Image enhancement based on selective-retinex fusion algorithm

ISL Lab Seminar
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Retinex Theory

What colors are this dress?

So let's settle this: what colors are this dress?

68% White and Gold 2.3M votes
32% Blue and Black 1.1M votes

But actually the answer is **Blue and Black!!!**

We can explain this problem using **Retinex theory.**
What’s the meaning of Retinex Theory.

Retinex = Retina + Cortex

Both the eye and the brain are involved in the Image processing.

If we just use the eye,

A = B

But actually we use both the eye and the brain

A ≠ B

Single-Scale Retinex (SSR) & Multiple-Scale Retinex (MSR)

**SSR**

\[ I(x, y) = L(x, y)R(x, y) \]

We can use the log function.

\[ \log(I(x, y)) = \log(L(x, y)R(x, y)) \]
\[ \log R(x, y) = \log I(x, y) - \log L(x, y) \]
\[ \log R(x, y) = \log I(x, y) - \log(G(x, y)^* I(x, y)) \]

**MSR**

\[ R_{msr}(x, y) = \sum_{n=1}^{N} w_n R_{ssr}(x, y) \]
Selective-Retinex Fusion Algorithm

★ S curve

\[ f = 0.5 + \frac{\arctan(a \cdot x - b)}{2t} \]
Selecting Reticex Fusion Algorithm

★ The modified Retinex algorithm

\[ P_r(i, j) = 0.5 + \frac{\text{arctan}(a \cdot R(i, j) - b)}{2\pi} \]

![Source](image1)

![Modified Retinex](image2)

**BUT** we can also see the shade information is eliminated!!!

So we need to recognize **two different part**.

1) **Light part** need to reduce the brightness and its halo.
2) **Dark part** need to be enhanced according to the distance between the light source to keep distance information
Selective-Retinex Fusion Algorithm

The selective and nonlinear gray mapping

[Four steps]

1) Find the light sources in the image.
   erode first to eliminate speckles, then dilate to recover the area.
   we can obtain the point light source \( P_n, n = 1 \ldots N \).

2) Reduce the halo.
   compute the luminance-enhanced factor related to the distance.
   \[
   f_T(i, j) = \min \left\{ \exp \left( -c \sqrt{(i - i_{on})^2 + (j - j_{on})^2} \right) \right\}, \quad n = 1 \ldots N
   \]

3) Deal with the two part differently.
   compute the luminance-enhanced factor related to the luminance.
   \[
   f_L(i, j) = \begin{cases} 
   1 & \text{in the area of each point light source} \\
   d \cdot (p(i, j) - \text{Light})^2 + 1 & \text{other parts in the image}
   \end{cases}
   \]
   \[
   d = \begin{cases} 
   6 & \text{image is very dark (the luminance average is less than 0.15)} \\
   3 & \text{otherwise}
   \end{cases}
   \]

4) Enhance the luminance component of the whole image by using \( P_T(i, j) \).
   compute the luminance-enhanced factor related to the luminance.
   \[
   P_T(i, j) = p(i, j) f_L(i, j) \cdot f_T(i, j)
   \]
Selective-Retinex Fusion Algorithm

★ The selective and nonlinear gray mapping

[luminance image of the source]

[luminance image by the method]
Selective-Retinex Fusion Algorithm

\[
P_Y(i, j) = g \cdot P_R(i, j) + (1 - g) \cdot P_T(i, j)
\]

\[
P_k(i, j) = 0.5 + \frac{\arctan(a \cdot R(i, j) - b)}{2t}
\]

\[
P_T(i, j) = p(i, j) f_x(i, j) \cdot f_y(i, j)
\]

\[
g = \begin{cases} 
0.1 \sim 0.3 & \text{good light condition and visual observation distance} \\
0.3 \sim 0.6 & \text{otherwise}
\end{cases}
\]
Experimental Results

[Source] [Reference] [S-Retinex Fusion]


Experimental Results – modified retinex algorithm

[Source]  
[Gamma Correction]  
gamma= 2.2

[HE]  
[SSR]  
[BBHE]  
[Modified SSR]  
a=0.7, b=0, t=1.5
Experimental Results – modified retinex algorithm

[Source]

[HE]

[BBHE]

[Gamma Correction]

\[\text{gamma} = 2.2\]

[SSR]

[Modified SSR]

\[a=0.7, \ b=0, \ t=1.5\]
04 Experimental Results – modified retinex algorithm

[Source]  [HE]  [BBHE]

[Gamma Correction]  gamma = 2.2

[SSR]  

[Modified SSR]  a = 0.7, b = 0, t = 1.5