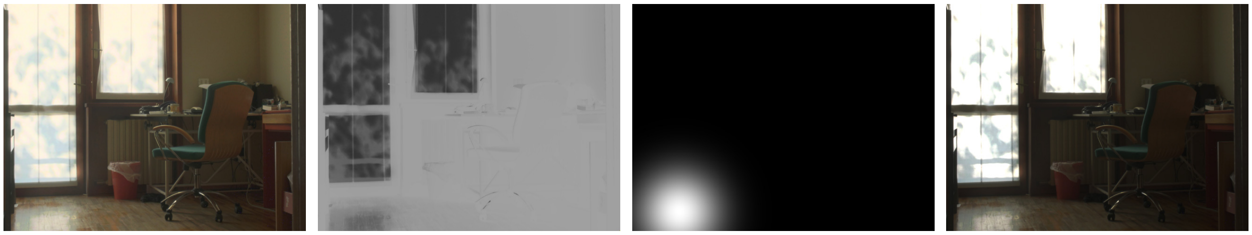
Æ-HDR: an Automatic Exposure Framework for High Dynamic Range Content

Francesco Banterle*
University of Warwick

Paolo Banterle†
University of Siena



(a) Tone Mapped HDR image (b) Exposure Map E_{map} (c) The density function $p(i,j)$ (d) The final result

Abstract

Automatic exposure (AE) is a common method implemented in consumer cameras to calculate the best exposure that tries to minimize under and over exposed pixels for a scene. We present a generalized framework for an AE algorithm for high dynamic range (HDR) imaging inspired by tone mapping operators (TMO) and pointing devices. Compared to other methods such as [Neumann et al. 1998] we propose a more general framework and an approach that enables exploring images and videos in different areas of the image/frame.

Keywords: High Dynamic Range Imaging, Tone Mapping

1 The Framework

Our framework can be divided in three steps: exposure map calculation, exposure calculation and motion stabilization. During exposure calculation the objective is to calculate the correct exposure for each pixel. Firstly the HDR luminance L_w is tone mapped to L_d using a TMO, Photographic operator [Reinhard et al. 2005] with automatically estimated parameters. Secondly, the exposure map is calculated as $E_{map} = L_w/L_d$. In the second part, we calculated the final exposure that will be used for scaling the HDR image. We decided to calculate the final exposure as a weighted average of a region of interest (ROI), with an arbitrary shape, that needs to be analyzed. The use of only the exposure in the center C of the ROI could cause flickering if C takes a high luminance value during video playback. We defined a density function $p(i,j) \in (0,1]$ in the ROI and $p(i,j) = 0$ outside it, which represents weights for the average. The value of $p(i,j)$ is normalized ($\int p(i,j)didj = 1$). So the final exposure e is defined as $e = \sum_{i,j} p(i,j)E_{map}(i,j)$. In our implementation we used a circle as the ROI with position (c_x, c_y) and radius $r = \min(w,h)/10$ where w and h are respectively the width and height of the image. Finally the density function was modeled with a Gaussian function $p(i,j) = \frac{1}{\sigma\sqrt{2\pi}} \exp(-(i-c_x)^2 + (j-c_y)^2/2\sigma^2)$ where $\sigma = r/3$. When the ROI is moved fast between a very dark region and a very bright region, flickering can occur. To avoid this problem we introduced motion stabilization as the last step of our framework. We modeled it using a simple average of n exposures calculated in the last $1/4$s, a value that we found to give good results from our experiments. The new exposure is calculated as follows $e' = \sum_{i=0}^{n} e_i \exp(-(\frac{i}{n})^2/(2\sigma_t^2))$, where e_0 is the current exposure, and $\sigma_t^2 = 0.25$ is the temporal variance. The main application of our framewrok is an easy tool for exploring HDR images or videos. Moving the ROI with a pointing device enables users to visualize regions of interest without the problem of changing the exposure for an areas that is needed to explore. Furthermore the application of an eye-tracker would improve the experience allowing automatic pointing and simulating real world experience. The advantages are mainly two: reduction of color shifting caused by TMOs and speed because only a linear slice of information is needed for each ROI . We implemented our framework on the GPU using shader model 3.0, and it performed more than 200fps for images and videos at 1080p on an Intel Pentium 4 HT 2.8GHz, 1Gb of Ram, and GeForce 7800 with 256 Mb of ram. A second possible application is the visualization of HDR images or video on an HDR display. As shown in [Akyüz et al. 2007] a LDR image or video can provide an HDR experience using inverse tone mapping [Banterle et al. 2006]. Therefore, an AE for HDR images/videos can be a proper solution. Furthermore, our framework can be seen as a compression tool, indeed HDR content can be processed using our framework and stored using common LDR standards. In particular for HDR videos the ROI can be positioned in a way that follows a particular object or a path, for keeping its details using tracking algorithms or matting masks.

*e-mail: f.banterle@warwick.ac.uk
†e-mail: banterle@unisi.it

References

AKYÜZ, A. O., FLEMING, R., RIECKE, B. E., REINHARD, E., AND BÜLTHOFF, H. H. 2007. Do hdr displays support ldr content?: a psychophysical evaluation. *ACM Trans. Graph. 26*, 3, 38.

BANTERLE, F., LEDDA, P., DEBATTISTA, K., AND CHALMERS, A. 2006. Inverse tone mapping. In *GRAPHITE '06: Proceedings of the 4th international conference on Computer graphics and interactive techniques in Australasia and Southeast Asia*, ACM, New York, NY, USA, 349–356.

NEUMANN, L., MATKOVIC, K., AND PURGATHOFER, W. 1998. Automatic exposure in computer graphics based on the minimum information loss principle. In *CGI '98: Proceedings of the Computer Graphics International 1998*, IEEE Computer Society, Washington, DC, USA, 666.

REINHARD, E., WARD, G., PATTANAIK, S., AND DEBEVEC, P. 2005. *High Dynamic Range Imaging: Acquisition, Display and Image-Based Lighting*. Morgan Kaufmann Publishers, December.

SIGGRAPH 2008, Los Angeles, California, August 11–15, 2008.
ISBN 978-1-60558-466-9/08/0008