

Contributions

- We introduce a novel approach for tone mapping High Dynamic Range (HDR) images using contrast measures derived from Local Binary Patterns (LBPs) namely **1)** contrast by difference of means and **2)** contrast by variance. The main motivation for choosing LBP is its computational simplicity.
- We have employed the extended version of LBPs which uses circular neighbourhood [2].
- Advantages of using circular neighborhood:
 - ▷ Circular neighbourhood gives the liberty to have high sampling density as opposed to traditional sampling methods where the choices for sampling density are limited.
 - ▷ The measures obtained from circular neighbourhood are more symmetric compared to those obtained from square neighbourhood.
 - ▷ The radius of the circular neighbourhood can be varied according to the texture of the image.

Methodology

1 Extraction of luminance channel: The luminance channel of the HDR image I is extracted using the following relation:

$$L = 0.2126I_R + 0.7152I_G + 0.0722I_B \quad (1)$$

2 Computation of contrast measure: A circular neighbourhood of radius R is computed for each pixel in the luminance channel and sampled into P pixels. The contrast corresponding to the central pixel is measured in the following ways [2]:

- **Contrast by difference of means:** Contrast = mean(intensity values higher than or equal to that of central pixel) - mean(intensity values lower than that of central pixel).
- **Contrast by variance:** Let g_p denote the intensity values of the pixels in circular neighbourhood. The contrast measure based on variance (var) is given by:

$$var = \frac{1}{P} \sum_{p=0}^{P-1} (g_p - \mu)^2, \quad \text{where} \quad \mu = \frac{1}{P} \sum_{p=0}^{P-1} g_p \quad (2)$$

3 Histogram adjustment of contrast measure: C denotes the value of the contrast threshold corresponding to which there is steep decline in the number of pixels in the histogram. The contrast values between 0 and C are scaled to the range $0 - 1$ and the values higher than the threshold C are clamped to 1.

4 Design of kernel and Generation of tone mapped image: A Gaussian kernel is applied on the luminance channel in the logarithmic domain. The Gaussian kernel is given by:

$$\phi(c) = \frac{\alpha}{\sigma\sqrt{2\pi}} e^{\left(\frac{-c^2}{2\sigma^2}\right)} \quad (3)$$

σ and α are the parameters controlling the amount of local and overall contrast respectively in the tone mapped image.

$$L_{new} = e^{\phi(c) \ln(L)} \quad (4)$$

The tone mapped LDR image is obtained using the equation:

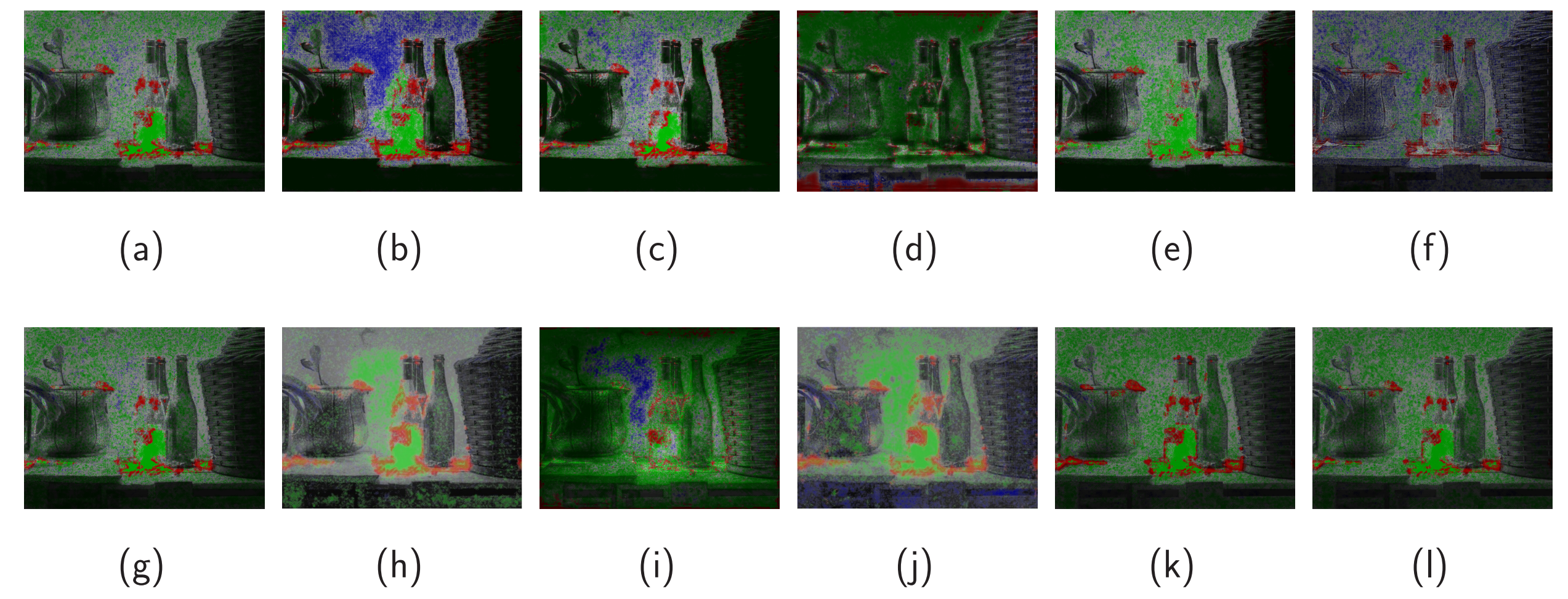
$$I_{R_{new}} = \left(\frac{L_{new}}{L}\right) I_R, \quad I_{B_{new}} = \left(\frac{L_{new}}{L}\right) I_B, \quad I_{G_{new}} = \left(\frac{L_{new}}{L}\right) I_G \quad (5)$$

