Possion Matting

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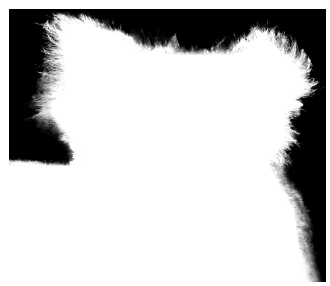
Outline

- What is Image Matting?
- Related Work
- Poisson Matting
  - Global Matting
  - Local Matting
- Results

Original Koala

High Quality Poisson Matte

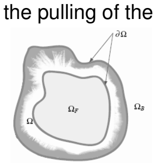


Extracted Koala with blue background

Composite Koala

What is Image Matting?

- Model an Image as a blend of foreground and background
  - $I_{x,y}=\alpha_{x,y}F_{x,y}+(1-\alpha_{x,y})B_{x,y}$
  - Finding α, F and B from I is the pulling of the matte problem
    - Under constained
    - Trimap
      - Definite foreground
      - Definite background
      - Unkown

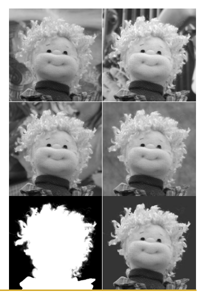


Related Work

- Color statistics
  - Ruzon and Tomasi 2000
    - Un-oriented Gaussians
  - Berman et al. 2000, Knockout
    - Weighted average of perimeter pixels.
  - Hillman et al. 2001
    - PCA
  - Chuang et al. 2001, Bayesian Matting
    - Maximum a posterior on oriented Gaussian clusters
    - Previous best

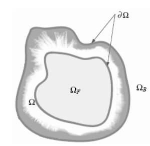
Related Work

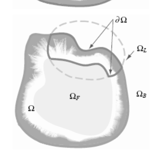
- Other Techniques
  - Smith and Blinn 1996
    - Triangulation using 2 images with different known backgrounds
  - Qian and Sezan 1999, Difference Matting
    - 2 images, one with and one without the background
  - Chuang et al. 2002, Video matting
    - Bayesian matting using optical flow to propagate the trimap between frames



Related Work

- Lessons learned
  - A human needs to be in the loop
    - Manual tweaking key to matting performance
      - Rich set of controls required
  - Color Statistics
    - Error-prone in complex scenes
    - No local/manual refinement





Poisson Matting

1. Estimate the gradient of the matte [Mitsunaga et al. 1995]

$$I=\alpha F+(1-\alpha)B$$

$$\nabla I=(F-B)\nabla\alpha+\alpha\nabla F+(1-\alpha)\nabla B$$

If F and B are smooth, i.e ∇F & ∇B are small, then

$$(F-B)\nabla\alpha >> \alpha\nabla F+(1-\alpha)\nabla B$$

$$\nabla\alpha\approx\frac{1}{F-B}\nabla I$$

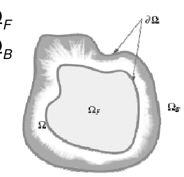
$$\alpha^{*}=\arg\min_{\alpha}\iint_{p\in\Omega}\left\|\nabla\alpha_p-\frac{1}{F_p-B_p}\nabla I_p\right\|^2 dp \qquad \alpha_p|_{\partial\Omega}=\begin{cases}1 & p\in\Omega_F\\ 0 & p\in\Omega_B\end{cases}$$

2. Solve the associated Poisson equation.

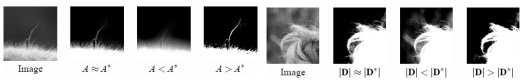
$$\Delta\alpha=div\left(\frac{\nabla I}{F-B}\right)$$

Global Poisson Matching

1. Approximate (*F-B*) using nearest Ω_F and Ω_B
2. Gaussian smooth the (*F-B*) image
3. Reconstruct α using the Poisson equation
4. Add all pixels with $\alpha > 0.95$ to Ω_F
5. Add all pixels with $\alpha < 0.05$ to Ω_B
6. Repeat until
   1. Convergence of α
   2. No pixels added to Ω_F or Ω_B



Local Poisson Matting

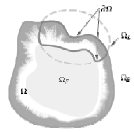


$$\nabla I = (F - B)\nabla\alpha + \alpha\nabla F + (1-\alpha)\nabla B$$

$$A = \frac{1}{F - B}$$

$$\mathbf{D} = \alpha\nabla F + (1-\alpha)\nabla B$$

$$\nabla\alpha = A(\nabla I - \mathbf{D})$$



$$\alpha^* = \arg\min_{\alpha} \iint_{p\in\Omega_L\cap\Omega} \left\| \nabla\alpha_p - \frac{1}{F_p - B_p}(\nabla I_p - D_p) \right\|^2 dp \qquad \alpha_p|_{\partial\Omega} = \begin{cases} 1 & p\in\Omega_F \\ 0 & p\in\Omega_B \\ \alpha_{global} & p\in\Omega \end{cases}$$

