Advanced-Color-to-Gray-Conversion

Problem

Different color channel values are converted to same grayscale value. It lost original contrast.

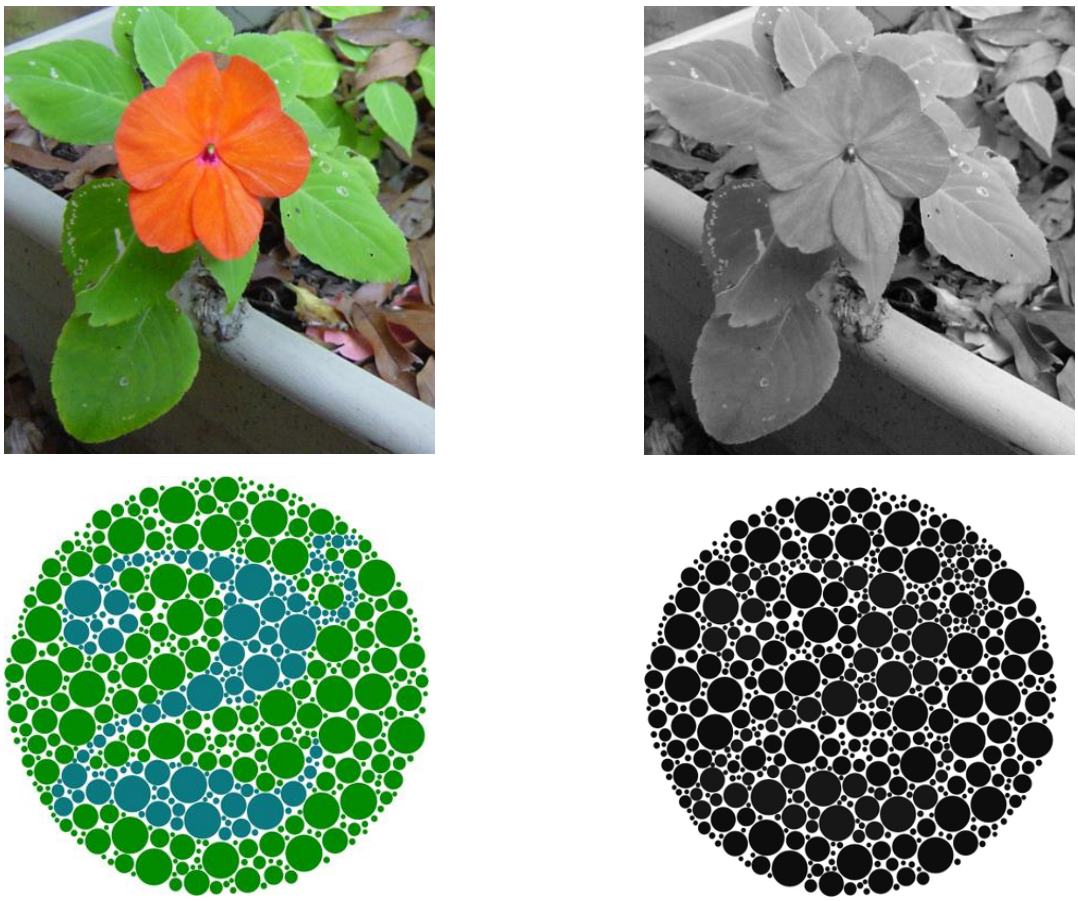

Figure 1 Left: original image, right: result in grayscale image.

Solution

Reference this paper [1] to solve problem. Create candidate weight and selected the best candidate converted to a grayscale image. The general form of linear conversion:

$$Y = w_r \cdot R + w_g \cdot G + w_b \cdot B$$
$$w_r, w_g, w_b \geq 0$$
$$w_r + w_g + w_b = 1$$

There will be 66 weight combinations of gray conversion. Choosing the converting grayscale image that has original similar contrast.