Results

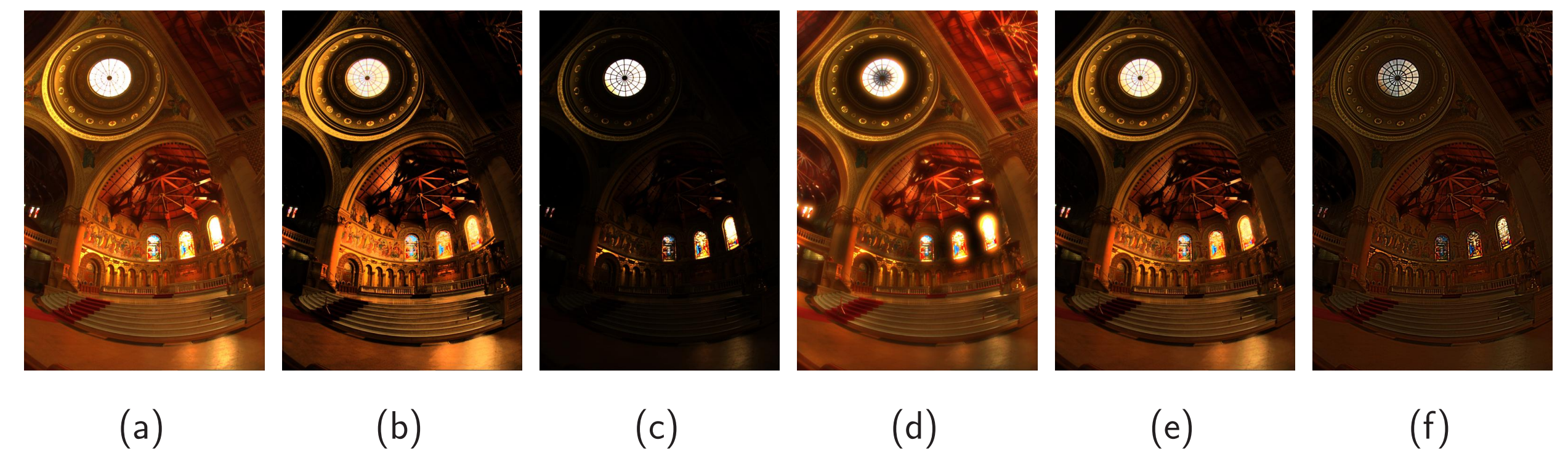


1. The input HDR image is BottlesSmall.hdr. (a) TumblinRushmeierTMO (CMax = 1), (b) WardHistAdjTMO (nBin = 100), (c) DragoTMO (Dragob = 0.1), (d) ChiuTMO (k = 5), (e) ReinhardTMO(pLocal = 1), (f) AshikhminTMO (LdMax = 1), (g) DuarandTMO (CMax = 85), (h) DurandTMO (CMax = 55), (i) FattalTMO (fBeta = 0.95), (j) YeeTMO (nLayer = 64), (k) Proposed MeanTMO ($\sigma = 0.5$, $\alpha = 0.5$), (l) Proposed VarianceTMO ($\sigma = 0.5$, $\alpha = 0.5$).

