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Translucent Image Recoloring through Homography Estimation Supplementary Material

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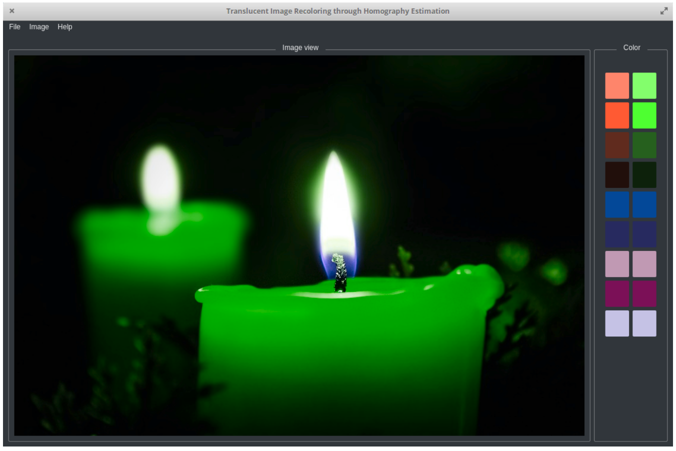


Figure 1: *Main graphic user interface of our recoloring tool. The left panel consists of the image view. The right panel consists of the color view. Users can operate on the color view and preview the result in the image view.*

In this supplementary material, we first present the detailed a-b color value transformation equation in Section 1. Next, we discuss the parameter λ in non-linear optimization in Section 2. In addition, we introduce information visualization recoloring through the proposed method in Section 3. Finally, we show the example questionnaire of one image in Section 5.

1. a-b Color Value Transformation Equation

We define the origin color in the source image as $c = (a,b)$. The target color $c' = (a',b')$ is what we want where f is a function to map c to c' with unknown paramters p. We assume there is a linear relationship between the amount of motion $\Delta c = c' - c$ and the parameters p as follows:

$$\Delta c = c' - c = J(c)p \tag{1}$$

where $J = \frac{\partial f}{\partial p}$ is the Jacobian transformation f with respect to p. We wish to ensure that each color pair (c,c') will be transformed accurately as much as possible. Thus, we need to minimize the total square residuals as the following expression:

$$\begin{aligned} E_{TLS} &= \sum_i^K \|J(c_i)p - \Delta c_i\|_2^2 \\ &= p^T \left[\sum_i J^T(c_i)J(c_i)\right] p - 2p^T \left[\sum_i J^T(c_i)\Delta c_i\right] + \sum_i \|\Delta c_i\|_2^2 \\ &= p^T Ap - 2p^T b + c \end{aligned} \tag{2}$$

By obtaining the minimum, we hypothesize the derivative of E_{TLS} equals zero.

$$\frac{dE_{TLS}}{dp} = 0 \tag{3}$$

Finally, we get the equation,

$$Ap = b \tag{4}$$

where

$$A = \sum_i J^T(c_i)J(c_i) \tag{5}$$

and

$$b = \sum_i J^T(c_i)\Delta c_i \tag{6}$$

. To get the paramters p, we can solve the equation (5) by SVD [GVL96].

2. Parameter λ in Non-linear Optimization

This section discusses the parameter λ ($0 \leq \lambda \leq 1$) in non-linear optimization. First, we test the image of high quality as shown in Fig. 2. All the results with $\lambda = 0.3, 0.5, 0.8$ are satisfactory. Further, we test the noised image as shown in Fig. 3. All the results with $\lambda = 0.3, 0.5, 0.8$ are satisfactory too.

In addition, the result is not sensitive to the parameter λ due to the fact that the colors in the same a-b plane change gradually. The bigger the parameter λ is, the smaller the cost time is. Considering the run time of non-linear optimization and the result, we choose $\lambda = 0.3$ by default.

