Title:

Biologically-inspired tone mapping

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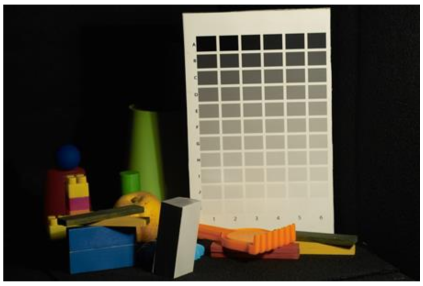
Summary:

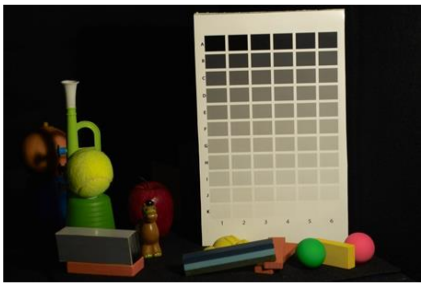
The processing of high dynamic range images into lower dynamic range representations is something that the human visual system easily does all the time. However, this task (i.e. Tone Mapping or TM) is very difficult for machines. Our aim is to apply well-known primate visual mechanisms to tone-mapping algorithms to improve their performance.

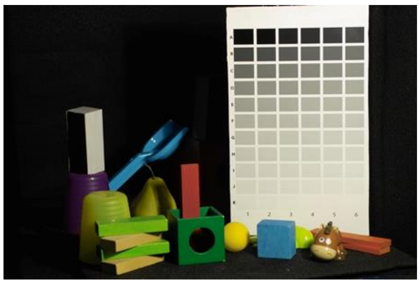
Extended abstract:

In almost all naturalistic viewing situations, we are immersed in scenes that could be described as High Dynamic Range (HDR), in other words, the intensity difference between the brightest and the darkest patch is much higher than the difference both imaging and capturing devices can faithfully capture. For instance, the energy ratio between sunlight and starlight is approximately about 100,000,000 to 1 (one Giga to 10). If the Human Visual System (HVS) was to linearly represent these extreme differences in its normal daylight operation, it would require a much larger sensitivity range for its retinal sensors (cones) and neural pathways than is achievable within biological limitations. Instead, millions of years of evolution have solved this problem by adapting the sensorial and neural machinery, allowing it to non-linearly convert the large natural intensity range into a much smaller range of about 10,000 to 1.

Background: In engineering terms, an image is said to be high dynamic range (HDR) when its dynamic range exceeds that of the display device by far. Displaying an HDR image on a relatively low dynamic range (LDR) device often results in perceived changes with respect to the original scene and doing it in a way that closely matches human perception is a nontrivial task [1]. The purpose Tone Matching Operators (TMO) is to capture the characteristics of HDR images that are necessary to ensure a faithful reproduction when displayed on LDR devices. To this end, many elegant TM solutions have been proposed, from simple logarithmic compressions of the dynamic range (gamma or sigmoid functions) to more sophisticated local TM algorithms that exploit the context information to increase the local contrast. These algorithms can be classified according to their internal operations into “local-information based” or “global-information based”.







Tone Mapping in the brain is achieved through a complex visual machinery that includes neurons in the primate primary visual cortex (V1) conducting dynamic centre-surround computations. Simulations of these dynamic centre-surround mechanisms have been shown to improve the state-of-the-art in areas such as *colour constancy* [2] and *boundary detection* [3] and it is also likely that they also contribute to compress the information on a high dynamic range scene to preserve its details. For example, a cortical processing mechanisms based on two Gaussian functions whose kernels and weights dynamically adapt according to the centre-surround contrast, is likely to reduce halo artefacts and effectively enhance the local details of bright and dark parts, and therefore contribute build to an optimal TM operation.

To do: We expect the MSC candidate to create a TM algorithm based on dynamic centre-surround computations of the Akabarinia and Parraga model [2] and test it computationally and psychophysically against other methods.

References:

1. Cerda-Company X, Parraga CA and Otazu X (2018) Which tone-mapping operator is the best? A comparative study of perceptual quality. J. Opt. Soc. Am. A.
2. Akbarinia and C. A. Parraga. Colour constancy beyond the classical receptive field. TPAMI, 2017
3. Akbarinia A and Parraga CA (2017) Feedback and Surround Modulated Boundary Detection. Int. J. Comp. Vis. 126.