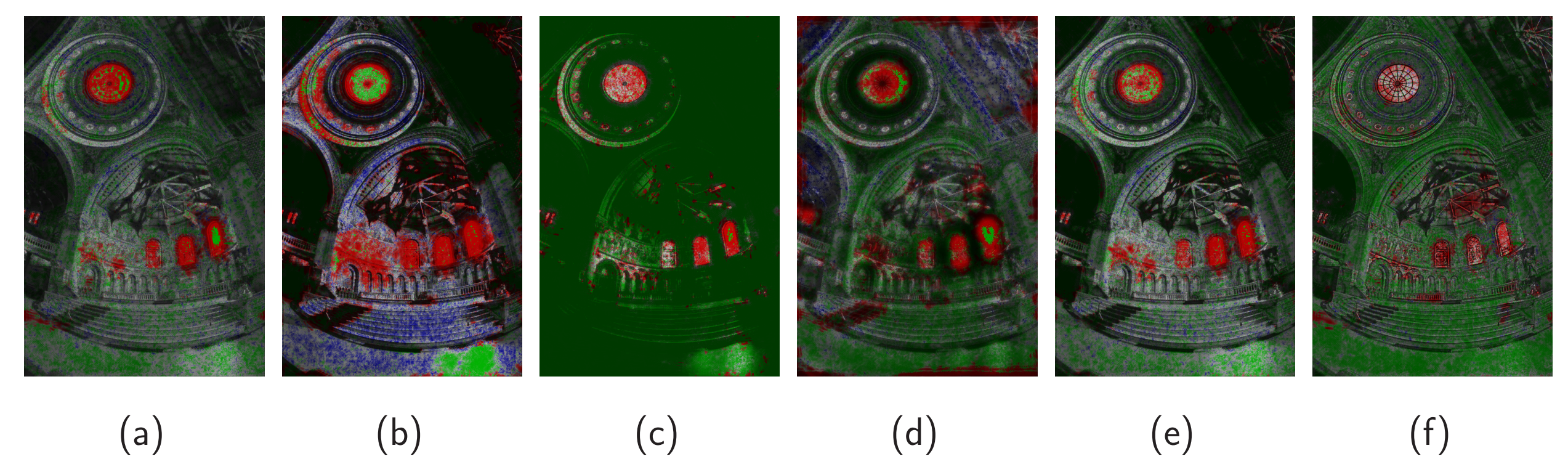
Results



2. Dynamic Range (ln)dependent Metrics comparison results for corresponding TMOs in figure 1. The color code of the metric is given in figure 6.



