

Poisson Matting (ID:25)

Team: MADE ONLINE
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<https://github.com/Digital-Image-Processing-IIITH/project-made-online>

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- 1) Global Matting
- 2) Local Matting
 - a) Boosting Brush
 - b) Clone Brush
 - c) High Pass
 - d) Diffusion Filtering
- 3) Applications
 - a) Multi Background

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GOALS

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- Matting for natural images in complex scenes by calculating the gradient of matte from image.
- Solving Poisson equation.
- Integrating user's knowledge and calculating matte in semi-supervised way(global and local matting)

IMAGE MATTING

Image matting involves the following steps:

1. Image matting in our setting refers to foreground extraction from any given image.
2. A new image can be blended from a background image and foreground image with its "alpha matte".
3. $I(x,y) = \alpha(x, y)F(x, y) + (1 - \alpha(x,y))B(x, y)$
where F is the foreground, B is the new background and α is the matte calculated

In natural image matting: α , F and B need to be estimated.

GLOBAL MATTING

STEPS INVOLVED

Global matting involves the following steps:

1. Find approximate foreground and background using an alpha.
2. Find the Poisson Equation for this image.

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

where, $\Delta = \left(\frac{\partial^2}{\partial x^2}, \frac{\partial^2}{\partial y^2} \right)$ is Laplacian Operator and div is divergence operator

STEPS INVOLVED

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3. Apply the following Gauss Siedel Iteration to find a good approximate for alpha.

Given,

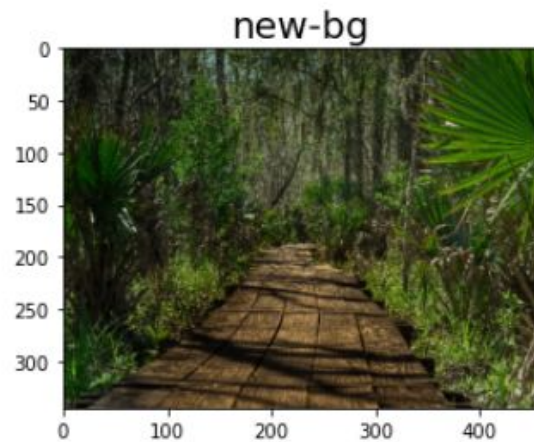
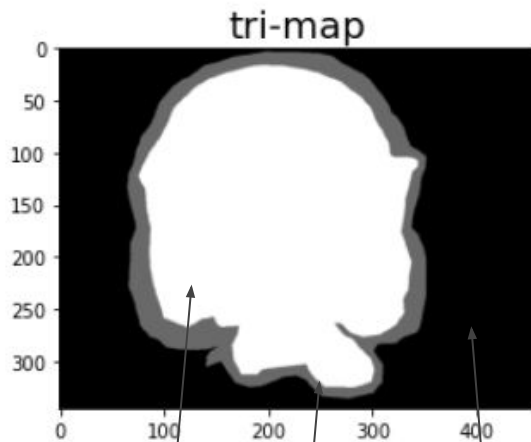
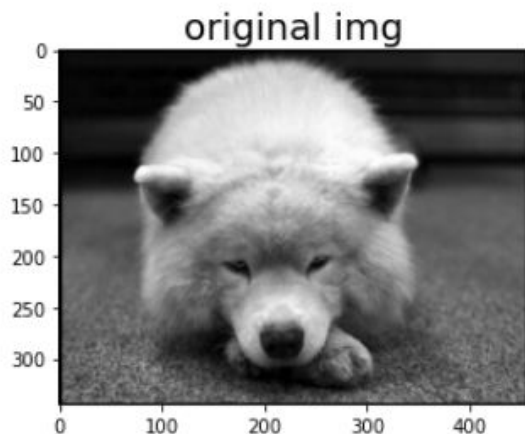
$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = S$$