3. Information Visualization Recoloring

This section presents recoloring the translucent images especially heatmaps in information visualization area. The heatmap is generated by the map background image and the density estimation of the data with a pre-defined opacity α as the following:

$$I_r = \alpha * I_b + (1-\alpha) * I_d \tag{7}$$

where I_b represents the map background image and I_d represents the colored density estimation image with a specific colormap. However, it is very difficult for non-experts to transfer the heatmap image to their preferred colormap. As shown in Fig. 4(a), it is difficult to determine the boundary between the heatmap and the background. We propose to use saliency detection [PKPH12] to detect the heatmap area. After getting the appropriate mask, we recolor the heatmap to another colormap. We can observe that our result is more smoothing than [CFL*15] through the results shown in Fig. 4(e) and Fig. 4(f). To be clear, all results except for Fig. 4 in this paper do not use any masks.

In the last paragraph, we discuss recoloring the heatmap with a mask. This paragraph discusses recoloring the point-based heatmap as shown in Fig. 5. There are a lot of wonderful point-based heatmaps on the Internet. It is almost impossible to run the programming script again to generate another heatmap with different color distributions, especially for the non-experts. We have consulted with three researchers who focus on information visualization. They all comment that the recolored results are satisfactory and it will be of great help for story-tellers to convert the heatmap to their preferred heatmap with different color distributions.

4. Recoloring normal images

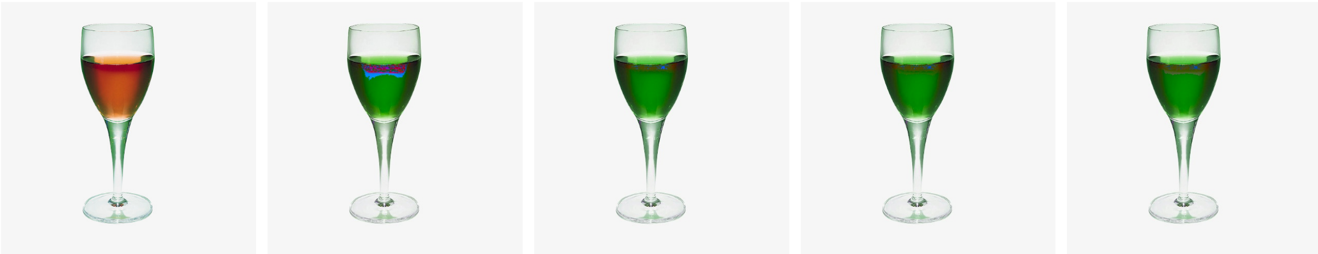
The results of recoloring normal images are shown in Fig. 6. Though we focus on recoloring translucent images, the proposed methods Hmeans and Homography estimation can also be used to recolor normal images.

5. Questionnaire

This section presents the questionnaire used in user study. We show the questionnaire of one image in the page 4 in this document.

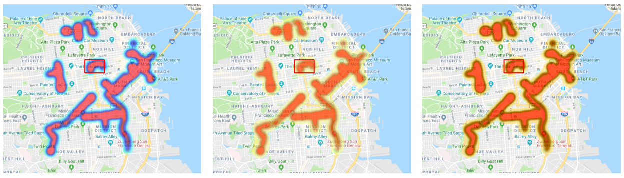
(a) Original (b) Out-of-gamut (c) $\lambda = 0.3$ (d) $\lambda = 0.5$ (e) $\lambda = 0.8$

Figure 2: *The non-linear optimization comparisons. (a) The original image. (b) The out-of-gamut result. (c),(d) and (e) are the results of different parameter $\lambda = 0.3$, $\lambda = 0.5$ and $\lambda = 0.8$ correspondingly.*



(a) Original (b) Out-of-gamut (c) $\lambda = 0.3$ (d) $\lambda = 0.5$ (e) $\lambda = 0.8$

