Robust Movement Detection Based on a New Similarity Index for HDR Imaging

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Figure 1: *The HDR images by (a) FDRTOOLS. (b) PHOTOMATIX. (c) QTPFSGUI. (d) Ours with Debevec and Malik's scheme.*

It is known that a high dynamic range (HDR) image can be produced by sequentially capturing a set of low dynamic range (LDR) images with different exposure times [Debevec and Malik 1997]. However, ghosting artifacts could be produced via this method when there are moving objects in a scene. In this poster, a similarity index is first introduced for such LDR images by using intensity mapping functions (IMFs) among them. The index is then applied to detect moving objects such that ghosting artifacts are removed from the eventual HDR image. The details are given as below.

1) A New Similarity Index

Consider two LDR images $\mathbf{Z}_1$ and $\mathbf{Z}_2$. $\Lambda_{1,2,l}(z)$ and $\Lambda_{2,1,l}(z)$ are the IMFs from the lth color channel of image $\mathbf{Z}_1$ to that of image $\mathbf{Z}_2$ and vice verse, respectively. *A pixel level similarity index*, $S_l(Z_{1,l}(i,j), Z_{2,l}(i,j))$, is defined as

$$S_l(Z_{1,l}, Z_{2,l}) = \begin{cases} \frac{2\Lambda_{1,2,l}(Z_{1,l})Z_{2,l}+1}{\Lambda^2_{1,2,l}(Z_{1,l})+Z^2_{2,l}+1}; & \text{if } Z_{1,l} \text{ is more reliable} \\ \frac{2Z_{1,l}\Lambda_{2,1,l}(Z_{2,l})+1}{Z^2_{1,l}+\Lambda^2_{2,1,l}(Z_{2,l})+1}; & \text{otherwise} \end{cases}. \tag{1}$$

The function of IMFs $\Lambda_{1,2,l}(z)$ and $\Lambda_{2,1,l}(z)$ is to improve the robustness of the proposed index with respect to scale changes between $Z_{1,l}(i,j)$ and $Z_{2,l}(i,j)$.

2) An IMF Based Robust Movement Detection

Let n_0 be the total number of LDR images. A middle image, $\mathbf{Z}_{k_0}$, is selected as a basis for the movement detection. All pixels in $\mathbf{Z}_{k_0}$ are marked as valid. Pixel $Z_k(i,j)$ in the kth $(1 \le k \le n_0, k \ne k_0)$ image is marked as valid if the similarities between all color channels of $Z_k(i,j)$ and those of its co-located pixel $\widehat{Z}_k(i,j)$ in the reference image are high, i.e.,

$$S_l(Z_{k,l}(i,j), \widehat{Z}_{k,l}(i,j)) > \text{Thr}_{k,l}(i,j) \triangleq \frac{2\xi_{k,l}(i,j)}{1+\xi^2_{k,l}(i,j)}, \tag{2}$$

where the value of $\xi_{k,l}(i,j)$ is $(\frac{15}{16} - \max\{\epsilon(Z_{k,l}(i,j)), \epsilon(\widehat{Z}_{k,l}(i,j))\}\varrho(k, \text{Ref}(k)))$, $\text{Ref}(k)$ corresponds to the exposure time of the reference image of image k, $\varrho(k, \text{Ref}(k))$ is $\sqrt{\max\{\Delta t_k, \Delta t_{\text{Ref}(k)}\}/\min\{\Delta t_k, \Delta t_{\text{Ref}(k)}\}}$, and the scale factor $\epsilon(z)$ is defined as

$$\epsilon(z) = \begin{cases} \frac{1}{128}(1-\frac{2z}{255})^{(\frac{z}{17})^{16}}; & \text{if } z > 127 \\ \frac{1}{16}(1-\frac{2z}{255})^{(50-\frac{10z}{51})^{16}}; & \text{otherwise} \end{cases}. \tag{3}$$

The values of $\Lambda_{k,\text{Ref}(k),l}$ and $\Lambda_{\text{Ref}(k),k,l}$ are computed by using the accumulated histograms of the kth image and its reference image [Grossberg and Nayar 2003]. All LDR images are processed in the order of $(k_0-1), \cdots, 1, k_0, (k_0+1), \cdots, n_0$. Since the correlation between two successive images is the strongest, the reference image is updated after checking all pixels in the current image. All valid pixels are adopted to replace their co-located pixels in the reference image. The IMFs are used to synthesize pixels to replace other pixels in the reference image. The updated reference image is applied to classify all pixels of the subsequent image.

In the remaining part of this poster, we shall verify the proposed movement detection scheme by combining it with the scheme in [Debevec and Malik 1997] to form a framework for the synthesis of HDR images. This framework is suitable for both static and dynamic scenes. To illustrate the efficiency of the combined framework, we compare it with three commercial softwares [FDRTOOLS, PHOTOMATIX, and QTPFSGUI 2009] by testing an image sequence that is composed of 11 images with waiving leafs. It is shown in Fig. 1 that ghosting artifacts, due to moving leafs, are not removed by using these commercial softwares, especially by the QTPFSGUI. However, they are removed by our method.

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