Demo: Image Sensing Scheme Enabling Fully-Programmable Light Adaptation and Tone Mapping with a Single Exposure

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ABSTRACT

This demo showcases a High Dynamic Range (HDR) technique recently reported. We demonstrate that two intertwined photodiodes per pixel can perform tone mapping under unconstrained illumination conditions with a single exposure. The proposed technique has been implemented on a prototype smart image sensor achieving a dynamic range of 102dB. It opens the door to the realization of smart cameras and vision sensors capable of rendering HDR images free of artifacts without requiring any digital post-processing at all.

CCS Concepts

• Hardware → Communication hardware, interfaces and storage → Displays and imagers • Computing methodologies → Computer vision → Image and video acquisition.

Keywords

High dynamic range; split-diode; adaptive image capture; tone mapping.

1. INTRODUCTION

Distributed smart cameras have to deal with a wide range of illumination conditions in unstructured environments. In application scenarios where objects move at high speed – e.g. traffic surveillance, automotive vision systems etc. –, traditional HDR techniques [1] are not suitable. They give rise to artifacts caused by motion, light flicker, etc. during the cumbersome process of rendering the final image. In turn, those artifacts can mislead actuators working on the outcome of the scene analysis. In order to reach the required performance in those scenarios, the imaging industry is departing from standard solutions where reducing the pixel pitch – i.e. reaching the maximum possible image resolution – is the primary design driver. A representative example is the split-diode HDR technique recently reported [2]. This approach features dual concurrent exposure, with a large photodiode for high sensitivity and a small one for low sensitivity.

In this demo, a two-photodiode HDR technique also recently proposed [3] will be showcased. Unlike in [2], a single exposure suffices in our case, with the large photodiode sensing the pixel value itself and the small one enabling the concurrent tunable balance between local and global adaptation. As a result, the HDR image representation is available at the focal plane without requiring further processing. Smart cameras and vision sensors can clearly benefit from this early representation by unrestrictedly exploiting parallel image processing at any point of the signal processing chain.

2. EXPERIMENTAL SETUP

The same prototype smart image sensor, test board and OpenCV-based software environment described in [4] will be used for this live demo. A reconfiguration loop is implemented between our prototype and an ad-hoc image processing algorithm, as depicted in Fig. 1. The parameter T_s encoding the tunable balance between local and global illumination as described in [3] is readjusted on-line in order to adapt the sensor response to the content of the scene. The FPGA reconfigures the control signals of the sensor chip for the next frame to be captured accordingly.

During the demo, the visitors will witness how our sensor performs in comparison with the camera embedded within an iPad mini. A HDR scene will be generated by moving a picture of Lena just in front of a lamp, as shown in Fig. 2(a). It will be demonstrated that the proposed technique can retrieve more details from highly illuminated areas than the camera module of the iPad. An example of the resulting outcome in both systems is depicted in Fig. 2(b). Other HDR scenes could also be set up in the demo booth according to visitors' requirements.

3. CONCLUSIONS

An image sensing scheme capable of linearly adapting to any possible illumination conditions with a single exposure is experimentally showcased in this demo. This HDR technique simultaneously fulfills three characteristics not reported to coincide in any previous approach, to the best of our knowledge. First, a single exposure suffices to generate the HDR image representation. This significantly reduces motion artifacts when compared to multi-exposure techniques. Second, such representation is available for readout or further processing at the very focal plane. Smart cameras and vision sensors can clearly benefit from this feature by exploiting parallel processing at any point of the signal chain. And third, it affords the use of standard Active Pixel Sensor (APS) structures for high-quality image capture.

ACKNOWLEDGMENTS

This work was supported in part by the Spanish Government through Project TEC2015-66878-C3-1-R MINECO (co-funded by ERDF-FEDER), in part by Junta de Andalucía through Project

P12-TIC 2338 CEICE, in part by CNPq/Brazil under Research Grant 204382/2014-9, and in part by the Office of Naval Research (USA) under Grant N000141410355.

