Automatic Image Colorization

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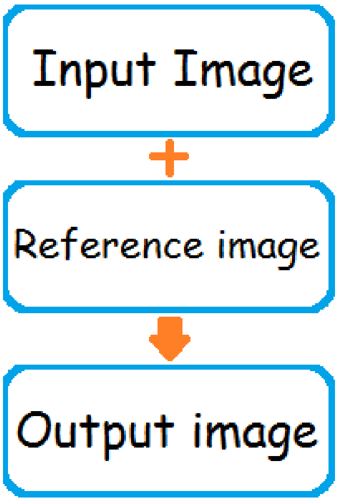
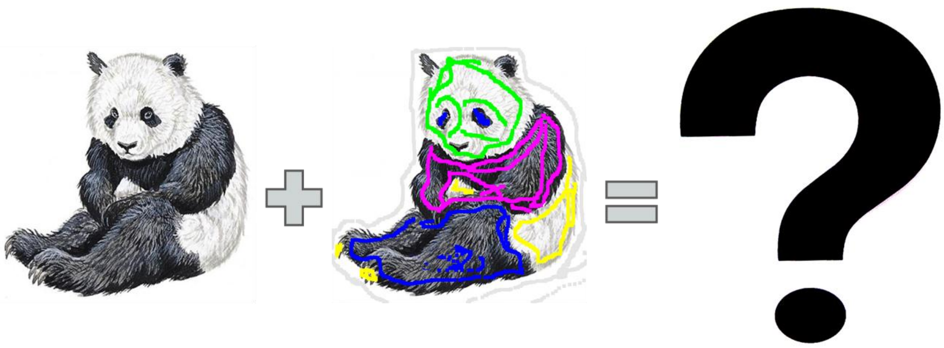
Introduction

Automatic Image Colorization is a computer-assisted process to color a black-and-white image. It can be applied in video color recovery, recoloring and matting. This project aims to develop a generic colorization application which can colorize any images regardless of its content.





Methodology

(1) Interpretation of an image

$$\begin{bmatrix}Y\\U\\V\end{bmatrix} = \begin{bmatrix}0.299 & 0.587 & 0.114\\ -0.147 & -0.289 & 0.436\\ 0.615 & -0.515 & -0.100\end{bmatrix}\begin{bmatrix}R\\G\\B\end{bmatrix}$$

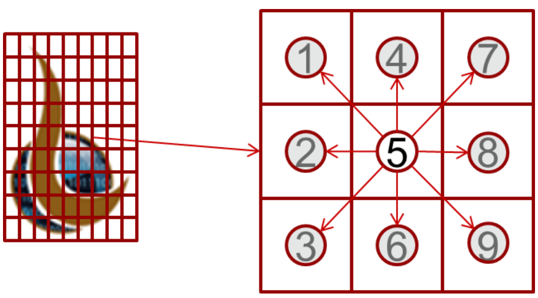
From RGB space to YUV space

Y = intensity(black-and-white value)
U, V = color parameters

The U and V values are *unknown variables* which represent colors

(2) Principle of colorizing a pixel

Neighboring pixels that have similar intensity should have similar color



$$J(U) = \sum_{r,s} w_{rs}(U(r) - U(s))^2 + \lambda \sum_{k} (U(k) - \tilde{U}_k)^2$$

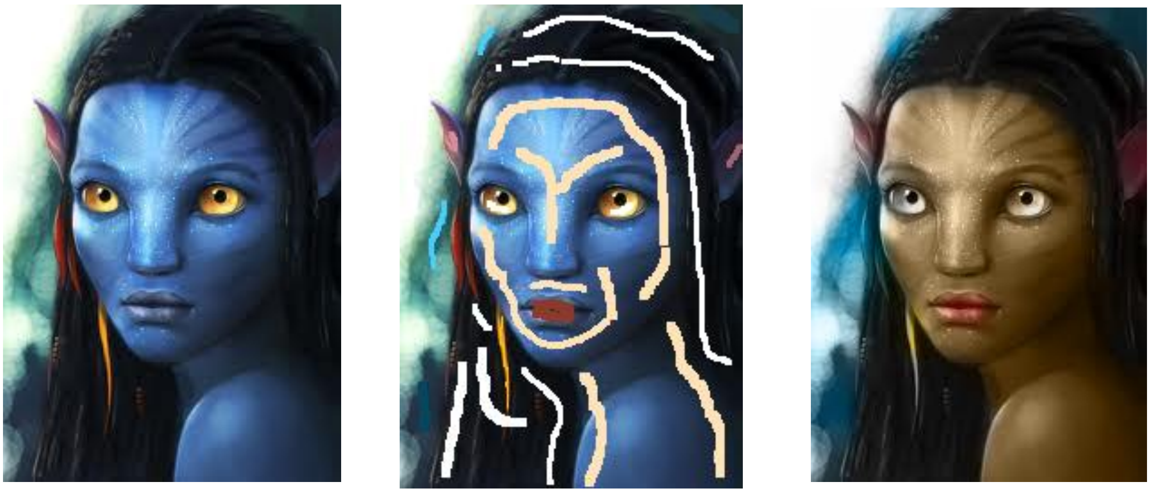
$$J(V) = \sum_{r,s} w_{rs}(V(r) - V(s))^2 + \lambda \sum_{k} (V(k) - \tilde{V}_k)^2$$

w_{rs} = weight factor
$\tilde{U}$ = U value on the reference image
$\tilde{V}$ = V value on the reference image
λ = influential factor

(3) Optimal solution

J(U) and J(V) represent the degree of difference of the output image to the input image and the reference image, so the goal is to find U^* and V^* so that J(U) and J(V) are minimized. After applying Calculus and Linear Algebra technique, it is shown that U^* and V^* can be found by solving a system of linear equations.

Results



Fast colorization implementations are also provided for colorizing an image. Our results showed that the colorized images are hardly distinguishable while the performance has been significantly improved.

Image mask

Fast result

Extreme fast result

Original image

Evaluation

No. of Column	No. of Row	Total size	Standard(s)	Fast(s)	Extreme fast(s)
512	512	262144	3.846	0.811	0.16
1366	768	1049088	40.746	5.298	1.045
189	267	50463	0.484	0.109	0.062
391	219	85629	0.734	0.187	0.062
1680	1050	1764000	24.336	6.006	1.27
960	768	737280	12.93	2.169	0.499
600	401	240600	2.964	0.561	0.156
1200	801	961200	20.685	3.038	0.721
396	599	237204	2.627	0.515	0.14
259	194	50246	0.374	0.094	0.032