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**

   From RGB space to YUV space
   
   \[
   \begin{bmatrix}
   Y \\
   U \\
   V
   \end{bmatrix} = \begin{bmatrix}
   0.299 & 0.587 & 0.114 \\
   -0.147 & -0.289 & 0.436 \\
   0.615 & -0.515 & -0.100
   \end{bmatrix} \begin{bmatrix}
   R \\
   G \\
   B
   \end{bmatrix}
   \]

   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

   \[
   J(U) = \sum_{r,s} w_{rs} (U(r) - U(s))^2 + \lambda \sum_{k} (U(k) - U^R_k)^2
   \]

   \[
   J(V) = \sum_{r,s} w_{rs} (V(r) - V(s))^2 + \lambda \sum_{k} (V(k) - V^R_k)^2
   \]

   \[w_{rs} = \text{weight factor}\]

   \[U^R = U \text{ value on the reference image}\]

   \[V^R = V \text{ value on the reference image}\]

   \[\lambda = \text{influential factor}\]
(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.

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<th>Extreme fast(s)</th>
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