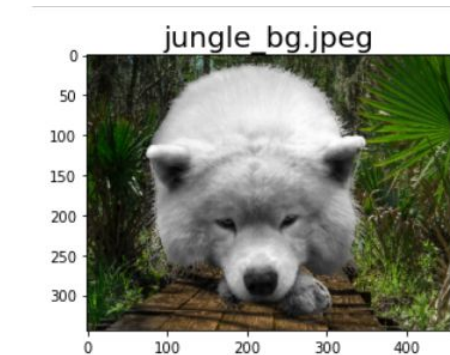
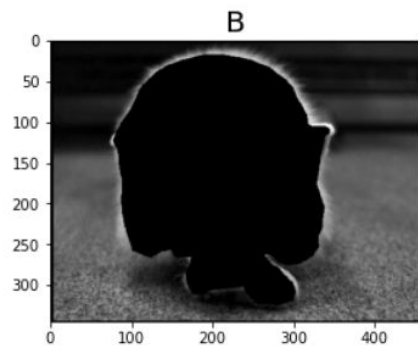
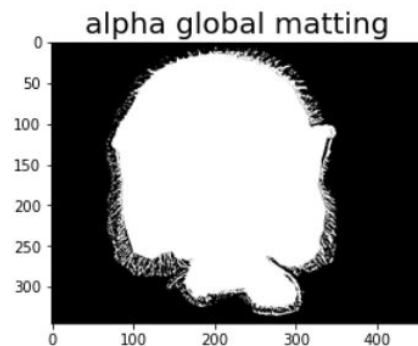
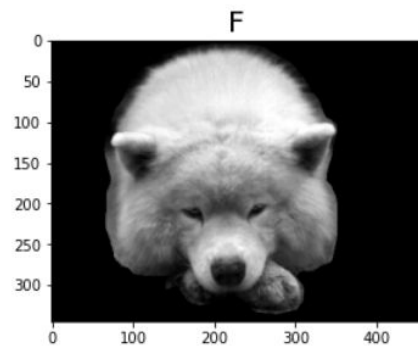
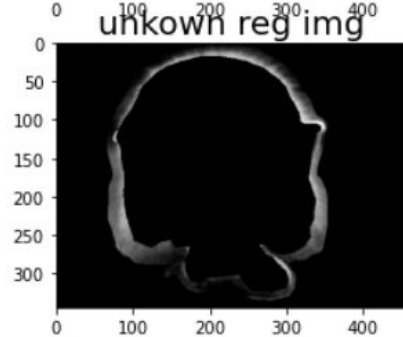
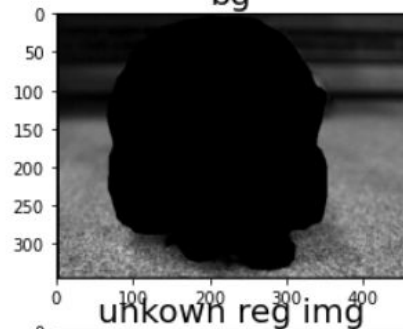
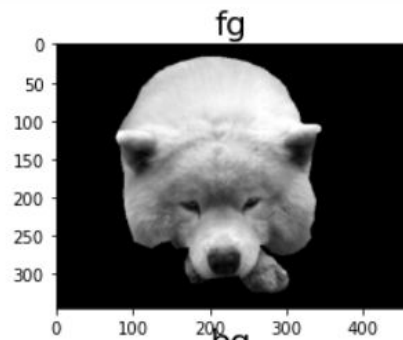
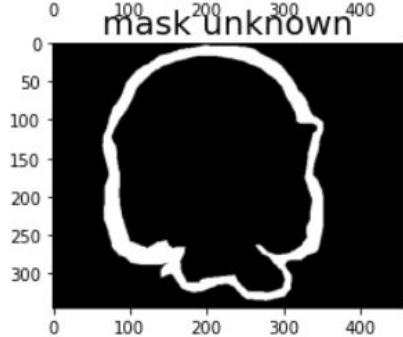
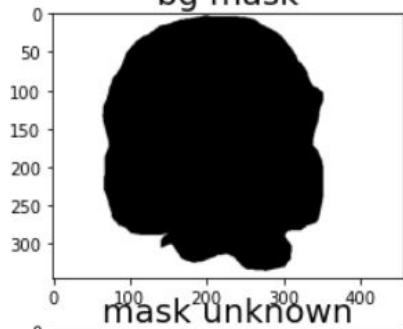
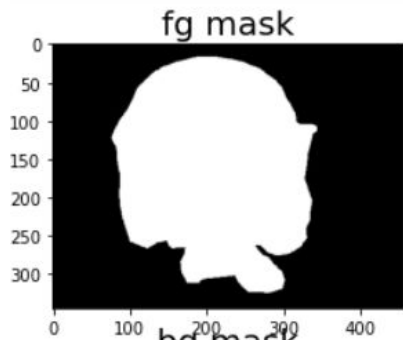
$$f_{i,j}^{(n+1)} = \frac{\beta}{4}(f_{i+1,j}^{(n)} + f_{i-1,j}^{(n+1)}) + f_{i,j+1}^{(n)} + f_{i,j-1}^{(n+1)} - S_{i,j} + (1 - \beta)f_{i,j}^{(n)}$$

where, β lies in the range (1,2)

4. Use this alpha to get the final new image.

Working of global matting (inputs)





working of Global matting
(Outputs)



Image



Trimap



Estimate
Matte



New
Background



Image with
new bg



Image



Trimap



Estimate
Matte



New
Background



Image with
new bg



Image



Trimap



Estimate
Matte



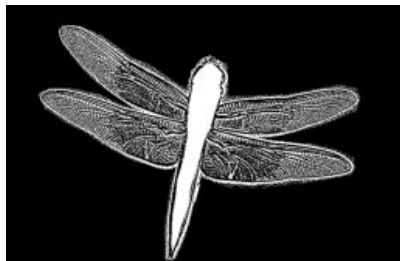
New
Background



Image with
new bg



Image



Estimate
Matte



New
Background



Image with
new bg



Trimap

LOCAL MATTING

Poisson Matting in Local Region

- To refine the result of poisson matting, the user can select regions to improve the matte.
- This is needed when the background/foreground is complex and the assumption $\alpha \nabla F + (1 - \alpha) \nabla B \approx 0$ fails.
- Hence now we have to solve this new poisson equation

$$\nabla \alpha = \frac{1}{F - B} (\nabla I - \alpha \nabla F - (1 - \alpha) \nabla B)$$

Where F and B are initial foreground and background image and α is alpha estimated from global matting.

