\ R_{d_2} \end{bmatrix}$$

Direct components Brightness Clear layers

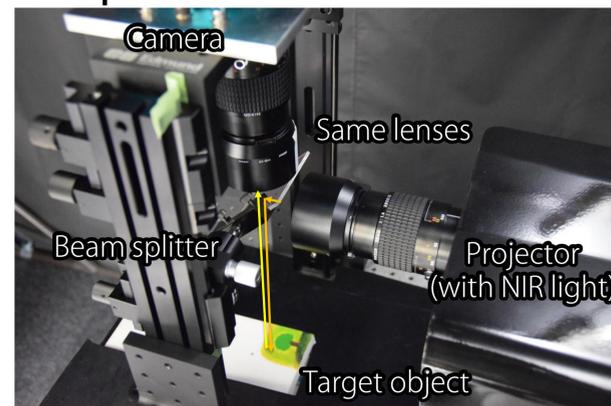
Detail **A2**

[1] S. K. Nayar et al. Fast separation of direct and global components of a scene using high frequency illumination, SIGGRAPH 2006.

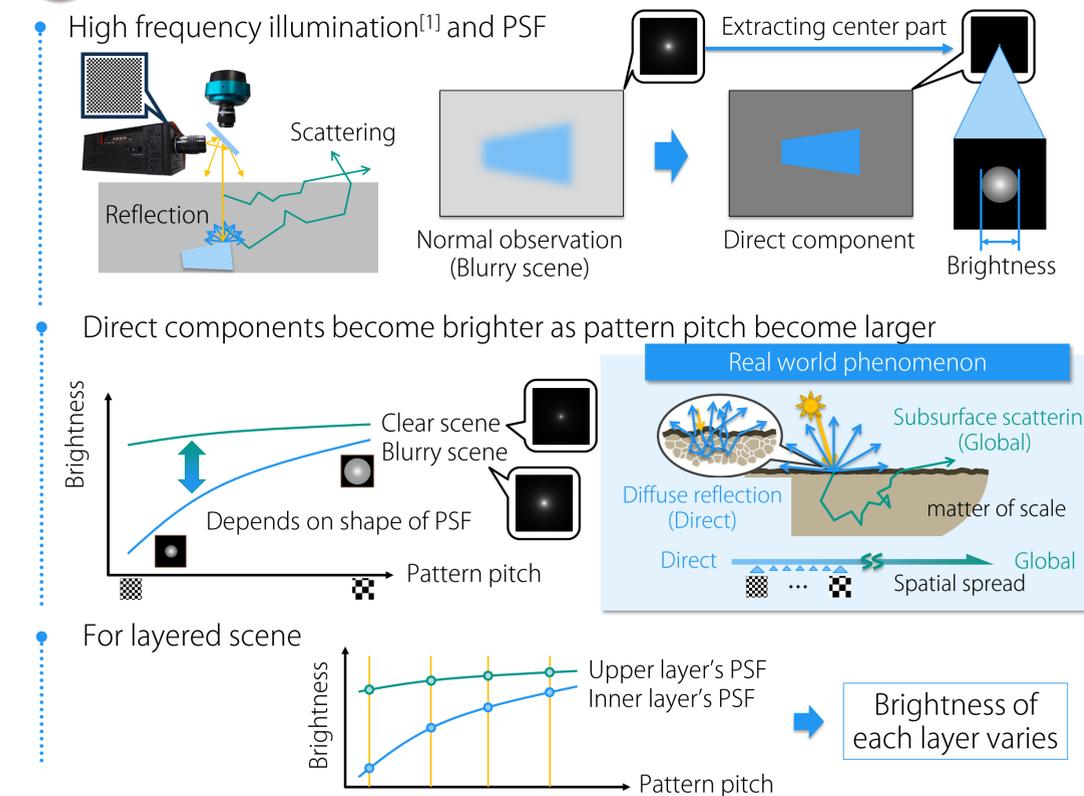
Results



Experimental setup



A1 Why brightness of direct component changes?



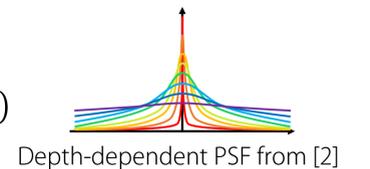
A2 Optimization

1. Prepare matrix A from many candidate depths

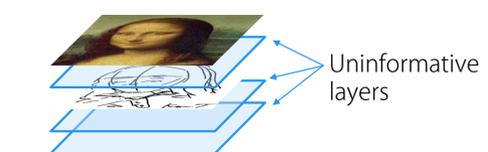
Just as [1] do

$$\alpha(p, d) = \max(l_p * h_d * h_d) - \min(l_p * h_d * h_d)$$

Checker pattern of the pitch p PSF of the depth d



2. Informative layer exists sparsely along depth



$$\arg \min_R \|D - AR\|_2^2 + \lambda \|R\|_1$$

subject to $R \geq 0$

$$\begin{bmatrix} \alpha(p_1, d_1) & \cdots & \alpha(p_1, d_n) \\ \vdots & \ddots & \vdots \\ \alpha(p_m, d_1) & \cdots & \alpha(p_m, d_n) \end{bmatrix} \begin{bmatrix} R_1 \\ \vdots \\ R_n \end{bmatrix}$$

From many candidate depths

Uninformative layer goes to 0

[2] S. G. Narasimhan et al. Shedding light on the weather, CVPR 2003.