Flow

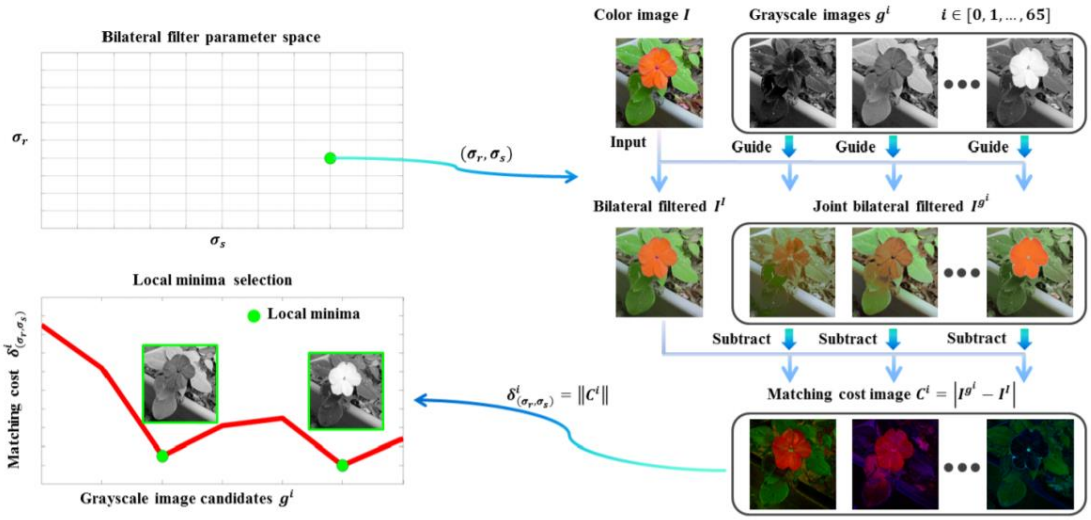

Figure 2 The pipeline of paper [1] approach.

1. Input image I.
2. Create candidate weight w^i and grayscale g^i.
3. Down sampling image (Speed up time. Original paper didn't do this step).
4. Bilateral filtering image with itself I^I.
5. Joint bilateral filtering image I^{g^i} and g^i as guidance image.
6. Calculate matching cost $|I^{g^i} - I^I|$.
7. The candidates with local minimum cost values are voted.
8. After run all (σ_s,σ_r) parameter setting, select the candidates with more votes. The different (σ_s,σ_r) combination means it will test in multi-scale contrast preservation.

Joint bilateral filter

$$\mathbf{I}^{\mathbf{J}}(\mathbf{p}) = \frac{\sum_{\mathbf{q}\in\Omega_{\mathbf{p}}} G_{\sigma_s}(||\mathbf{p}-\mathbf{q}||)G_{\sigma_r}(||\mathbf{J}(\mathbf{p})-\mathbf{J}(\mathbf{q})||)\mathbf{I}(\mathbf{q})}{\sum_{\mathbf{q}\in\Omega_{\mathbf{p}}} G_{\sigma_s}(||\mathbf{p}-\mathbf{q}||)G_{\sigma_r}(||\mathbf{J}(\mathbf{p})-\mathbf{J}(\mathbf{q})||)}$$

Symbols define:

I is the input image.

p is the input image pixel index.

J is the guidance image.

$I^J(p)$ is the output image pixel value in correspond index p.

Ω_p is the mask in index p.

q is a pixel in the neighborhood of pixel p.

G_{σ_s} and G_{σ_r} are the spatial and range filter kernels measuring the spatial and range similarity. It using Gaussian kernel.

Symbols correspond size and type:

I, J : h x w array. h and w is image height and weight.

Ω_p : r × r array. r is mask height and width.

J(p), p : Numeric value.

I(q), J(q), q, $G_{\sigma_s}(||p-q||)$, $G_{\sigma_r}(|J(p)-J(q)|)$: r × r − 1 array.

In programming, q can contain center pixel. Because when J(q) is central pixel, $J(p)-J(q)$ is zero. Same result in $G_{\sigma_s}(||p-q||)$ when p equal q.

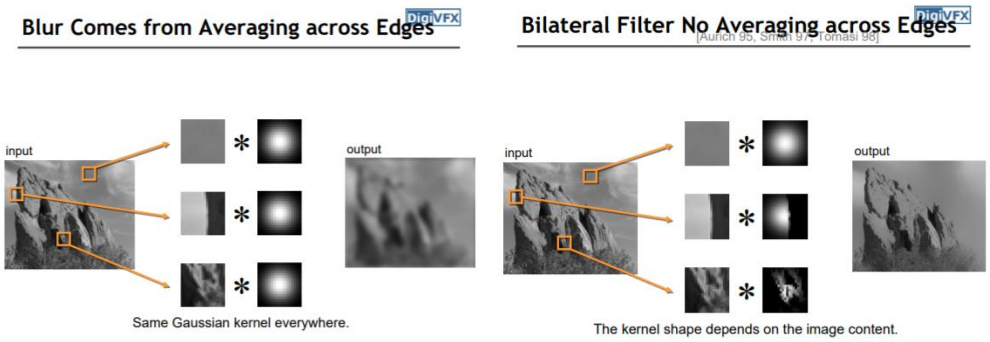

Figure 3 Compare with Gaussian blur and bilateral filter blur. Reference by DigiVFX course[3].