Local Matting by solving Poisson equation

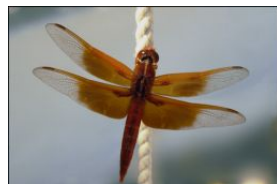
- Above equation can be written as $\nabla\alpha = A(\nabla I - D)$
- This solves to the following.

$$\Delta\alpha \approx \text{div}(A(\nabla I - D)) \quad \text{s.t. } \alpha|_{\partial\Omega} = \begin{cases} 1 & \mathbf{x} \in \Omega_F \\ 0 & \mathbf{x} \in \Omega_B \\ \alpha_g & \mathbf{x} \in \Omega \cap \Omega_L \end{cases}$$

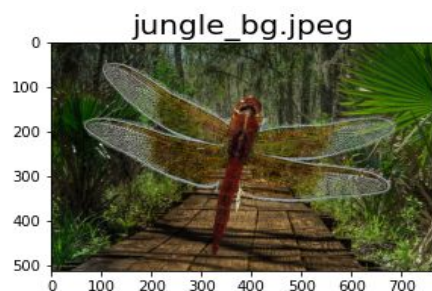
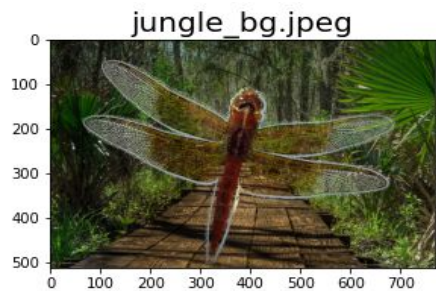
- This can be solved using similar to that of global matting.



Global Matting

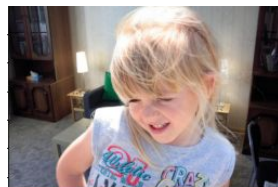


Local Matting

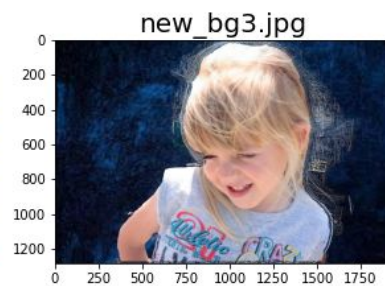
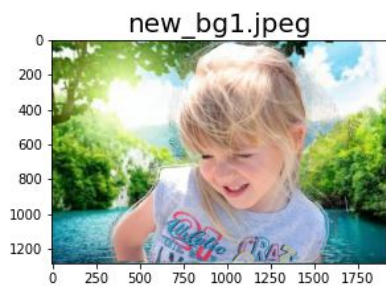
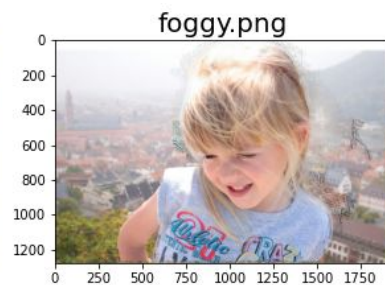
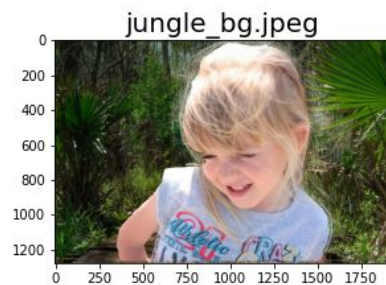
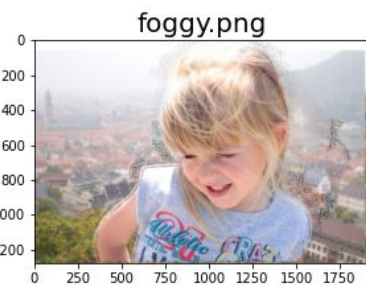
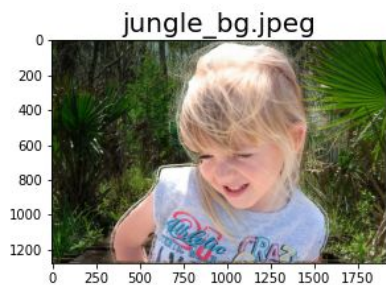




Global Matting



Local Matting





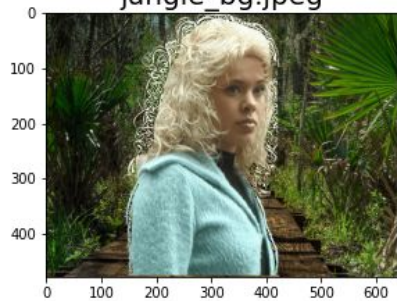
Global Matting



Local Matting



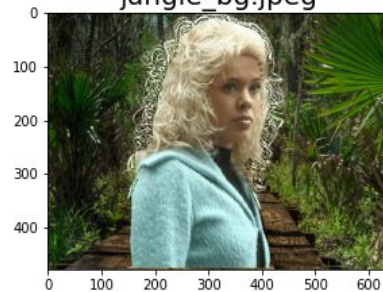
jungle_bg.jpeg



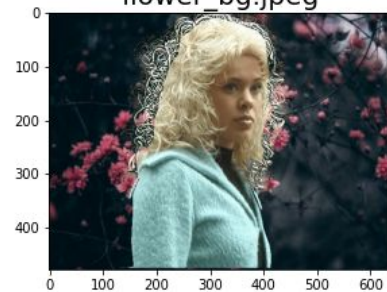
flower_bg.jpeg



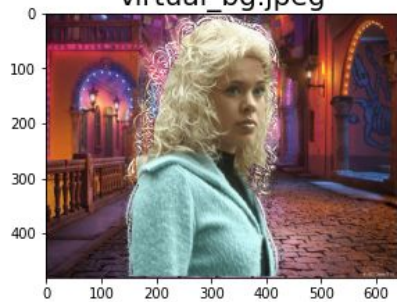
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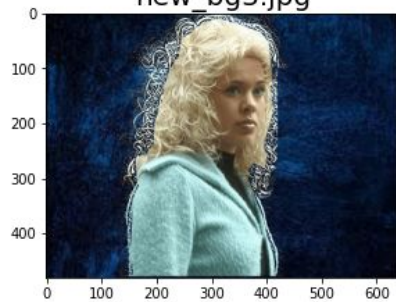
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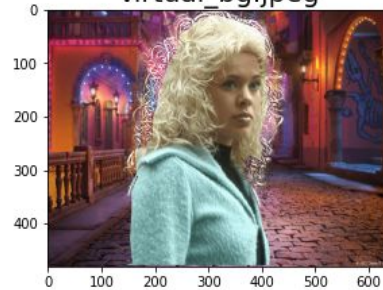
virtual_bg.jpeg



