Image Fusion with Guided Filtering

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Image Fusion

- Through image fusion, different images of the same scene can be combined into a single fused image.
- A good fusion algorithm takes care of the following:
  - It can preserve most of the useful information of different images.
  - It does not produce artifacts.
  - It is robust to imperfect conditions and noise.

Guided Filter

- The guided filter assumes that the filtering output *O* is a linear transformation of the guidance image *I* in a local window *ωk* centered at pixel k.

$$O_i = a_k * I_i + b_k \quad \forall \quad i \in \omega_k$$

- The constants can be obtained by minimizing the error expression given by:

$$E(a_k, b_k) = \sum_{i \in \omega_k} \left((a_k I_i + b_k - P_i)^2 + \epsilon a_k^2 \right)$$

- By minimizing the above expression, we obtain the following:

$$a_k = \frac{\frac{1}{|\omega|} \sum_{i \in \omega_k} I_i P_i - \mu_k \overline{P}_k}{\delta_k + \epsilon}$$

$$b_k = \overline{P}_k - a_k \mu_k$$

Image Fusion using Guided Filtering

The algorithm consists of three steps:

1. Two Scale Image Decomposition
2. Weight Map construction with Guided Filtering
3. Two scale image reconstruction

Two Scale Image Decomposition

The image is decomposed into a base layer containing large scale variations in intensity, and a detail layer capturing small scale details.

- The base layer can be obtained by convolving the source images with a simple averaging filter.
- The detail layer can be easily obtained by subtracting the base layer from the source image.

Original Image I1

Base Layer B1

Detail Layer D1

Original Image I2

Base Layer B2

Detail Layer D2

Weight Map construction with Guided Filtering

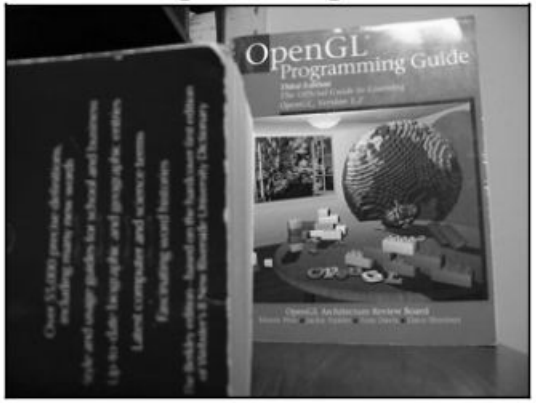
- Saliency maps are obtained by applying a laplacian followed by a gaussian on the two images and then using the following condition to generate the preliminary weight maps

$$P_n^k = \begin{cases} 1 \text{ if } S_n^k = \max\left(S_1^k, S_2^k, \ldots, S_N^k\right) \\ 0 \text{ otherwise} \end{cases}$$

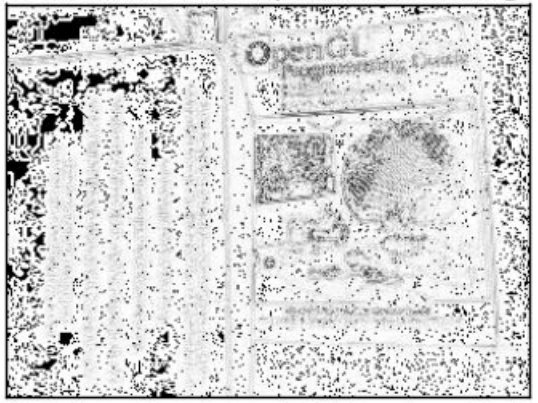
- Guided image filtering is performed on each weight map P_n with the corresponding source image I_n serving as the guidance image to obtain the base and detail weights.

$$W_{nB} = G_{r1},\varepsilon_1 (P_n, I_n) , \quad W_{nD} = G_{r2},\varepsilon_2 (P_n, I_n)$$