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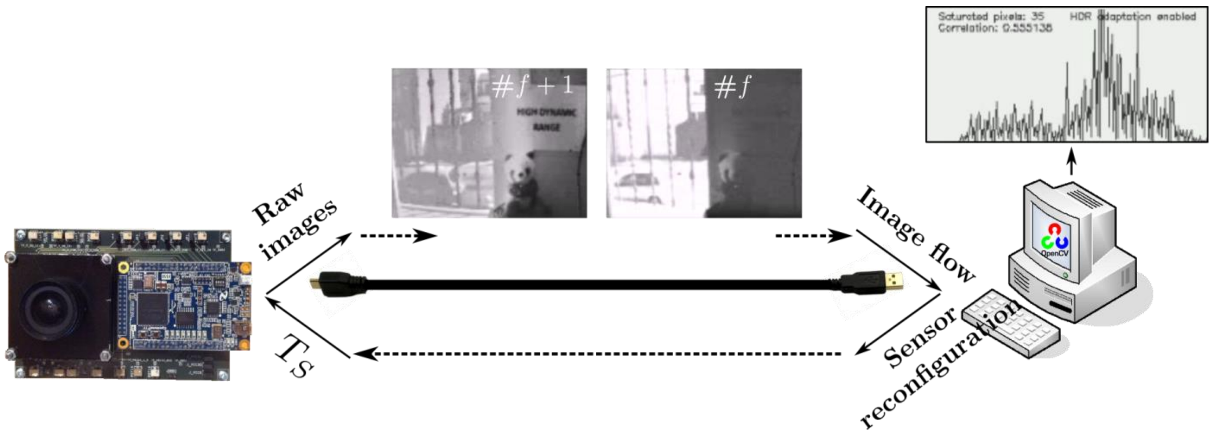

Fig. 1. Reconfiguration loop between our prototype smart image sensor and an ad-hoc OpenCV-based algorithm. The parameter T_s described in [3] is thus adjusted according to the sensor response and the content of the scene.

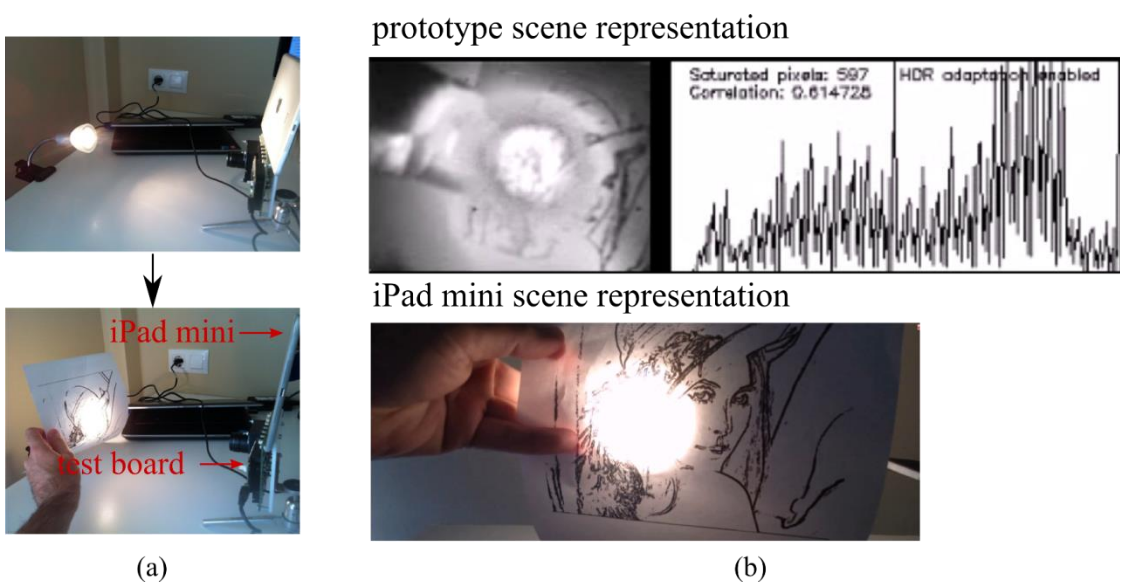

Fig. 2. (a) A HDR scene will be generated by moving a picture of Lena just in front of a lamp; (b) the output provided by our sensor with a single exposure contains more details from highly illuminated areas than the output rendered by the camera module of an iPad mini.