Subpixel-based Down-sampling

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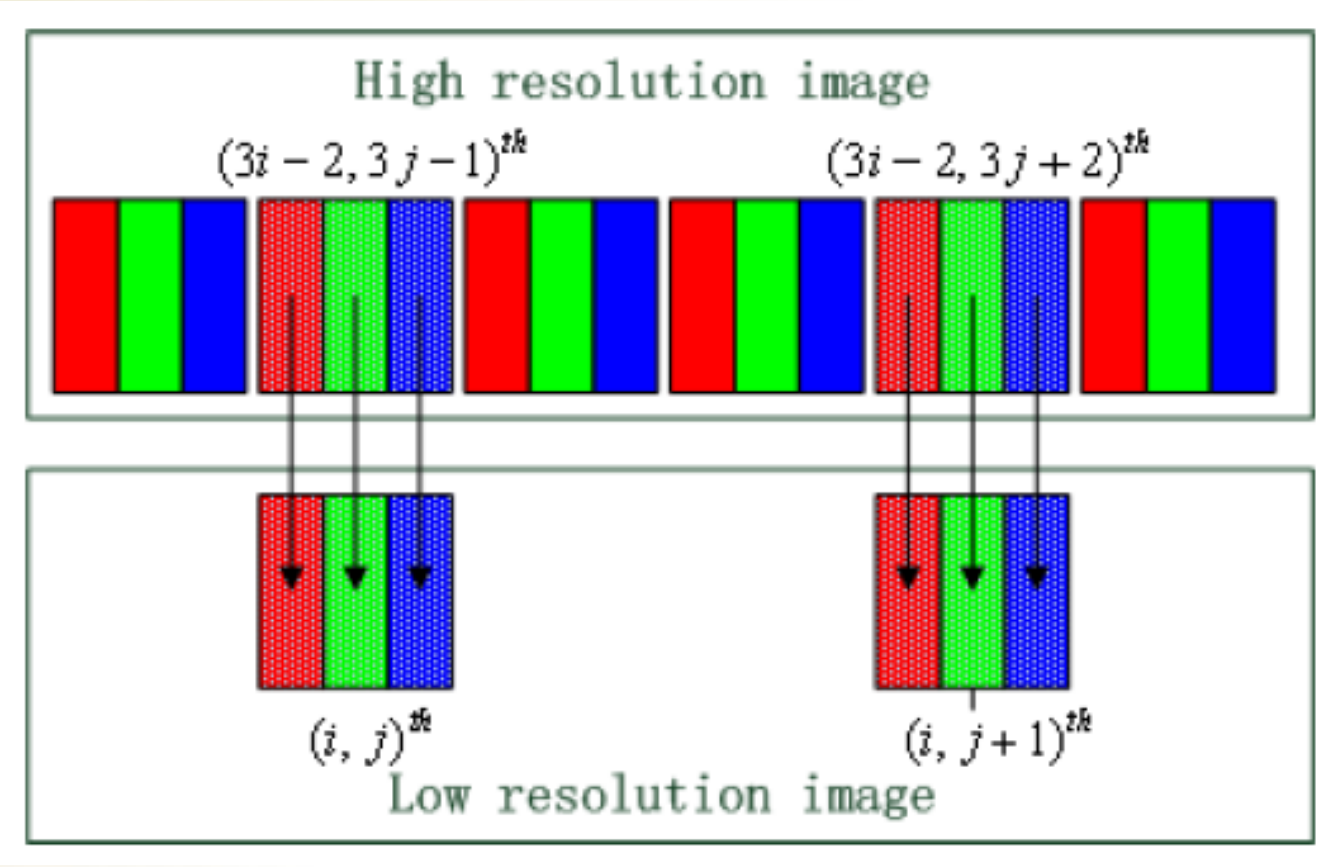
Problem Statement

- **Problem Statement**

  To shrink a high resolution image such that the visual distortion introduced is reduced.

