Electronic Letters on Computer Vision and Image Analysis 0(0):1-7, 2000

Single Sensor Multi-Spectral Imaging

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Date and location of PhD thesis defense: 27 September 2019, Universitat Autònoma de Barcelona

Received 1 January 2000; revised 1 January 2000; accepted 1 January 2000

Abstract

This dissertation presents the benefits of using a multispectral Single Sensor Camera (SSC) that, simultaneously acquire images in the visible and near-infrared (NIR) bands. The principal benefits while addressing problems related to image bands in the spectral range of 400 to 1100 nanometers, there are cost reductions in the hardware setup because only one SSC is needed instead of two; moreover, the cameras' calibration and images alignment are not required anymore. Concerning to the NIR spectrum, even though this band is close to the visible band and shares many properties, the sensor sensitivity is material dependent due to different behavior of absorption/reflectance capturing a given scene compared to visible channels. Many works in literature have proven the benefits of working with NIR to enhance RGB images (e.g., image enhancement, dehazing, etc.). In spite of the advantage of using SSC (e.g., low latency), there are some drawbacks to be solved. One of these drawbacks corresponds to the nature of the silicon-based sensor, which in addition to capturing the RGB image when the infrared cut off filter is not installed it also acquires NIR information into the visible image. This phenomenon is called RGB and NIR crosstalking. This thesis firstly faces this problem in challenging images and then it shows the benefit of using multispectral images in the edge detection task.

Then, three methods based on CNN have been proposed for edge detection. While the first one is based on the most used model, holistically-nested edge detection (HED) termed as multispectral HED (MS-HED), the other two have been proposed observing the drawbacks of MS-HED. These two novel architectures have been designed from scratch; after the first architecture is validated in the visible domain a slight redesign is proposed to tackle the multispectral domain. A dataset is collected to face this problem with SSCs. Even though edge detection is confronted in the multispectral domain, its qualitative and quantitative evaluation demonstrates the generalization in other datasets used for edge detection, improving state-of-the-art results. One of the main properties of this proposal is to show that the edge detection problem can be tackled by just training the proposed architecture one-time while validating it in other datasets.

Key Words: Multispectral single sensor camera, RGB-NIR, NIR, image processing, deep learning, color restoration, edge detection.

Experimental Results

Since the publication of the boundary detection datasets (BSDS: Berkeley Segmentation DateSet), back in 2004—BSDS300 and 2011—BSDS500 [5, 1], much deep learning based edge detectors [2] have used these

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Recommended for acceptance by <name>
ELCVIA ISSN:1577-5097
Published by Computer Vision Center / Universitat Autònoma de Barcelona, Barcelona, Spain

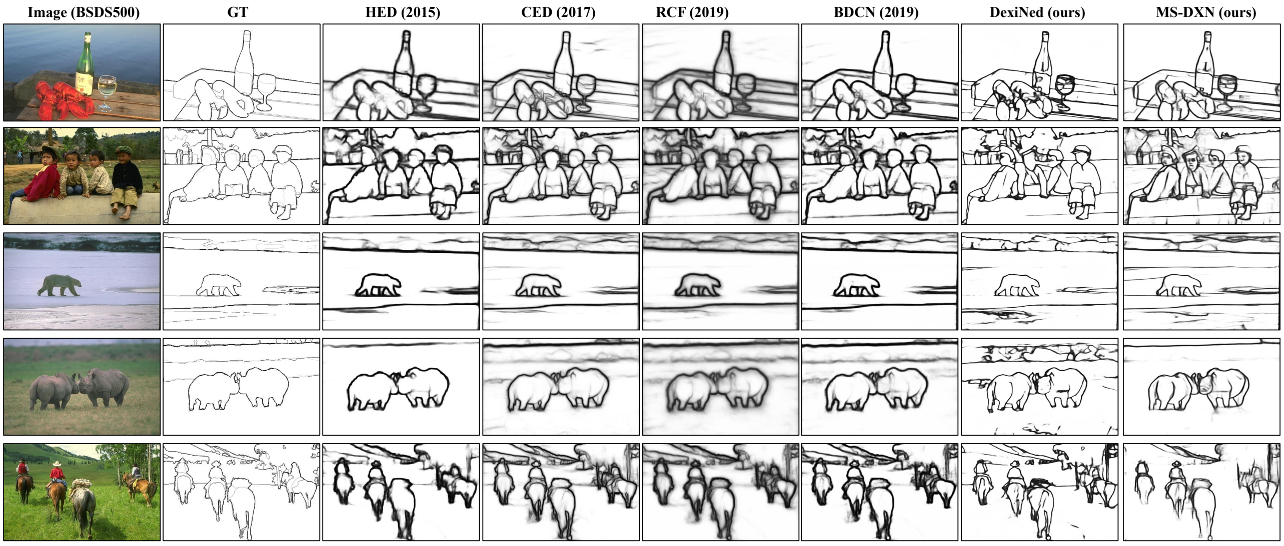

Figure 1: Qualitative comparison of proposed models and the state-of-the-art algorithms with BSDS dataset.

images for the training and later for their performance evaluation. Figure 1 presents a qualitative comparison with the proposed models DexiNed (Dense eXtreme Inception Network for Edge Detection) and MS-DXN (MultiSpectral Dense Extreme Inception Network) with the state-of-the-art methods (i.e., HED [8], CED [7], RCF [4], BDCN [3]). Looking the drawbacks presented in BSDS datasets, another dataset for edge detection has been collected termed as Multispectral Barcelona Images for Perceptual Edge Detection (MBIPED). The validation in the edge detection datasets has been conducted in MBIPED and the edge based subset of Multicue Dataset for Boundary Detection (MDBD) [6]. The extensive comparison can be obtained in the *chapter 5* of this thesis, which can be acquired in *.

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