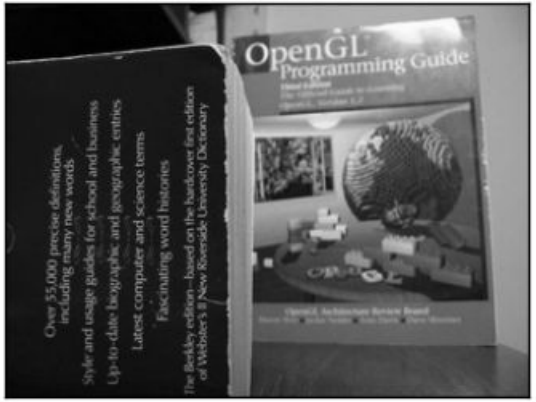
Original Image I1



Gaussian blurred Laplacian of Image I1

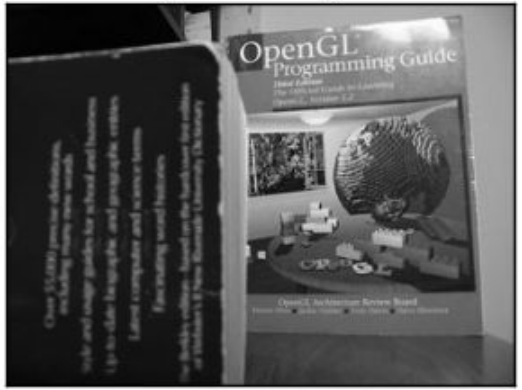


Original Image I2



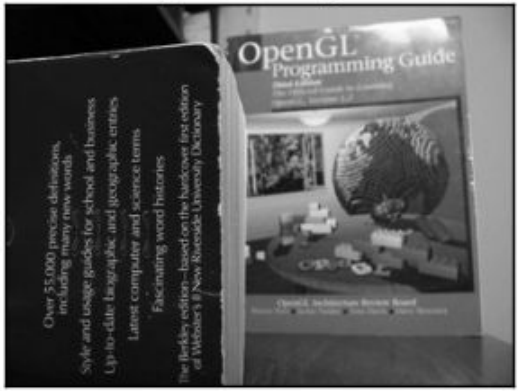
Gaussian blurred Laplacian of Image I2

Original Image I1



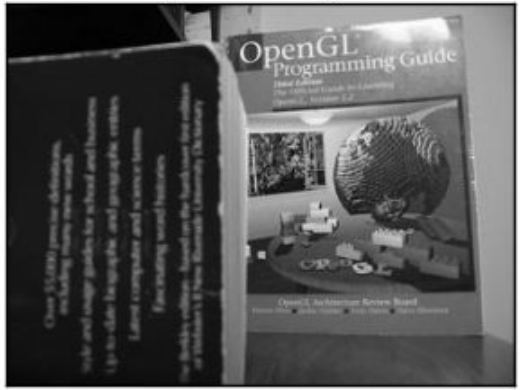
Weight Maps P1

Original Image I2



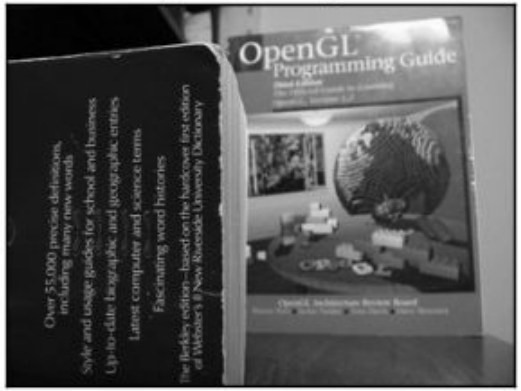
Weight Maps P2

Original Image I1

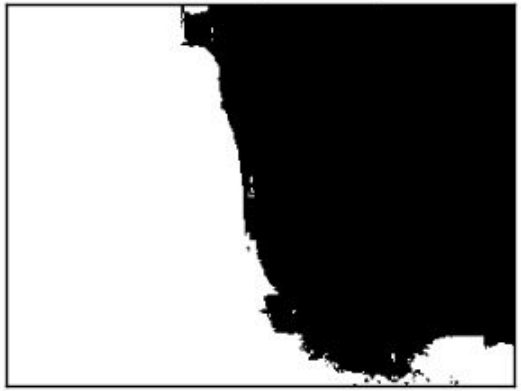


Refined Weight Maps W1