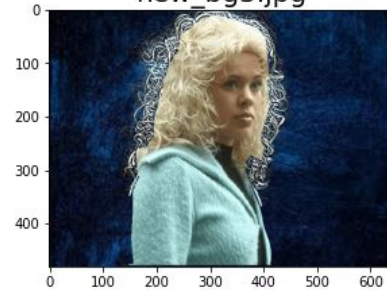
new_bg3.jpg



virtual_bg.jpeg



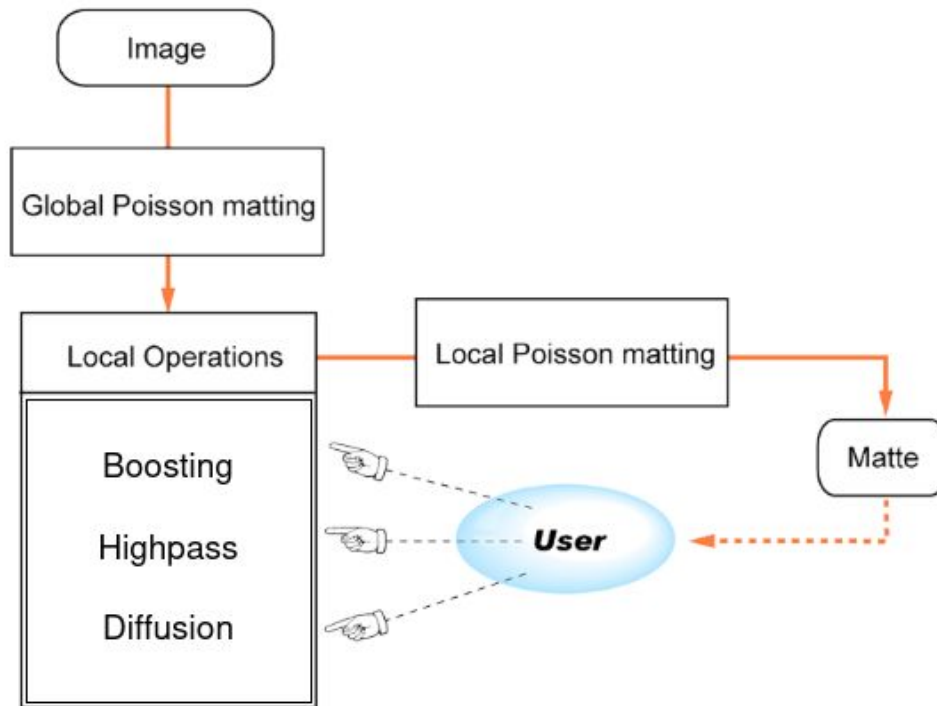
new_bg3.jpg



Local Operations: Refinement

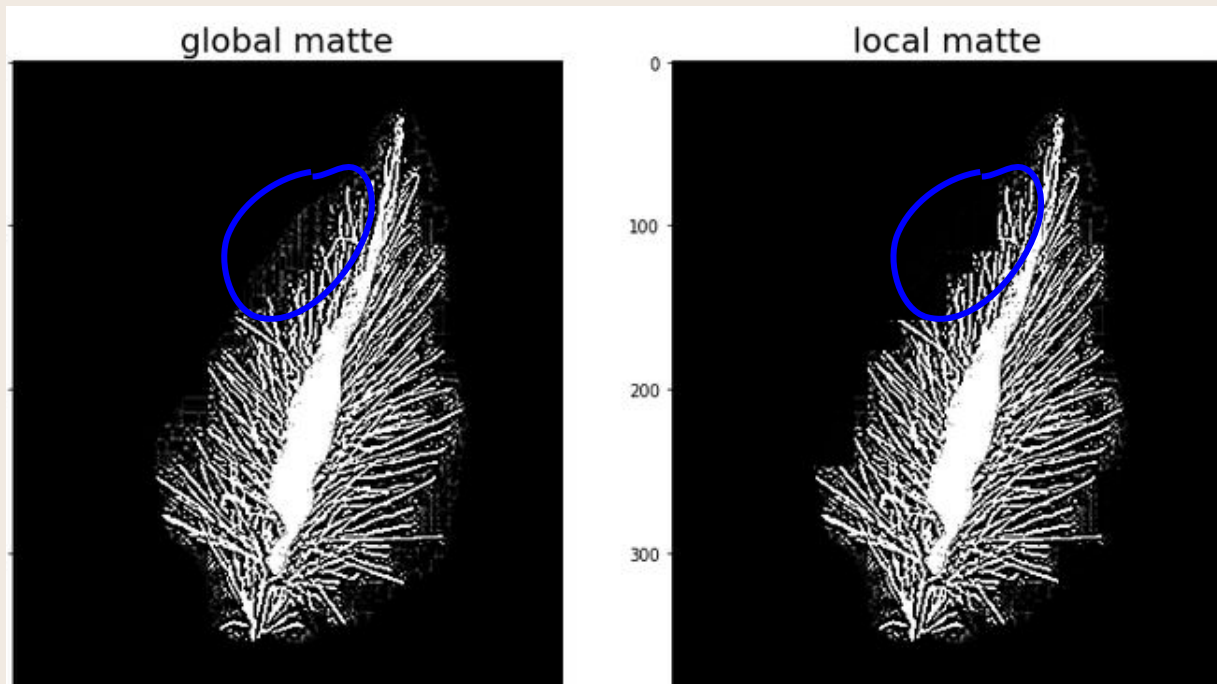
We have implemented the Local Filtering Operations to improve the matte:

- Diffusion (remove noise)
- Highpass (get ~D)
- Boosting (manipulate A)



Diffusion filtering

Since the image gradient is sensitive to noise, hence anisotropic diffusion is applied on images whenever required [Perona and Malik, 1990] to diffuse image. Then this diffuse image is used for any further local matting.



