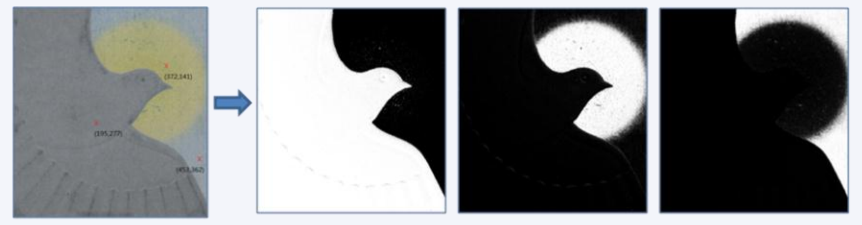
KNN Matting

Qifeng Chen, Dingzeyu Li, Chi-Keung Tang
{cs_cqx, dli}@stu.ust.hk, cktang@cse.ust.hk
The Hong Kong University of Science and Technology

Introduction

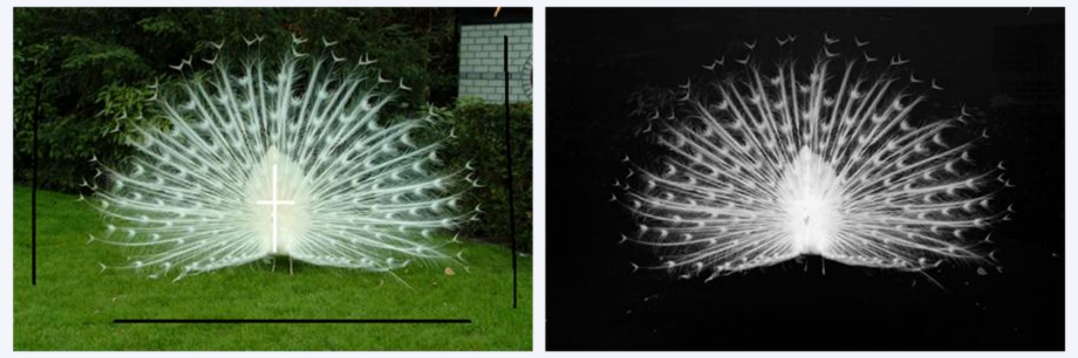
$$I = \sum_{i=1}^{n} \alpha_i F_i \qquad \sum_{i=1}^{n} \alpha_i = 1$$

We are interested in a general alpha matting approach for the simultaneous extraction of multiple image layers; each layer may have disjoint segments for material matting not limited to foreground mattes typical of natural image matting. The estimated alphas also satisfy the summation constraint.



I α_1 α_2 α_3

Challenge Given sparse user scribbles on each layer, how can we extract the alpha matte of each layer from an image?



User Scribbles KNN Matting Result

Methodology

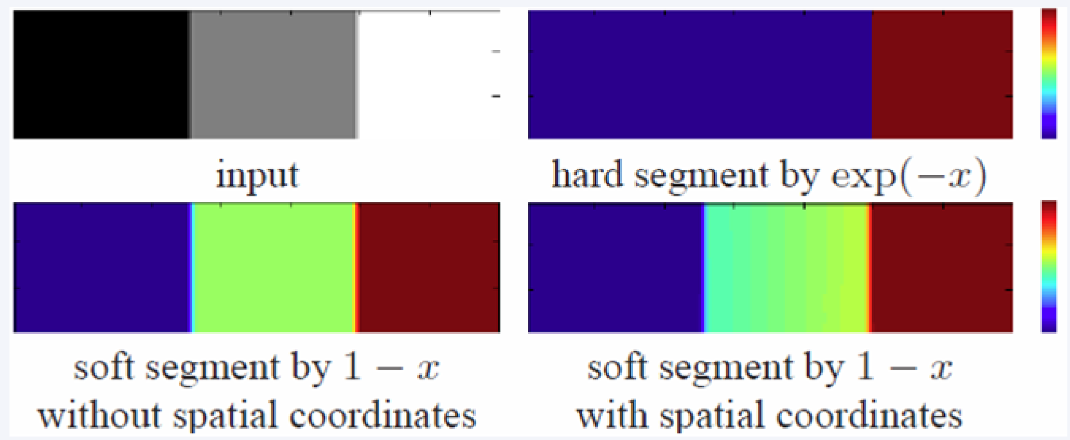
Observation If two pixels have similar colors or their locations are close, then their alpha values tend to be similar.

