A Study on Real-time Retinex Video Image Enhancement

- Adaptive image enhancement
  - Since each pixel value is adjusted based on the surrounding pixels’ value, each region in an image can be properly corrected.

- Drawbacks in its hardware implementation
  - High computational cost and iterative procedures

- This work focuses on an efficient hardware architecture for real-time adaptive video enhancement based on the Retinex theory and its QP (quadratic programming) model.
Image Enhancement based on the Retinex theory

- Retinex theory – by Land and McCann

\[
\begin{align*}
\text{Input image} & \quad I(x, y) \\
\text{Illumination image} & \quad L(x, y) \\
\times \quad \text{Reflectance image} & \quad R(x, y)
\end{align*}
\]

\[
R(x, y) = \exp\{\log(I(x, y)) - \log(L(x, y))\}
\]

Procedure
1. Estimate illumination image \( L \) from input image
2. Obtain \( R \) by subtracting \( L \) component from input image \( I \)

- QP (quadratic programming) model
  - One of the schemes to estimate illumination image.
  - The following cost function is minimized, assuming the smoothness of illumination image.

\[
F[l] = \int_{\Omega} \left( |\nabla l|^2 + \alpha(l - i)^2 + \beta|\nabla(l - i)|^2 \right) dx dy \quad i : \log I, \quad l : \log L
\]
FPGA Implementation result

- FPGA: Xilinx Virtex2
- Maximum frequency: 54MHz
- Memory usage: 342kbits
- I/O: NTSC (720x480, 30fps) YCbCr 4:2:2