Local Operators

1. Channel Selection
   - Optional: Diffusion filtering
2. High-pass filtering
3. Boosting Brush
4. Clone Brush

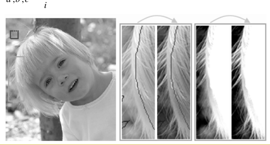
- Optional
  - Erase Brush
    - Remove unwanted alpha matt directly
  - Inverse Brush
    - Inverse the sign of the matt gradient

1: Channel selection

- Goal is to create a new channel $I^* = \mathbf{w} \cdot \mathbf{I}^T$ that minimizes background or foreground variation

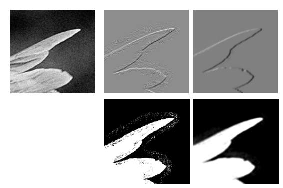
1. User selects color samples, local operator region
2. Minimize sample variation

$$\min_{a,b,c} \sum_i \left(\mathbf{w}\cdot\mathbf{I}^T - \mathbf{w}\cdot\overline{\mathbf{I}}^T \right)^2 \quad s.t.\ w_R + w_G + w_B = 1$$



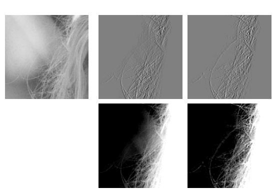
1-1: Diffusion Filtering

- ∇I is sensitive to JPEG blocking and noise
- Filter I with anisotropic diffusion then recompute ∇I
- Useful for hard edges



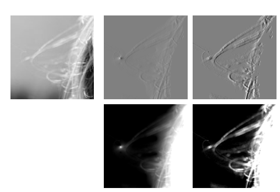
2: High-pass Filter

- Estimates D with a lowpass filter $\mathbf{D} = K * \nabla I$
- Synergistic with channel selection $K = N(p; p_0, \sigma^2)$



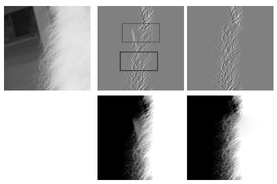
3: Boosting brush

- Directly increase or decrease *A*



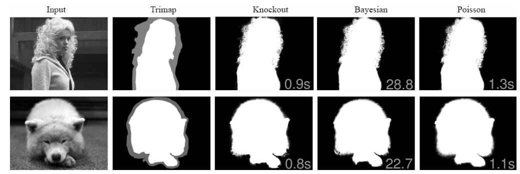
4: Clone Brush

- Directly copy the matt gradient $A(\nabla I - \mathbf{D})$
- For when the gradients are indistinguishable

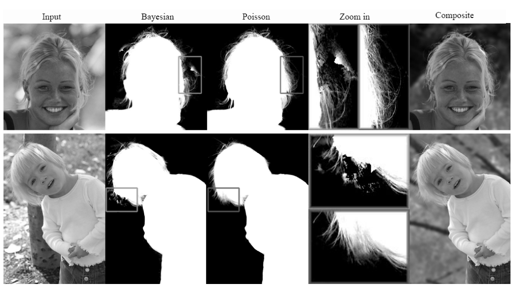


Results

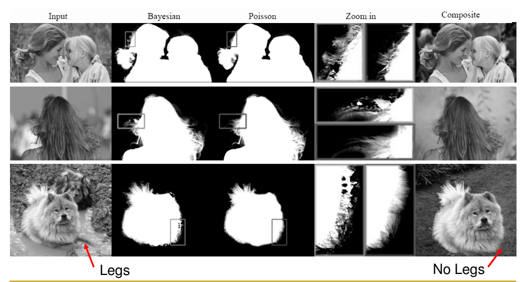
- ~7-20 local refinements per image
  - <10 minutes total processing time



Results



Results



Applications

- Multi-background
  - Mean image improves results by smoothing *B*
  - Backgrounds don't have to be known

Applications

- Defogging

$$I = I_{Clear} e^{-\beta d} + Fog\left(1 - e^{-\beta d}\right)$$

$$\nabla I_{Clear} = \nabla I e^{-\beta d}$$

  - β is the scatter coefficient
  - d is the depth value
  - Local refinement of $e^{-\beta d}$ using the boosting brush
  - Model from Narasimhan and Nayar 2003

Defogging

Defogging

Video

Questions?