Combine the color and location

Represent pixels as feature vectors

(R,G,B, x,y) In RGB space or (cos(h),sin(h),s,v, x,y) In HSV space

Kernel We propose a new linear function to better capture the affinity between two pixels.



$$k(i,j) = 1 - \frac{||X(i)-X(j)||}{C} \qquad \cancel{k(i,j) = \exp(-\frac{1}{h_1^2}||X(i)-X(j)||_g^2 - \frac{1}{h_2^2}d_{ij}^2)}$$

Sparse Affinity Matrix A For each pixel i, we find its K nearest neighbors (KNN) j in the feature space and set A(i,j) as k(i,j) while others remain zero.

Objective Function $\boldsymbol{L} \stackrel{\text{def}}{=}$ Laplacian matrix of $\boldsymbol{A}$, $\boldsymbol{D} \stackrel{\text{def}}{=} \text{diag}(\boldsymbol{m})$, $\boldsymbol{v} \stackrel{\text{def}}{=}$ scribbles on current layer, $\boldsymbol{m} \stackrel{\text{def}}{=}$ scribbles on all layers.

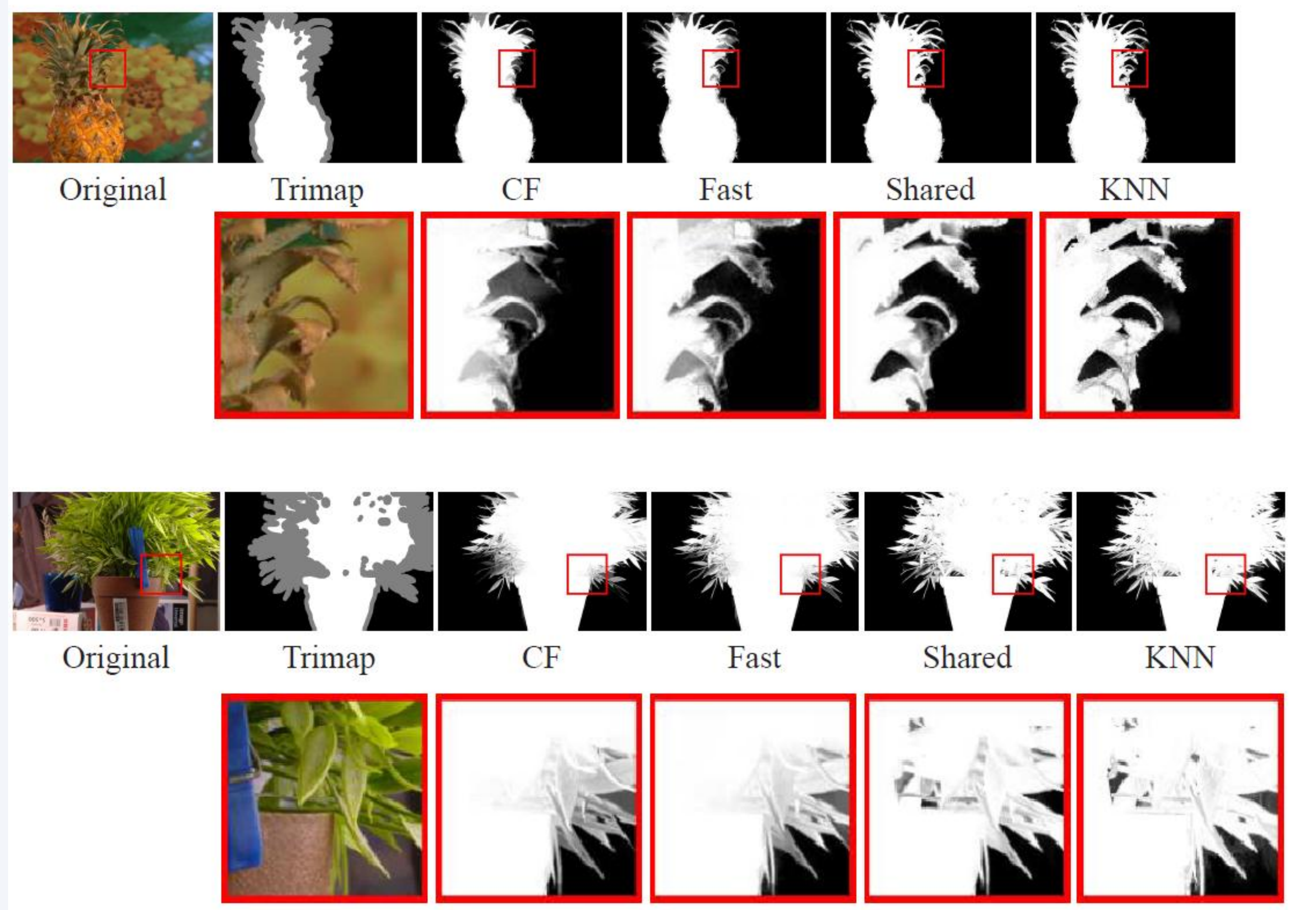
$$E(x) = \sum_i \sum_j A_{i,j}(x_i - x_j)^2 + \lambda \sum_{i \in m-v} x_i^2 + \lambda \sum_{i \in v} (1-x_i)^2$$