High-pass filtering

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The channel selection operation generates a smooth background or foreground, leading to low frequency gradients. Therefore, D is be estimated using the low-frequency parts of the image gradient:

$$\mathbf{D} = K * \nabla I$$

where $K = N(p; p_0, \sigma^2)$ is a Gaussian filter centered at pixel p_0 and $*$ is the convolution operator.

The matte is estimates as: $\nabla \alpha = A(\nabla I - K * \nabla I)$,

where $(\nabla I - K * \nabla I)$ corresponds to a high-pass filter.

Boosting brush

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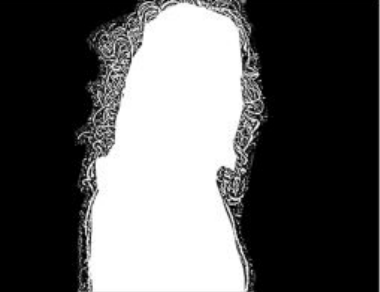
It smoothes or sharpens the matte by increasing/decreasing A .

It is modifies the Area A_p to A'_p as:

$$A'_p = [1 + \lambda \exp(-\frac{\|p - p_0\|^2}{2\sigma^2})] \cdot A_p$$

where p_0 is the coordinate of the brush center,

σ and λ are user defined parameters which control the size and strength of the boosting.