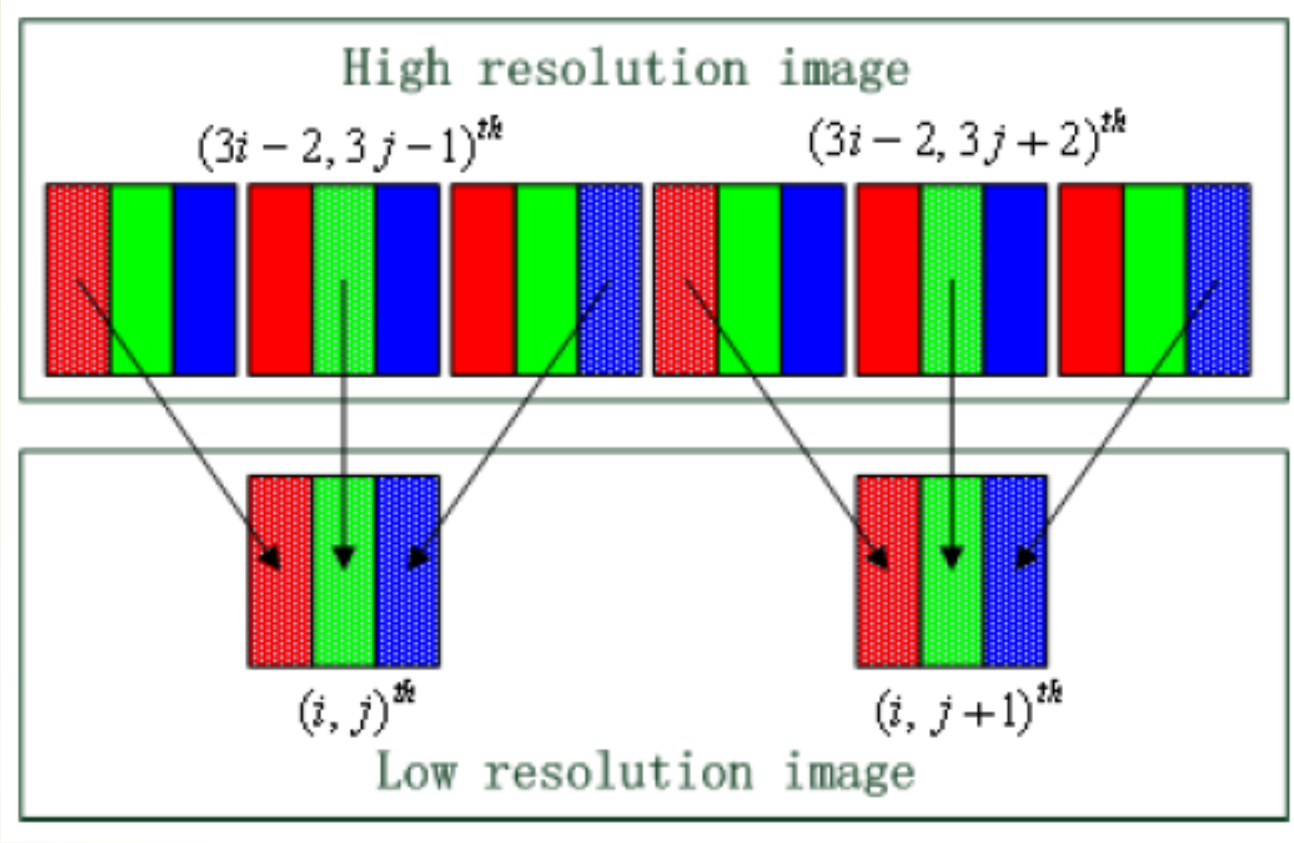
- **Motivation**
  - Display a 10 Mega Pixel or HD image on a low resolution display of a digital camera, mobile phone etc.
  - LCD displays are composed of individual addressable red, green, and blue sub-pixel stripes, hence sub-pixel rendering can increase the apparent resolution of the display.

