Light Field Layer Matting

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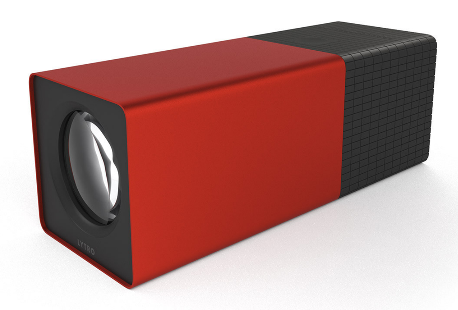

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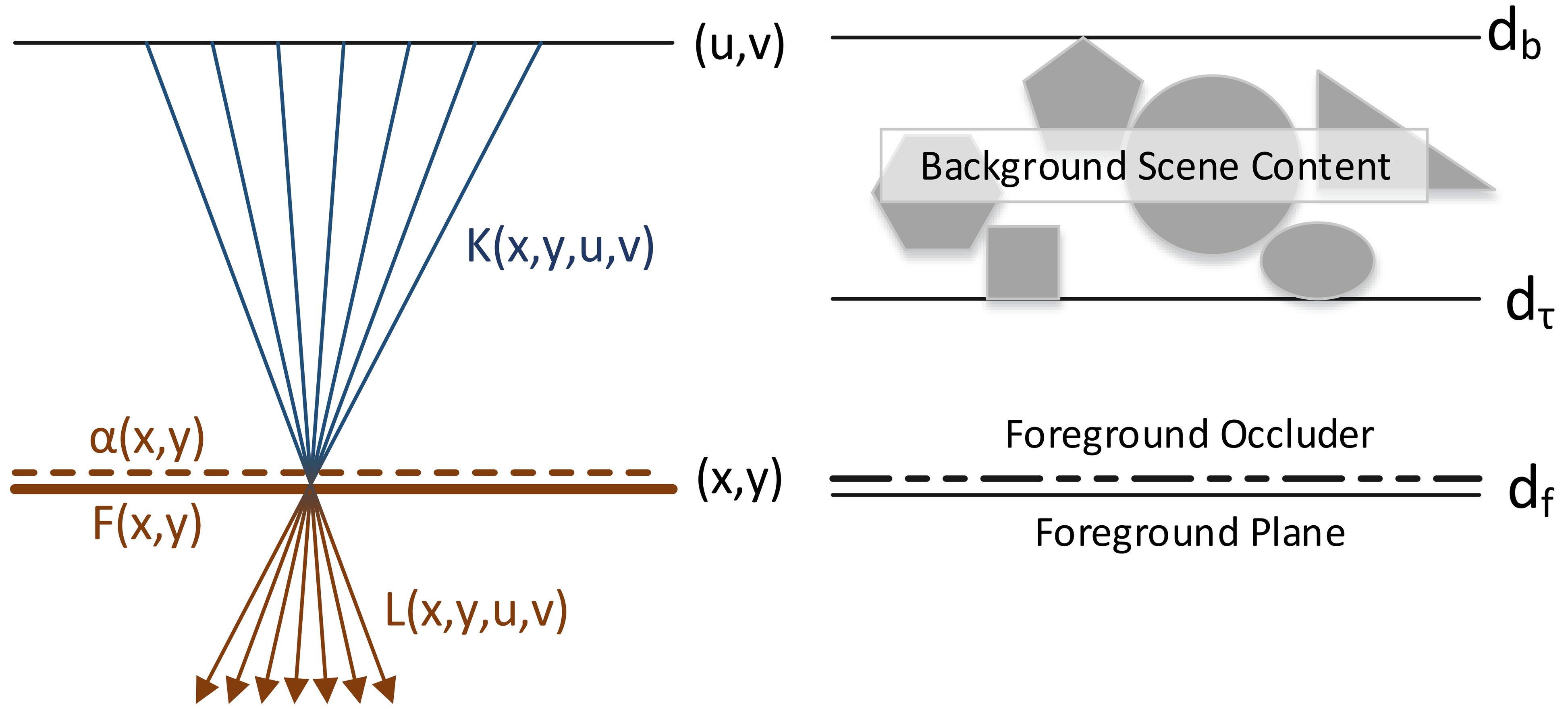
Problem

We use matting to separate fronto-parallel foreground layers from light fields captured with a plenoptic camera. Our method can remove a complex thin or translucent foreground occluder, for example dirt on a window, without specifying a trimap. We model the scene with two layers. We use this representation to render novel views while avoiding artifacts that commonly occur at thin occluders with a single-layer model.