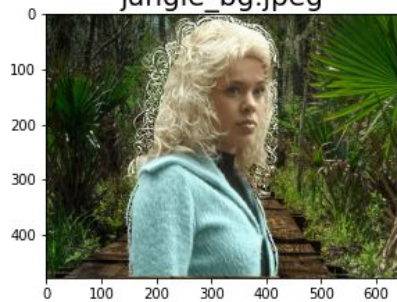
Global Matting



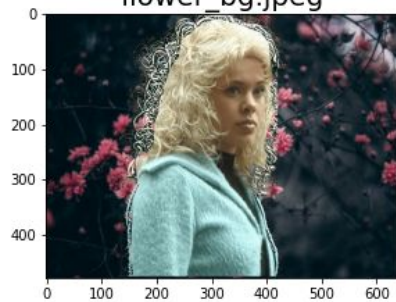
Refinement



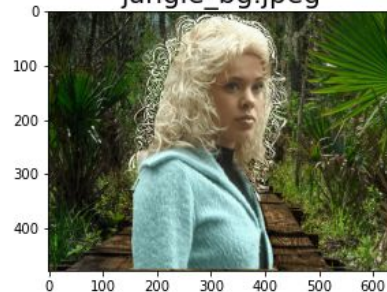
jungle_bg.jpeg



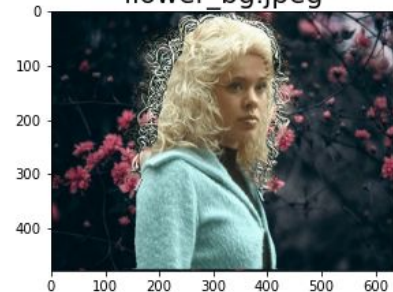
flower_bg.jpeg



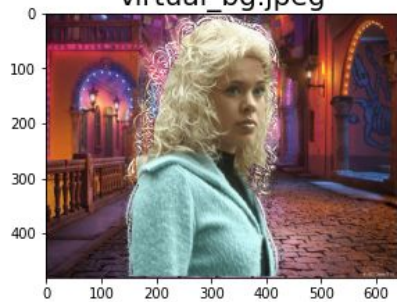
jungle_bg.jpeg



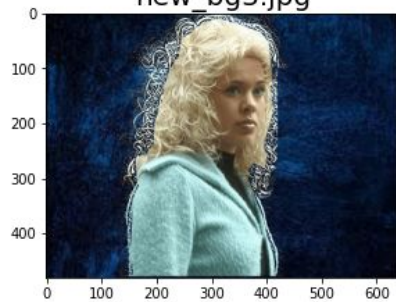
flower_bg.jpeg



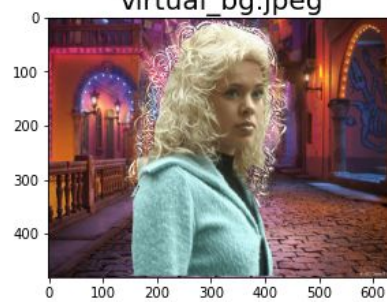
virtual_bg.jpeg



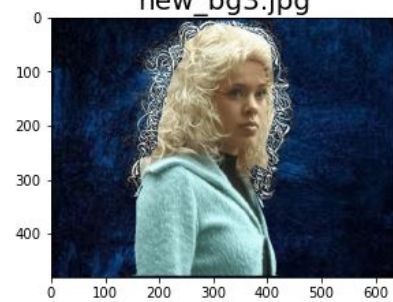
new_bg3.jpg



virtual_bg.jpeg



new_bg3.jpg

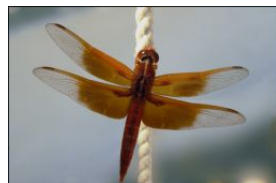




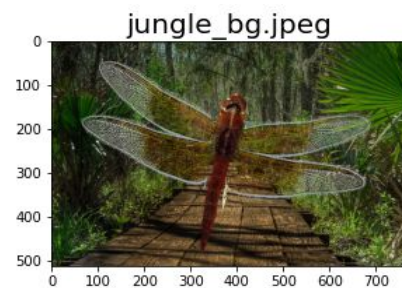
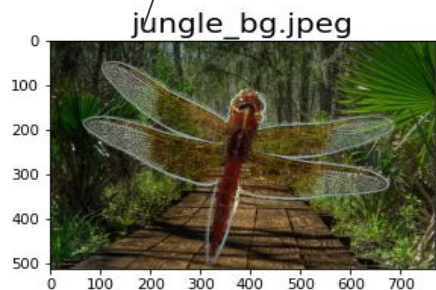
Global matting vs Refinement



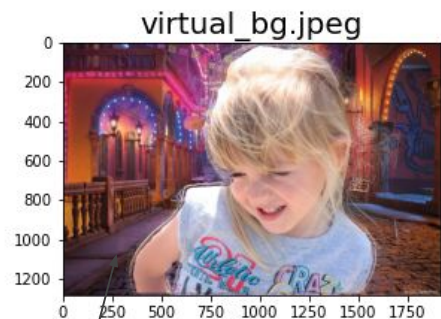
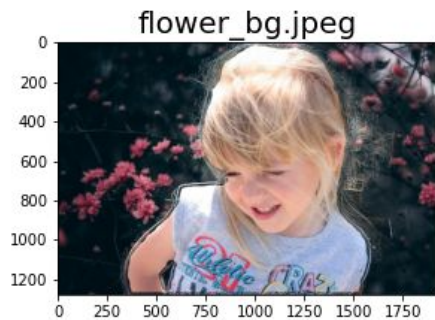
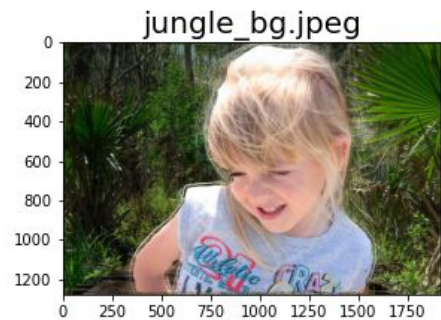
Global Matting



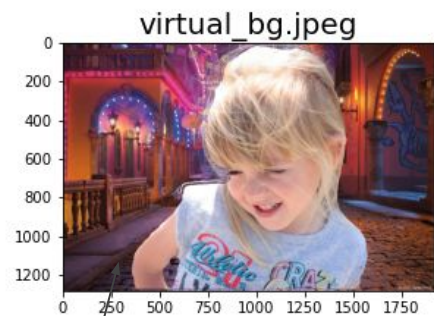
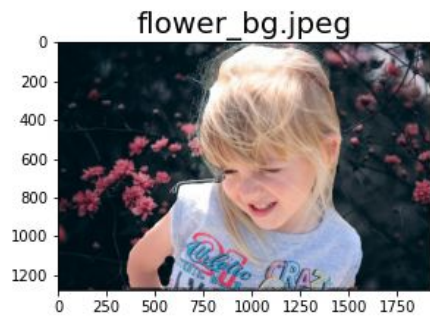
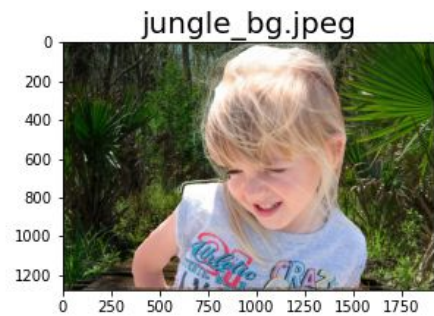
Refinement



global matting results



refined matting results



APPLICATIONS

Multi-Background

When a user has multiple images with **same foreground** but **different background** multi-background method can be used to obtain matte.

- Involves finding mean image
- Matte of mean image

Core idea: foreground is same in all images, mean of extracted backgrounds is calculated, Foreground and background are merged to produce **mean-image** which is used to calculate matte.

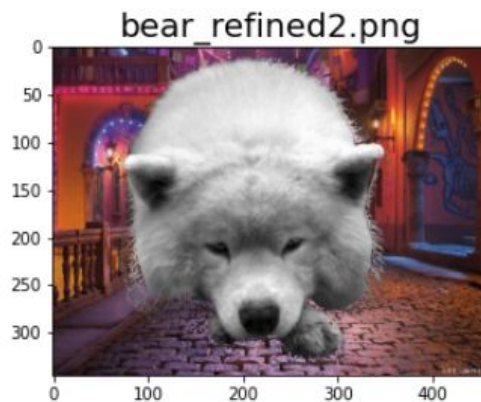
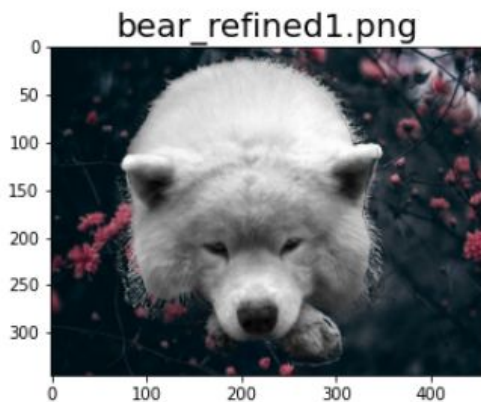
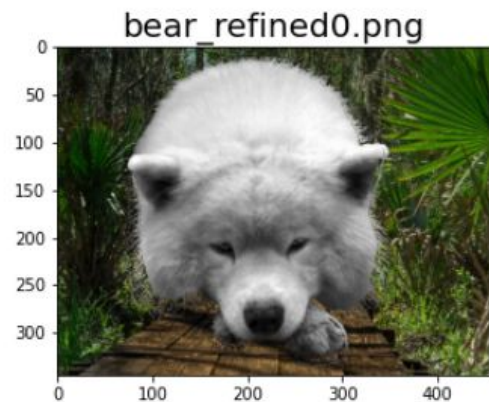
Multi-Background