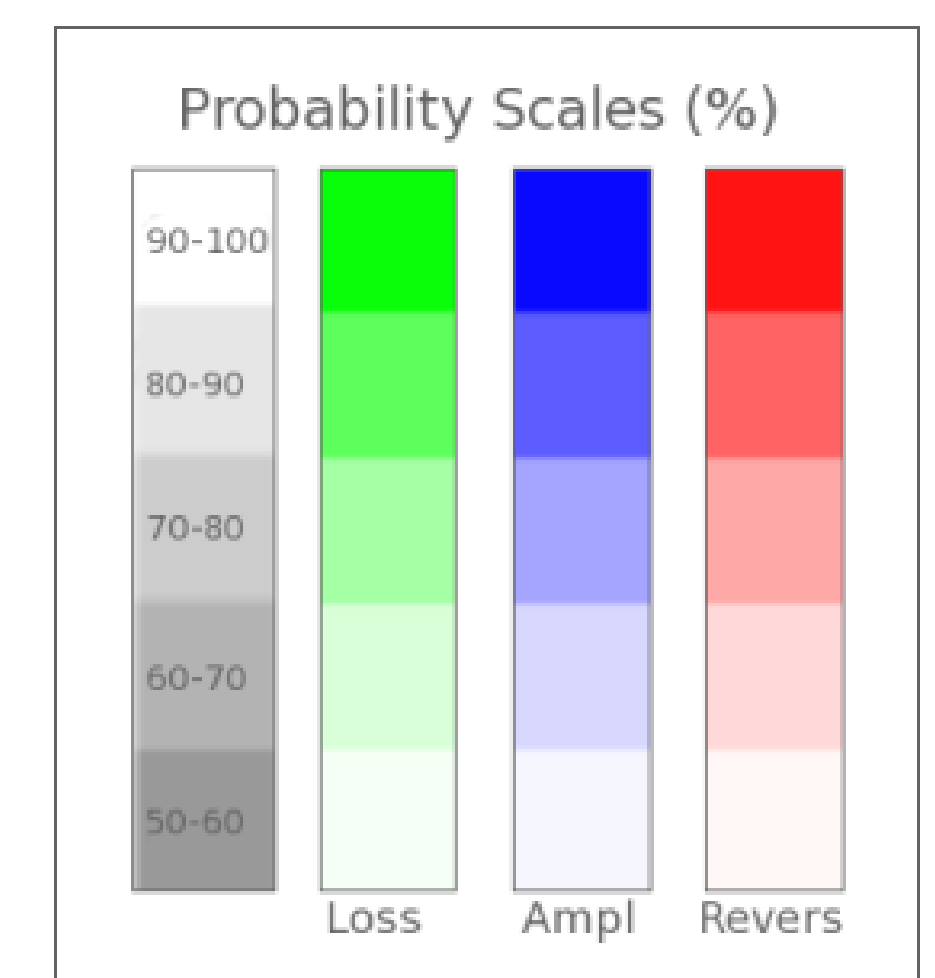
3. The input HDR image is Memorial.hdr. (a) TumblinRushmeierTMO (CMax = 1), (b) WardHistAdjTMO (nBin = 100), (c) DragoTMO (Dragob = 0.1), (d) ChiuTMO (k = 5), (e) ReinhardTMO (pLocal = 1), (f) AshikhminTMO (LdMax = 1), (g) DuarandTMO (CMax = 85), (h) DurandTMO (CMax = 55), (i) FattalTMO (fBeta = 0.95), (j) YeeTMO (nLayer = 64), (k) Proposed MeanTMO ($\sigma = 0.5$, $\alpha = 0.5$), (l) Proposed VarianceTMO ($\sigma = 0.5$, $\alpha = 0.5$).



4. Dynamic Range (ln)dependent Metrics comparison results for corresponding TMOs in figure 3. The color code of the metric is given in figure 6.

| Name of TMO | BottlesSmall | Memorial |
|---------------------|--------------|----------|
| TumblinRushmeier | 1.71 | 1.49 |
| WardHistAdj | 1.30 | 1.45 |
| Drago | 1.04 | 1.41 |
| Chiu | 13.72 | 10.26 |
| Reinhard | 1.62 | 1.53 |
| Ashikhmin | 3.97 | 2.75 |
| Durand (CMax = 85) | 7.72 | 5.47 |
| Durand (CMax = 55) | 6.80 | 5.73 |
| Fattal | 9.43 | 6.74 |
| Yee | 172.54 | 190.64 |
| Mean (Proposed) | 16.89 | 22.53 |
| Variance (Proposed) | 14.08 | 9.12 |

5. Execution time in seconds



6. DRIM Index [1]

Conclusions

- The proposed approach works well for bright as well as dark regions of the scene irrespective of the amount of contrast present in those scenes.
- The operators are comparable to the existing operators in terms of execution time while using only two variable parameters.
- Future work includes incorporation of wavelets and filter banks to process high pass and low pass coefficients separately in order to overcome loss and reversal of contrast.

References

- [1] Tunç Ozan Aydin, Rafał Mantiuk, Karol Myszkowski, and Hans-Peter Seidel. Dynamic range independent image quality assessment. In *ACM Transactions on Graphics (TOG)*, volume 27, page 69. ACM, 2008.
- [2] Matti Pietikäinen. *Computer vision using local binary patterns*. Springer, 2011.