We represent the input 4D light field as a 2D foreground color image layer with spatially varying alpha composited over 4D background light field.



Layered Light Field Equation:

$$L(x,y,u,v) = \alpha(x,y)F(x,y) + (1-\alpha(x,y))K(x,y,u,v)$$

Foreground-focused Matting Equation:

$$\underbrace{\int L(x,y,u,v)\,du\,dv}_{C(x,y)} = \alpha(x,y)F(x,y) + (1-\alpha(x,y))\underbrace{\int K(x,y,u,v)\,du\,dv}_{B(x,y)}$$

Input:
- Input light field **L**
- Foreground depth $\mathbf{d_f}$
- Threshold depth $\mathbf{d_\tau}$

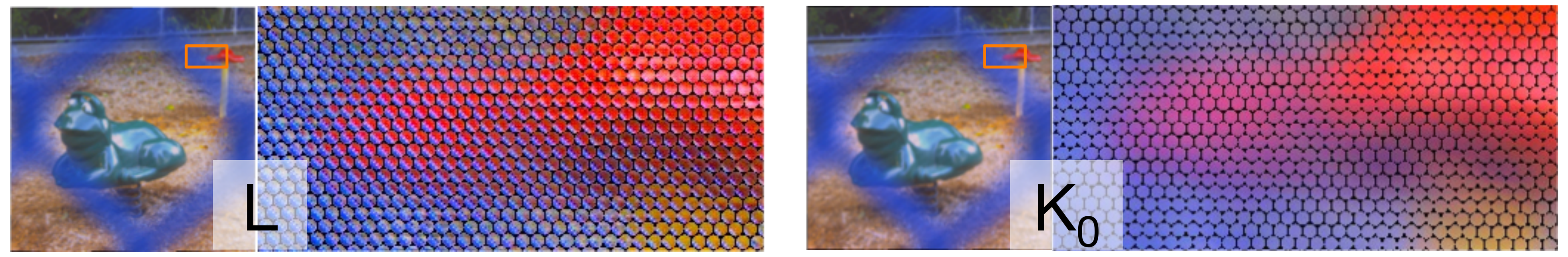
Output:
- Background light field **K**
- Foreground layer color image **F**
- Foreground layer alpha $\boldsymbol{\alpha}$

Method

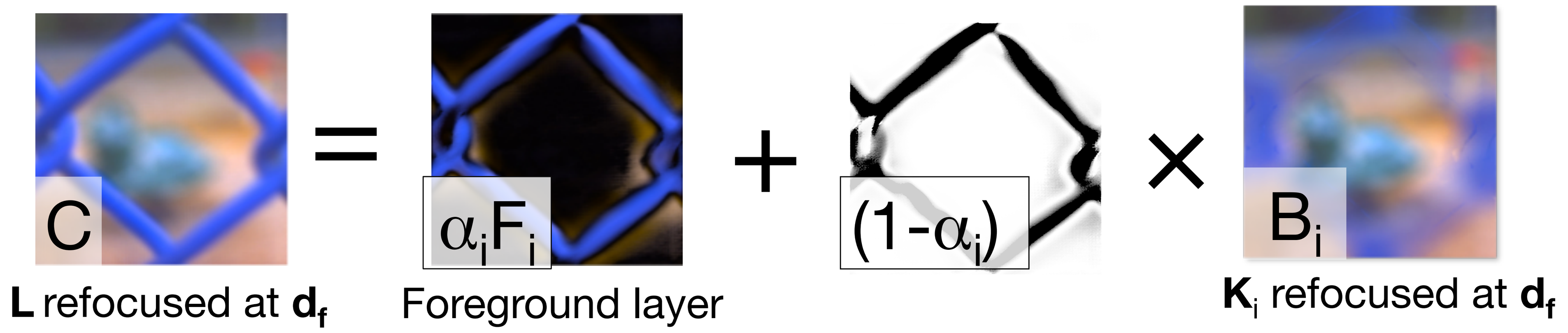
Iterate between computing background light field $\mathbf{K_i}$ and foreground matte $\boldsymbol{\alpha_i}\mathbf{F_i}$.