Poisson matting when multiple images with same foreground but different background gives better result on mean image which is given

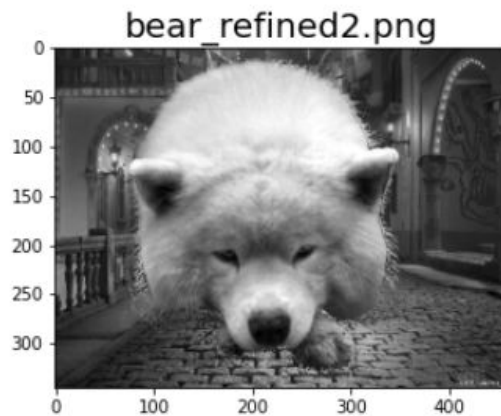
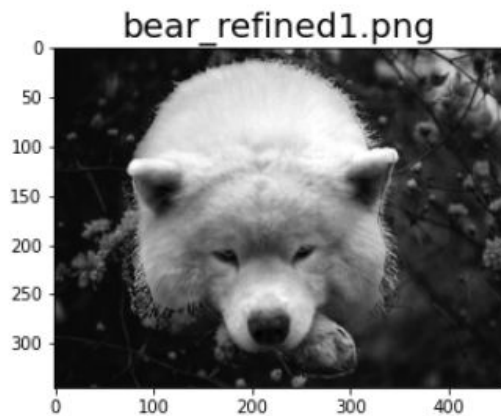
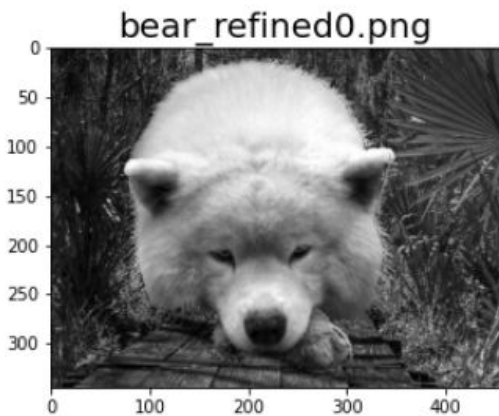
$$\bar{I} = \frac{1}{T} \sum_t^T (\alpha F + (1 - \alpha) B_t) = \alpha F + (1 - \alpha) \bar{B}$$

where, T is number of images, alpha is estimated matte of one image, F is estimated foreground, B_t : estimated background, \bar{B} is mean bg.

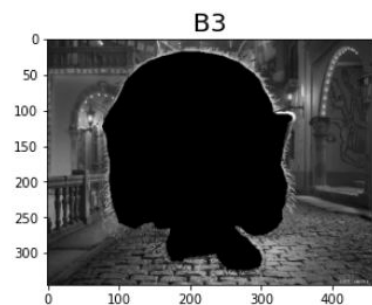
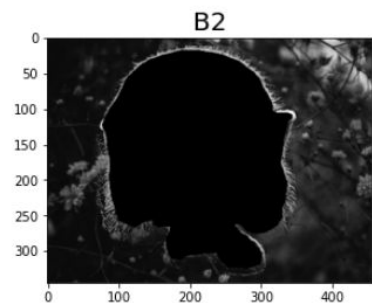
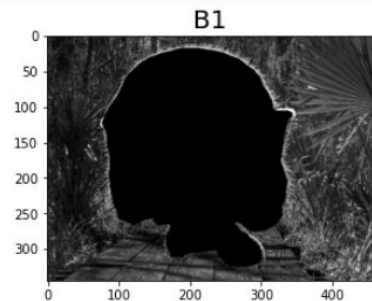
Mean-bg (input images)



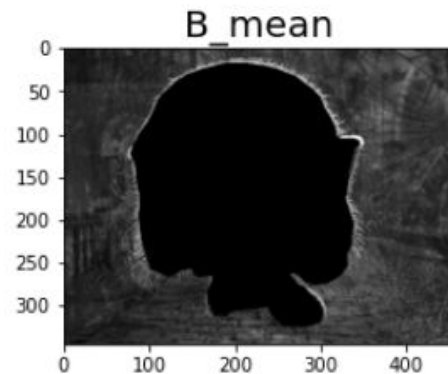
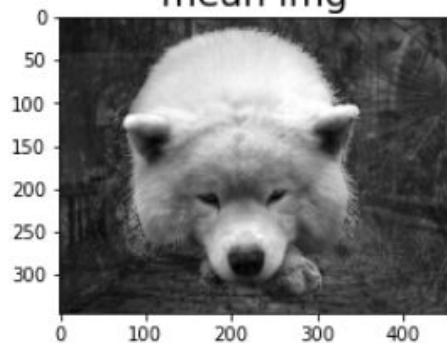
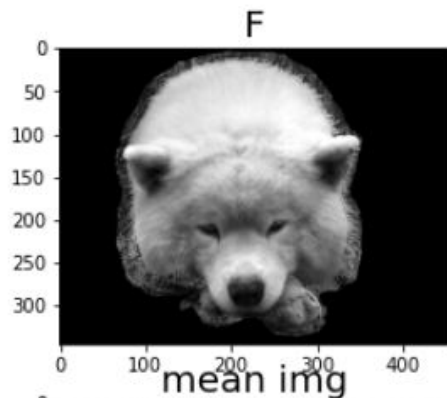
RGB images



