Image Colorization

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Approach

Steps to colorize a image -

- *Convert both the raw image and marked image to YUV color space*
  UV colorspace is a bit unusual. The Y component determines the brightness of the color (referred to as luminance or luma), while the U and V components determine the color itself (the chroma). Y ranges from 0 to 1 (or 0 to 255 in digital formats), while U and V range from -0.5 to 0.5 (or -128 to 127 in signed digital form, or 0 to 255 in unsigned form)
- Then apply the following optimization in U,V space w.r.t. the intensity vector Y.

$$J(U) = \sum_{\mathbf{r}} \left(U(\mathbf{r}) - \sum_{\mathbf{s} \in N(\mathbf{r})} w_{\mathbf{rs}} U(\mathbf{s}) \right)^2$$

where *weight is defined as -*

$$w_{\mathbf{rs}} \propto e^{-(Y(\mathbf{r})-Y(\mathbf{s}))^2/2\sigma_{\mathbf{r}}^2}$$

Also,the color at a pixel U(r) is a linear function of the intensity Y(r): U(r) = aiY(r)+ bi and the linear coefficients ai; bi are the same for all pixels in a small neighborhood around r.

Now given a set of locations ri where the colors are specified by the user u(ri) = ui; v(ri) = vi we minimize J(U); J(V) subject to these constraints. Since the cost functions are quadratic and the constraints are linear, this optimization problem yields a large, sparse system of linear equations, which may be solved using a number of standard methods.

We attempts to find the second smallest eigenvector of the matrix $D - W$ where W is a npixels$\times$ npixels matrix whose elements are the pairwise affinities between pixels (i.e., the $r; s$ entry of the matrix is w_{rs}) and D is a diagonal matrix whose diagonal elements are the sum of the affinities (in our case this is always 1). The second smallest eigenvector of any symmetric matrix A is a unit norm vector x that minimizes x^TAx and is orthogonal to the first eigenvector. By direct inspection, the quadratic form minimized by normalized cuts is exactly our cost function J, that is $x^T(D-W)x = J(x)$.

Results

Marked B/W image

Result

Marked B/W image

Result