Original Image I2



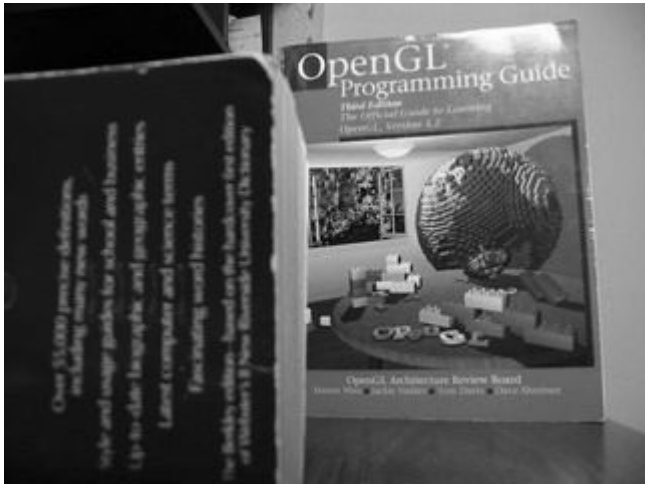
Refined Weight Maps W2



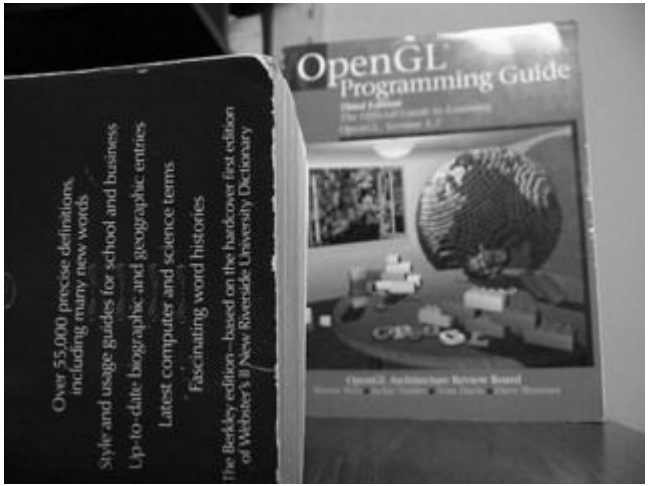
Two Scale image reconstruction

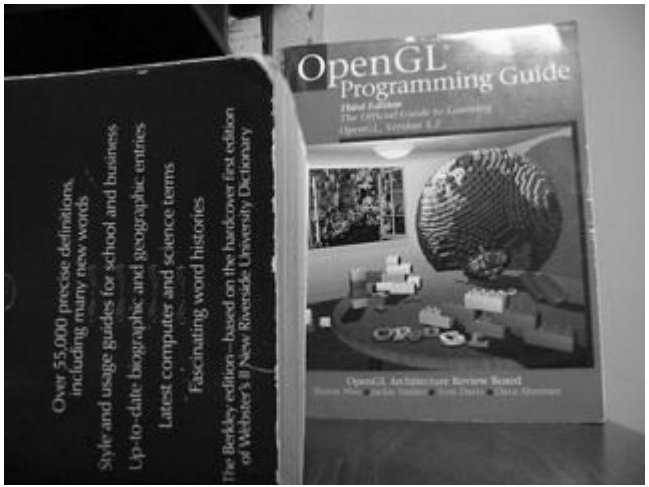
Two-scale image reconstruction consists of the following two steps.

- The base and detail layers of different source images are fused together by weighted averaging.
- The fused image F is obtained by combining the fused base layer and the fused detail layer.



Input Images





Final Image