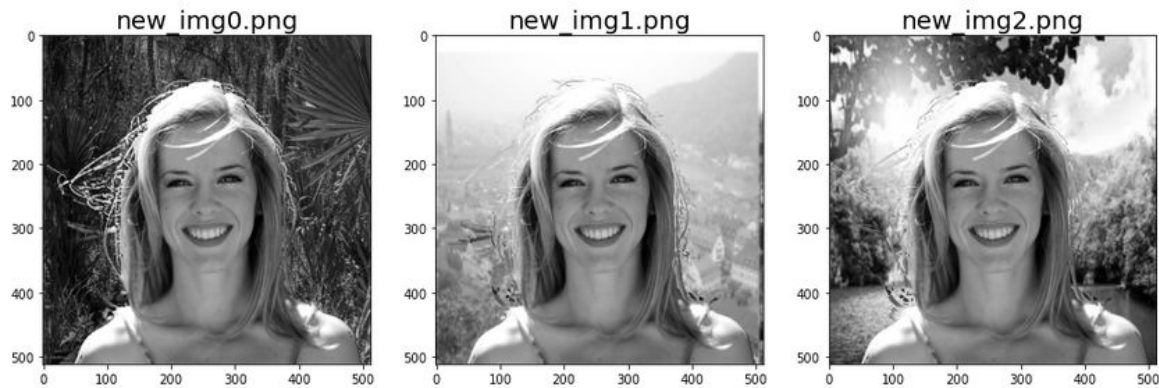
**corresponding
gray-scale
images**



Extracted
backgrounds

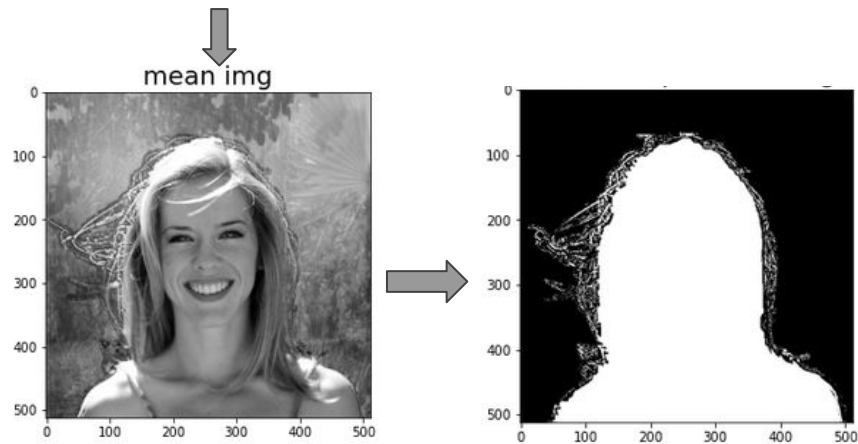


Notice: the **mean image**, is combination of gray-scale input images



<- Input
images

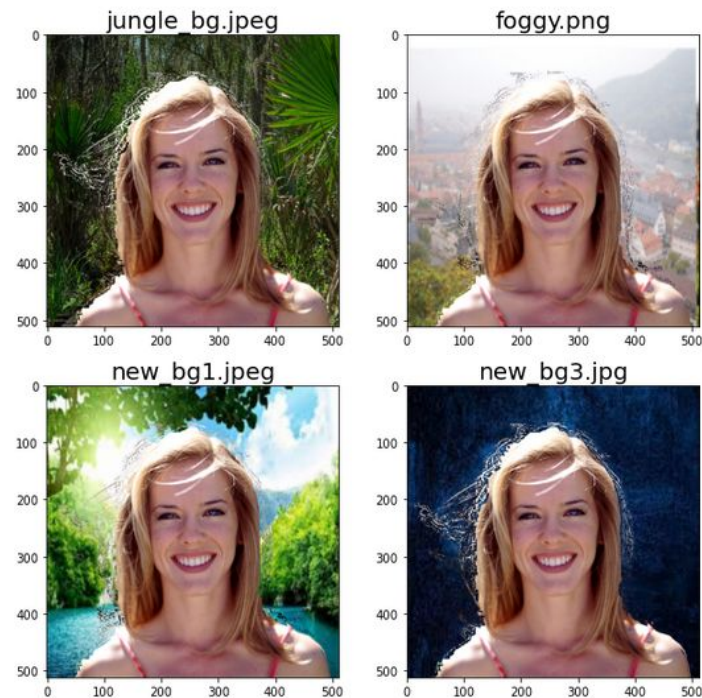
Output images on new bg



Mean gray image

Matte

Notice: the density and
volume of hair reduces



Work Division

— — —

NAME	PARTS ASSIGNED
Ansh Puvvada	Global Matting, Fine Tuning of Mattes
Avani Gupta	Boosting brush, Refinement of mattes, Multi-Bg, Fine Tuning of Mattes
Jayati Narang	Local Matting, Diffusion filtering, Fine Tuning of Mattes
Kajal Sanklecha	

A pink polka-dot pattern consisting of a grid of small, solid pink circles on a slightly darker pink background, located in the top right corner of the slide.

Demo Time!

THANK YOU

