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# Enhanced local tone mapping for detail preserving reproduction of high dynamic range images

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**Abstract** — *Enhanced Local Tone Mapping (ELTM) is a flexible tone mapping operator designed to provide a good global and local contrast simultaneously over various test scenes. Also, it has intuitive and decoupled tuning interface, providing the user with full control over final image appearance. ELTM is based on detail/base layer decomposition compressing the base plane in both linear and logarithmic domain. This provides robustness to ELTM, while modified tone compression function provides good local contrast. Results were validated using set of images with various content, brightness and resolution. In this testing ELTM performed as the best tone mapping operator, among 7 state-of-the-art global and local tone mapping operators. Even better overall results are achieved by using proposed brightness control, to handle extreme scenes. Robustness and flexibility to achieve desired appearance makes ELTM suitable for applications where user experience is the primary concern as is the case with consumer electronics products.*

## I. INTRODUCTION

Luminance variation in real world scenes is very high and can span 10 orders of magnitude. While the human eye can simultaneously perceive the contrast of about 4 orders of magnitude, current consumer cameras are able to capture only a limited portion of this dynamic range, which is approximately 2-3 orders of magnitude. Recently devised sensors are able to capture more of the scenes' dynamic range. These sensors are usually based on differently exposed sensor elements, which allows them to simultaneously capture the dark and bright parts of the scene. The high dynamic range (HDR) of the scene can also be captured with an ordinary low dynamic range (LDR) camera by combining multiple images taken with different exposure settings [1].

Although the aforementioned approaches are able to capture HDR scenes, there is a problem of reproduction of these images on standard display devices. Current commercial displays are able to reproduce images with a contrast of 2 orders of magnitude. There are prototype displays with much larger dynamic range, but this technology is still developing. Hence, to enable HDR image reproduction on ordinary LDR displays, an image needs to be processed using a tone mapping operator.

Tone mapping operators provide contrast reduction of HDR images while preserving image features as much as possible. These operators are, based on spatial adaptability, divided into two main categories: global and local operators.

Global operators apply the same mapping function to all image pixels, providing simplicity in implementation, and good global contrast. Unfortunately, global operators tend to suppress details in highlighted regions.

Local operators adapt to local luminance values, applying different mapping to each pixel, thus preserving details much better. Along with complexity local operators can produce several undesirable artifacts: halo artifacts, poor global contrast, surreal effect, etc.

In consumer electronics there is a constant need to provide users with the best subjective image quality. While some subjective image quality properties, such as global/local contrast, details strength, colorfulness, are defined, there are different opinions regarding which setting makes the best subjective impression. Hence, it is very important that the tone mapping operator intended for consumer electronics has the ability of easy tuning for desired image appearance. This enables companies or even the end user to adjust tone mapping settings in order to achieve the image quality goals for their specific device.

Enhanced local tone mapping operator (ELTM), presented in this paper, preserves and enhances details while providing good overall global contrast by maximally using the available output dynamic range. Thus, while it formally belongs to the group of local tone mapping operators, ELTM is actually positioned between global and local tone mapping operators, taking the best features from both approaches. ELTM also provides a set of decoupled tuning parameters, which give intuitive interface for achieving the desired output appearance.

## II. RELATED WORK

Human visual system (HVS) has a highly nonlinear response to light intensity variations. The Weber-Fechner law defines this characteristic as logarithmic, which is why logarithm and power based functions are one of the most used function families for global tone mapping. Global tone mapping operators [2]-[6] apply the same mapping function to all image pixels. Although these operators have very efficient realizations and are robust, they do not perform well when it comes to

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