$$x^* = (L + \lambda D)^{-1}(\lambda v) \Leftrightarrow (L + \lambda D)x^* = \lambda v$$

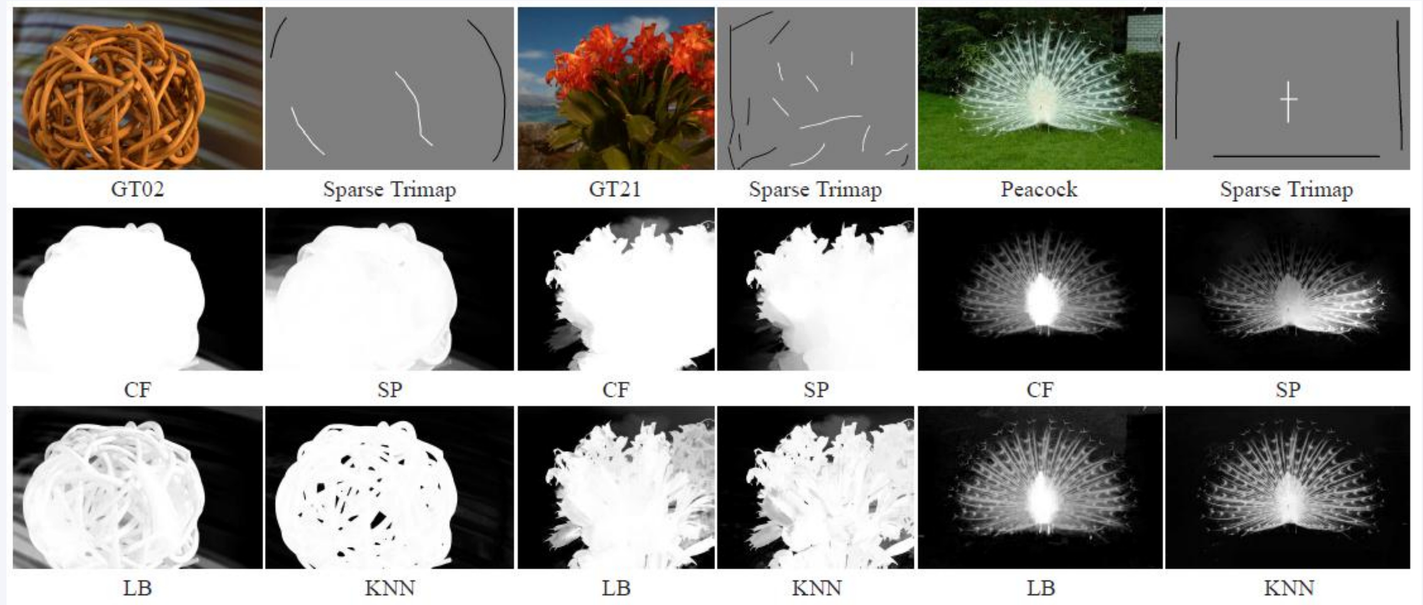
The optimal solution can be found efficiently by *preconditioned conjugate gradient* method.