Direct Pixel-based Downsampling (DPD)



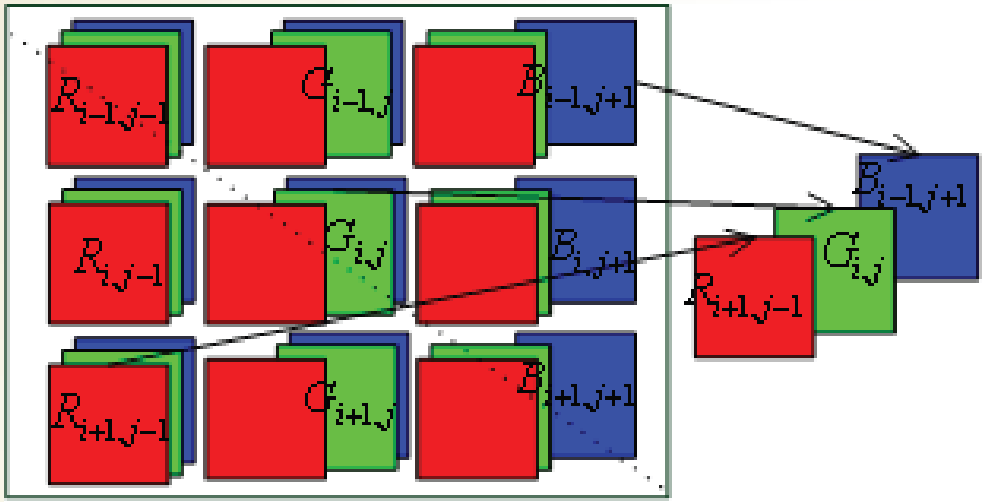
Results DPD

Direct Subpixel-based Downsampling (DSD)



Results DSD

Adaptive Subpixel-based Downsampling Scheme Using Edge Detection



3 × 3 block

$Y_{i-1,j-1}$	$Y_{i,j}$	$Y_{i-1,j+1}$
$Y_{i,j-1}$	$Y_{i,j}$	$Y_{i,j+1}$
$Y_{i+1,j-1}$	$Y_{i,j}$	$Y_{i+1,j+1}$

$$\begin{cases} Grad^{H}(Y_{i,j}) = |Y_{i,j+1} - Y_{i,j}| + |Y_{i,j} - Y_{i,j-1}| \\ Grad^{V}(Y_{i,j}) = |Y_{i+1,j} - Y_{i,j}| + |Y_{i-1,j} - Y_{i,j}| \\ Grad^{LD}(Y_{i,j}) = |Y_{i+1,j+1} - Y_{i,j}| + |Y_{i,j} - Y_{i-1,j-1}| \\ Grad^{RD}(Y_{i,j}) = |Y_{i+1,j-1} - Y_{i,j}| + |Y_{i,j} - Y_{i-1,j+1}| \end{cases}$$

Results

(a). DPD

(b). DSD

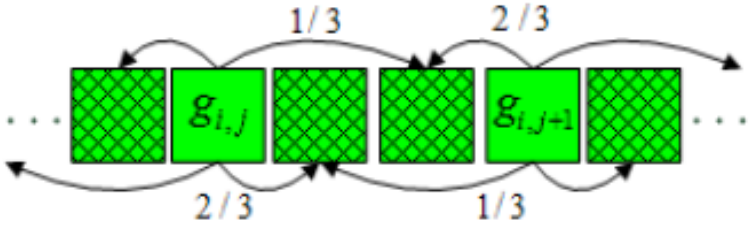
(c). Proposed

Subpixel-based Down-sampling via Min-Max Directional Error

- Step 1

$$G'_{3i-2,3j-1} = g_{i,j}, \quad G'_{3i-2,3j} = \frac{2}{3}g_{i,j} + \frac{1}{3}g_{i,j+1},$$

$$G'_{3i-2,3j+1} = \frac{1}{3}g_{i,j} + \frac{2}{3}g_{i,j+1}, \quad G'_{3i-2,3j} = g_{i,j+1}$$



