Assignment 1: Dynamic Compositing

Report

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Functionality

1. Chromakey and Matting

   A json file which combined with necessary key colors has been created for the synthetic content by using the sketch of lab 5. Comparing each pixel to the given key colors, removing the green background color by changing the pixel color to color (0 ,0, 0, 0). Updating all the pixels and returning frame, hence matting synthetic content has been got. To adapt to the background scene properly, the synthetic content will be resized in the end. The matting result also can be changed in this sketch by press key ',' or '.' To control the value of close color distance.

2. Dynamic Range

   A method to adjust dynamic range is compare the bright point and dark point between reference background image and synthetic content image. Since the synthetic content image will be resized, it is not necessary to use the whole background image as a reference. Instead, I use a part of background image which has same size and same location as the set synthetic image in background as a reference. Compare every pixel of the reference and the synthetic image. Then map the target pixels color from the range of synthetic image color to the range of reference. During this process, ignoring the useless point by one if statement to check if the alpha number is 0, cause these pixels have been set color (0, 0, 0, 0) in first step. After mapping, the dynamic range of synthetic image has been adjusted to background reference image. The effect of dynamic range is controlled by pressing key '/'.

The other method will be introduced in Color Transfer.

3. Color Transfer

Color transfer include three steps:

1. Change RGB to a de-correlated color space Lαβ.

$$\begin{bmatrix} L \\ \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} 0.3475 & 0.8231 & 0.5559 \\ 0.2162 & 0.4316 & -0.6411 \\ 0.1304 & -0.1033 & -0.0269 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

2. Calculate the three channels' mean and standard variance of reference/example and target/synthetic images' every pixel. Applying math method to adjust the variance of final target image.

$$\begin{aligned} L_{\text{target}} &= s_L \left(L_{\text{target}} - \bar{L}_{\text{target}}\right) + \bar{L}_{\text{target}} \\ \alpha_{\text{target}} &= s_\alpha \left(\alpha_{\text{target}} - \bar{\alpha}_{\text{target}}\right) + \bar{\alpha}_{\text{target}} \\ \beta_{\text{target}} &= s_\beta \left(\beta_{\text{target}} - \bar{\beta}_{\text{target}}\right) + \bar{\beta}_{\text{target}} \end{aligned}$$

$$\begin{aligned} s_L &= 1 - s + s \frac{\sigma_{L,\text{example}}}{\sigma_{L,\text{target}}} \\ s_\alpha &= 1 - s + s \frac{\sigma_{\alpha,\text{example}}}{\sigma_{\alpha,\text{target}}} \\ s_\beta &= 1 - s + s \frac{\sigma_{\beta,\text{example}}}{\sigma_{\beta,\text{target}}} \end{aligned}$$

3. Save the changes, return to RGB color space and uploads new pixels to final image.

According to mathematics, when s = 1, the final image gives the best color transfer effects because the standard variance is same between target image and reference image. Since a user scaling factor is provided, the dynamic range also can be changed. Since every pixel's color channel has been scaled, the range between brightness and darkness also been scaled. But it cannot be proved the darkest and brightest point can be matched by control s. In this sketch, the s is set to 1 to give the best effect of color transfer, while the dynamic range can be changed by using a changeDynamicRange function. In this sketch, using mouse press to control the color transfer.

Frame rate

The functionality analysis gives the theory and realize method of the dynamic composite. The whole calculation process is really heavy for cpu. The average frame rate of the video after applying color transfer and dynamic range is about 14. To achieve this, several methods has been used:

1. Reduce the resolution of synthetic image:

   In matting process, after comparing one pixel's color value to json file's key color, skip the next pixel. If the first pixel should be set color (0, 0, 0, 0), then the next one is regard as transparent. Although this will reduce the accuracy of matting, it reduces a lot of works. And in the comparing loop, if any value of key colors has been matched, then break the loop. This method will reduce unnecessary compare steps.

2. Reduce the number of pixels to be calculated:

   Both in dynamic range and color transfer, the transparent pixels of synthetic image will not be calculated and transferred.

3. Reduce the frame rate of movie:

   Represent one frame of every movie, which will reduce the loads of CPU.

4. Using GPU:

   Has not achieved in this sketch.

Finally, the color transfer and dynamic range adjust effect can be more obviously when the background movie is set to be "motocross-720p.mp4". But I think it looks better in "running-720p.mp4".