To detect whether contrast preservation. Using bilateral filtering image as the golden image. Different candidate weight as a guidance image to input joint bilateral filtering image. If the candidate weight grayscale image was contrast preservation, the joint bilateral filtering result will similar to bilateral filtering image.

Local minima selection

Using Euclidean distance to find candidate weight neighbor and compare with them. If this candidate is the minimum value, then it is local minimum weight.

Parameter in code

sigma_s: Decide mask size. The bigger value will smooth more feature.
sigma_r: Same as gaussian kernel.
resize_factor: Speed up processing time. Resize input image by opencv resize method.
dist_T : The threshold about distance of local minima selection at voting stage. The value bigger, it will compare more neighbor weight.

Result

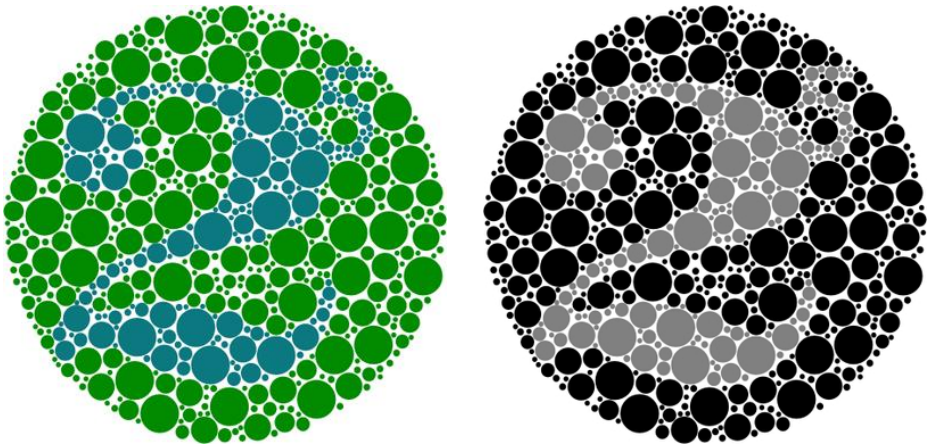

Figure 4 Left: Original image, right:$(w_r, w_g, w_b) = (0,0,1)$ and get 8 votes.

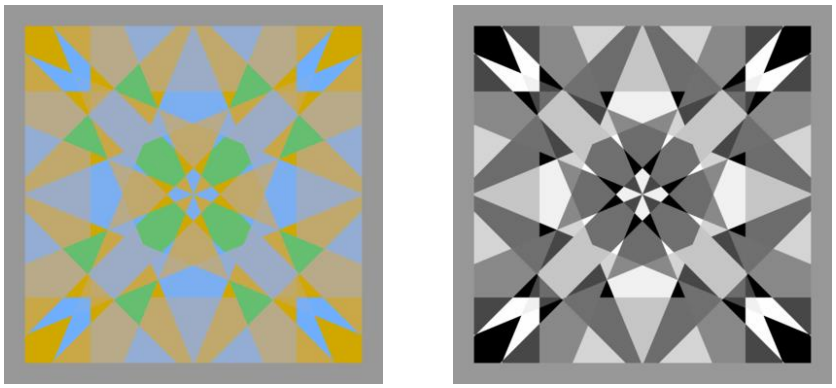

Figure 5 Left: Original image, right:$(w_r, w_g, w_b) = (0,0,1)$ and get 9 votes.

Reference

[1] Y. B. L. X. X. &. Y. Q. Song, “out?, Decolorization: Is rgb2gray (),” *SIGGRAPH Asia 2013 Technical Briefs,* pp. 1-4, 2013.

[2] Fall 2019 Computer Vision: from Recognition to Geometry(http://media.ee.ntu.edu.tw/courses/cv/19F/)

[3] 10 spring VFX bilateral filter (https://www.csie.ntu.edu.tw/~cyy/courses/vfx/10spring/lectures/handouts/lec14_bilateral.pdf)

[4] Advanced Color-to-Gray Conversion (http://media.ee.ntu.edu.tw/courses/cv/18F/hw/cv2018_hw01.pdf)