- Step 2

$$D^1_{i,j} = (G_{3i-2,3j-3} - (\frac{2}{3}g_{i,j-1} + \frac{1}{3}g_{i,j}))^2 + (G_{3i-2,3j-2} - (\frac{1}{3}g_{i,j-1} + \frac{2}{3}g_{i,j}))^2$$
$$+(G_{3i-2,3j-1} - g_{i,j})^2 + (G_{3i-2,3j} - (\frac{2}{3}g_{i,j} + \frac{1}{3}g_{i,j+1}))^2 + (G_{3i-2,3j+1} - (\frac{1}{3}g_{i,j} + \frac{2}{3}g_{i,j+1}))^2$$

$$D^2_{i,j} = (G_{3i-4,3j-1} - (\frac{2}{3}g_{i-1,j} + \frac{1}{3}g_{i,j}))^2 + (G_{3i-3,3j-1} - (\frac{1}{3}g_{i-1,j} + \frac{2}{3}g_{i,j}))^2$$
$$+(G_{3i-2,3j-1} - g_{i,j})^2 + (G_{3i-1,3j-1} - (\frac{2}{3}g_{i,j} + \frac{1}{3}g_{i+1,j}))^2 + (G_{3i,3j-1} - (\frac{1}{3}g_{i,j} + \frac{2}{3}g_{i+1,j}))^2$$

Similar analysis can be done for diagonal and anti-diagonal part also.

- Step 3

$$\min_{g} \sum_{i,j} \max\{D^1{}_{ij}, D^2{}_{ij}, D^3{}_{ij}, D^4{}_{ij}\}$$

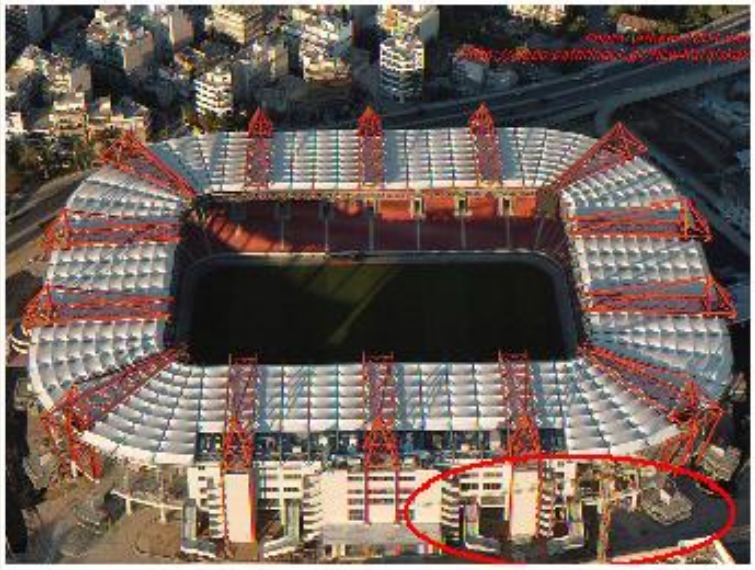
$$\begin{aligned} \min_{\mathbf{g},\mathbf{t}} \quad & \sum_{i,j} t_{i,j} \\ s.t. \quad & 0 \leq g_{i,j} \leq 255 \\ & t_{i,j} \geq D^1_{i,j} \\ & t_{i,j} \geq D^2_{i,j} \\ & t_{i,j} \geq D^3_{i,j} \\ & t_{i,j} \geq D^4_{i,j}. \end{aligned}$$

- Step 4

  For reducing complexity we choose the direction perpendicular to the current prevailing edge direction