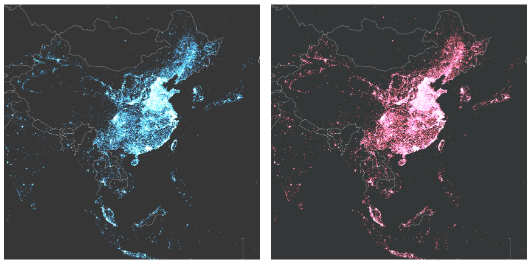
Figure 3: *The non-linear optimization comparisons with a noised image. (a) The original image. (b) The out-of-gamut result. (c),(d) and (e) are the results of different parameter $\lambda = 0.3$, $\lambda = 0.5$ and $\lambda = 0.8$ correspondingly.*



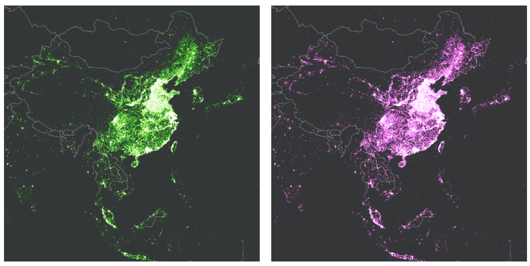
(a) Original (b) [CFL*15] (c) Our method

(d) Original (e) [CFL*15] (f) Our method

Figure 4: *The heatmap recolored results with a mask. (a) The source image. (b) The result of Chang et al. [CFL*15]. (c) The result of our method. (d),(e) and (f) are the highlight areas of the images above correspondingly. Compared with (e), our result (f) is more smoothing.*



(a) Original (b) Result 1



(c) Result 2 (d) Result 3

Figure 5: *The result of recoloring a point-based heatmap. (a) The original point-based heatmap. (b), (c) and (d) are different recolored results correspondingly.*

Figure 6: *More examples of recoloring results. The left column is the original image. The three right columns are recolored results. All of the images above are from CIR dataset [ZXST17].*

References

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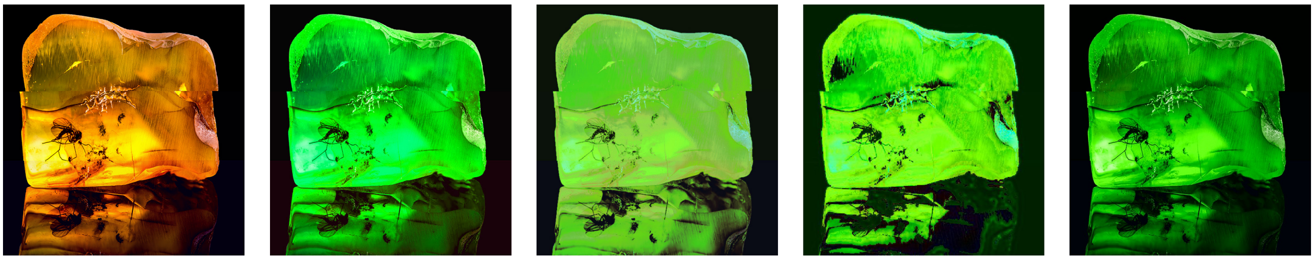

Figure 7: *Image comparisons. The image of the first column is the original image. The four rightmost columns show recolored results with different methods.*

1. Please rate the image of the second column in Fig 7.

structure similarity	◯1	◯2	◯3	◯4	◯5
overall visual effect	◯1	◯2	◯3	◯4	◯5
color harmony	◯1	◯2	◯3	◯4	◯5

2. Please rate the image of the third column in Fig 7.

structure similarity	◯1	◯2	◯3	◯4	◯5
overall visual effect	◯1	◯2	◯3	◯4	◯5
color harmony	◯1	◯2	◯3	◯4	◯5

3. Please rate the image of the forth column in Fig 7.

structure similarity	◯1	◯2	◯3	◯4	◯5
overall visual effect	◯1	◯2	◯3	◯4	◯5
color harmony	◯1	◯2	◯3	◯4	◯5

4. Please rate the image of the fifth column in Fig 7.

structure similarity	◯1	◯2	◯3	◯4	◯5
overall visual effect	◯1	◯2	◯3	◯4	◯5
color harmony	◯1	◯2	◯3	◯4	◯5