Result and Application

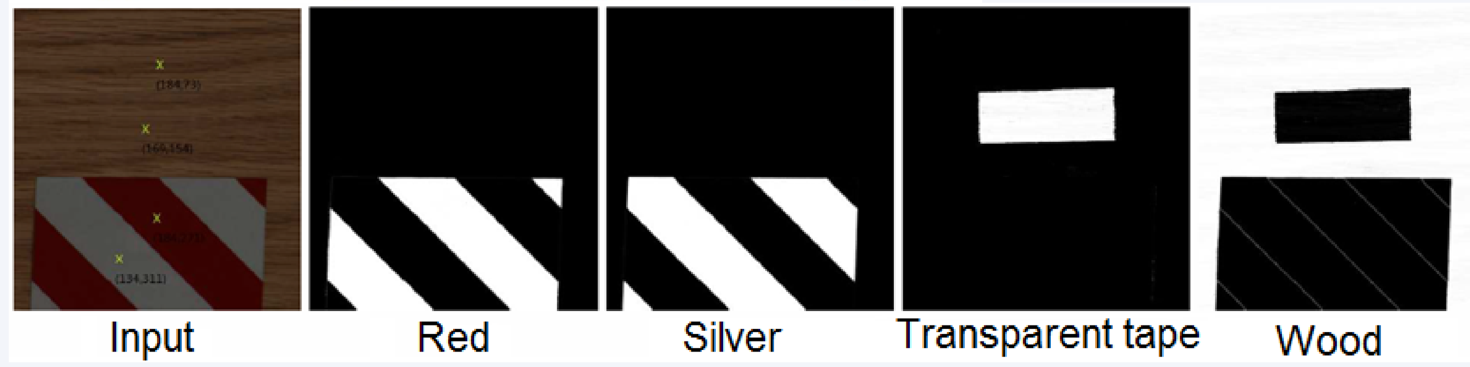
Natural Image Matting Comparison:



Sparse Input Comparison:



Material Matting Result:

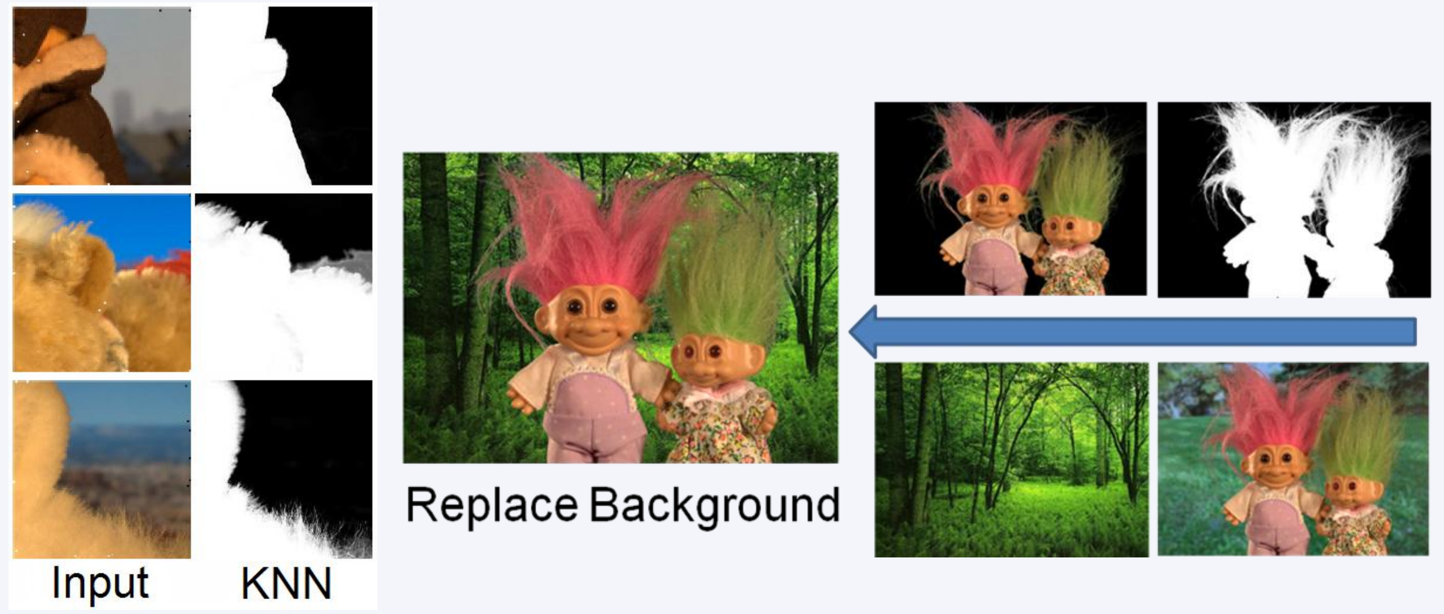


Overall Ranking on MSE

Name	Rank	Score	Name	Rank	Score
Shared Matting	1	3.6	Robust Matting	9	7.5
Segmentation-based Matting	2	4.2	High-res Matting	10	8.5
KNN Matting	3	4.3	Iterative BP Matting	11	11.4
Improved Color Matting	4	4.4	Random Walk Matting	12	11.5
Learning Based Matting	5	5.9	Geodesic Matting	13	12.3
Closed-Form Matting	6	6	Easy Matting	14	13.7
Shared Matting(Real Time)	7	6.1	Bayesian Matting	15	114
Large Kernel Matting	8	6.8	Poisson Matting	16	15.9

Normalized Scores on MSE

Name	Rank	Score	Name	Rank	Score
KNN Matting	1	84.6	Robust Matting	9	55.9
Shared Matting	2	79.6	High-res Matting	10	51.5
Segmentation-based Matting	3	77.2	Iterative BP Matting	11	34.5
Improved Color Matting	4	75.7	Random Walk Matting	12	36
Learning Based Matting	5	67.8	Geodesic Matting	13	25
Closed-Form Matting	6	66.1	Easy Matting	14	21.6
Shared Matting(Real Time)	7	65.4	Bayesian Matting	15	20
Large Kernel Matting	8	62.4	Poisson Matting	16	11



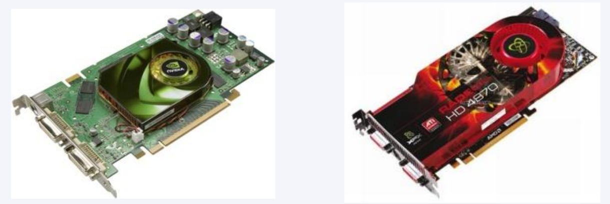
Future Work & Conclusion

Layer Estimation

Estimate the content of each layer, especially at the boundary of each layer, i.e. where $0 < \alpha < 1$.

GPU Acceleration

GPU acceleration can be applied to KNN and preconditioned conjugated gradient method.



Great Improvement

In summary, we propose a novel method to the matting problem with the following improvements:

- simultaneous multiple layer extraction
- feature vector enables KNN matting to handle SVBRDF
- collects nonlocal neighbors globally and efficiently
- demonstrated better performance by using a linear kernel
- leading a simplified solution without the edge problem
- fewer parameters (none in the kernel function)

References

[1] C. Rhemann, C. Rother, J. Wang, M. Gelautz, P. Kohli, and P. Rott. *A perceptually motivated online benchmark for image matting*. In *CVPR*, 2009.

[2] A. Buades, B. Coll, and J.-M. Morel. Nonlocal image and movie denoising. *IJCV*, 76(2):123–139, 2008.

[3] P. Lee and Y. Wu. Nonlocal matting. In *CVPR*, pages 2193–2200, 2011.

[4] A. Levin, D. Lischinski, and Y. Weiss. A closed-form solution to natural image matting. *IEEE TPAMI*, 30(2):228–242, 2008.

Acknowledgement

The research was supported by the Google Faculty Award and the Hong Kong Research Grant Council under grant no 619711