① Initialize the background light field $\mathbf{K_0}$ from the input light field **L.**

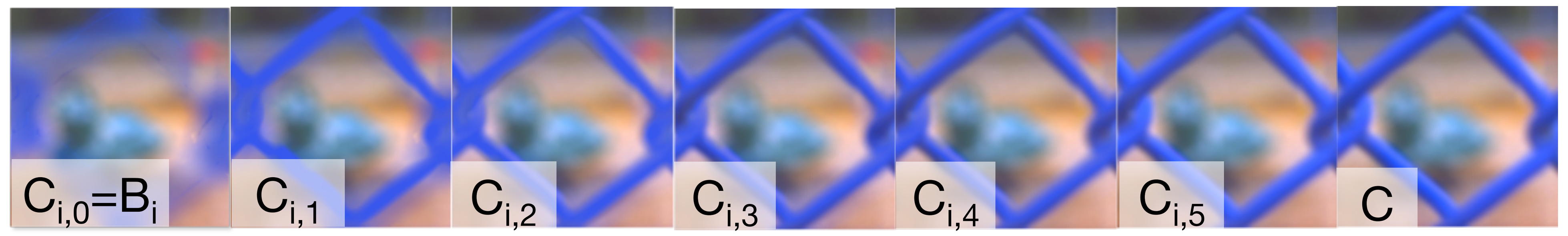
For each ray, find the depth (> $\mathbf{d_\tau}$) where **L** is most in focus for that ray. Assign background ray colors to $\mathbf{K_0}$ from **L** refocused at these depths.



② Estimate the foreground layer using matting at the foreground plane.

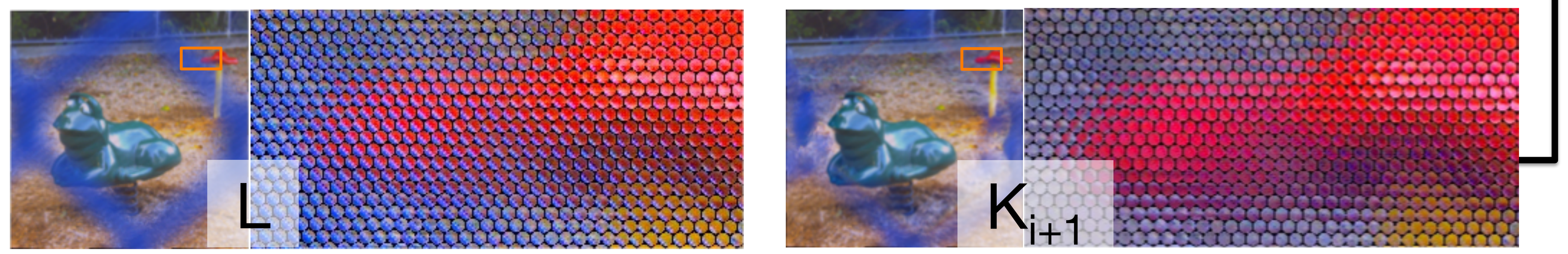


Solving for $\mathbf{F_i}$ and $\boldsymbol{\alpha_i}$ at each pixel is underconstrained. We iteratively solve for multiple foreground mattes, each with a constant foreground color, layered on top of each other with spatially varying alpha. Intermediate composite results $\mathbf{C_{i,0}}\ldots\mathbf{C_{i,m}}$ build layer-by-layer from $\mathbf{B_i}$ to **C**.