Results

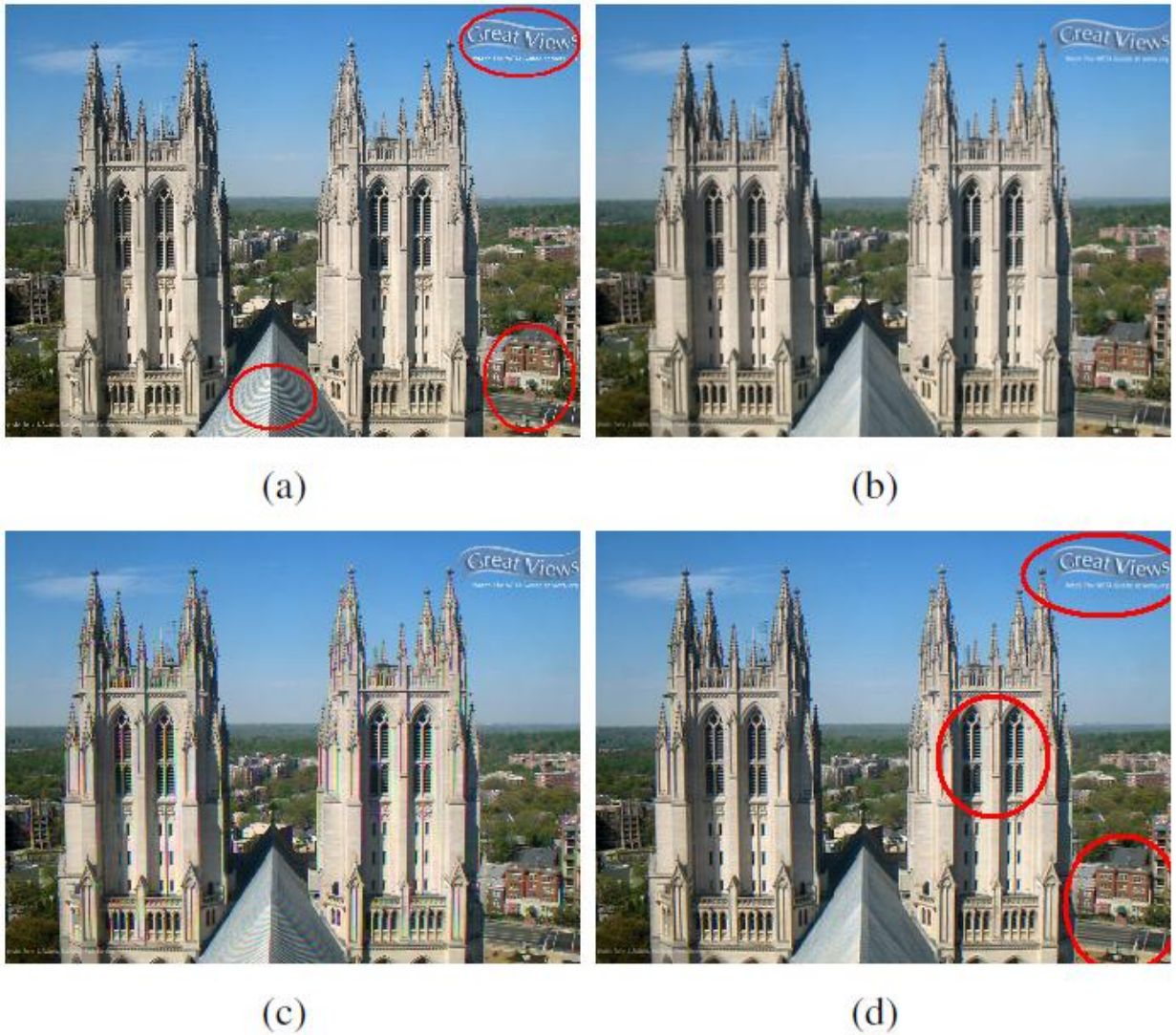
(a). DPD



(b). DSD

(c). MMDE

Conclusion



(a). DPD
(b). EDGE BASED
(c). DSP
(d). MMDE