③ Improve estimate of background light field $\mathbf{K_{i+1}}$

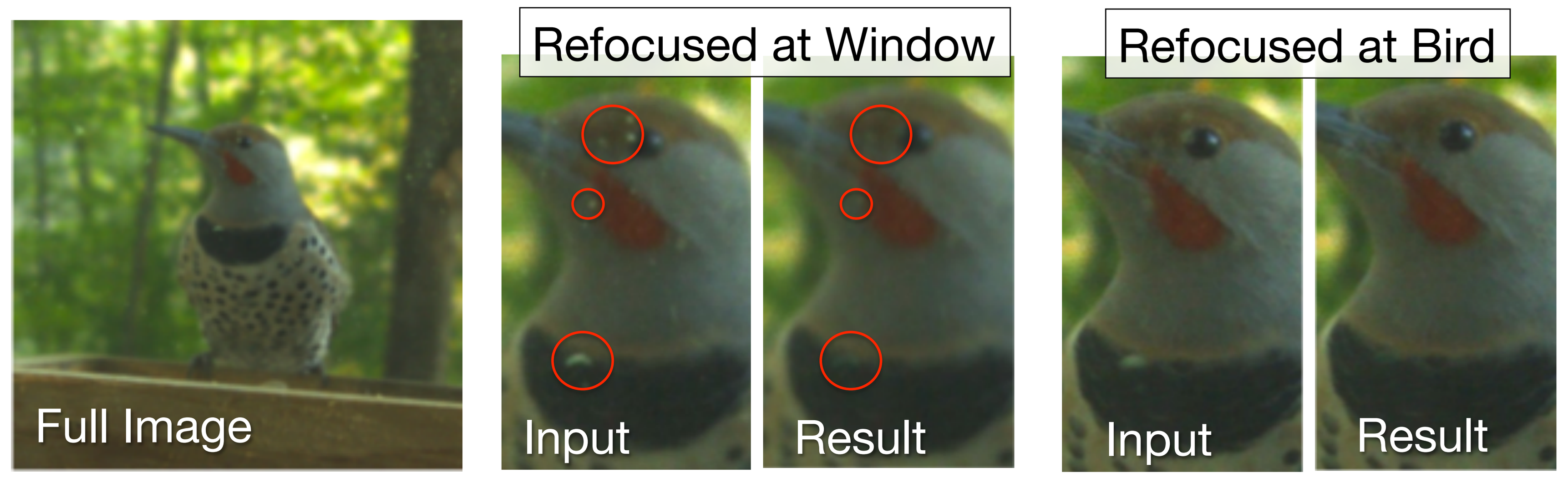
Decomposite to remove the influence of **F** from **L.** For highly occluded rays, blend the result with $\mathbf{K_i}$ and interpolated values from nearby rays.



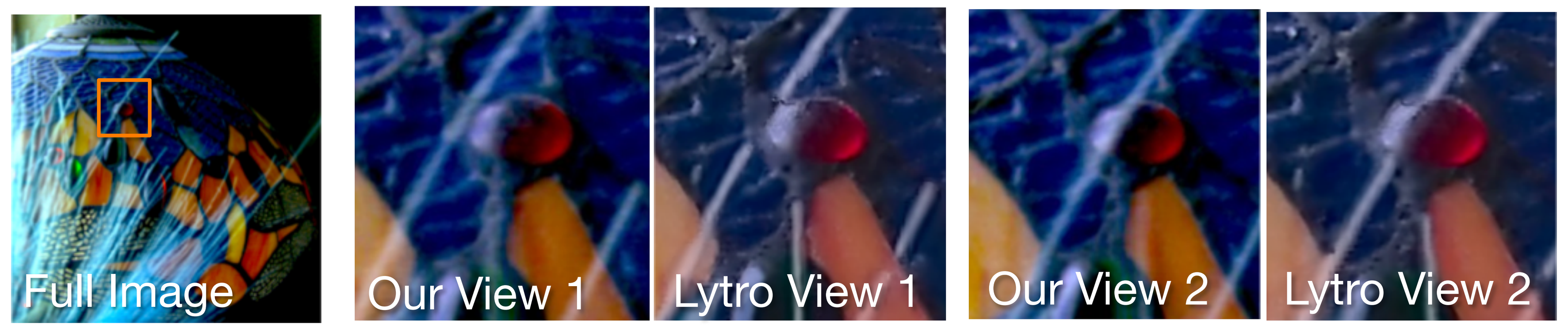
iterate

Applications and Results with Lytro Images

Foreground Occluder Removal: In this example, a bird is photographed behind a dusty window. We remove the dust.



Novel View Rendering: Depth estimation algorithms often have errors near thin, blurred, or translucent occluders. These errors lead to break and tears in the foreground when rendering novel views. Our method separately models the foreground and background. By compositing the shifted foreground over the shifted background, we avoid these artifacts. We compare to Lytro Perspective Shift.



http://grail.cs.washington.edu/projects/lflm/