

# CMOS IMAGE SENSOR SENSITIVITY IMPROVEMENT VIA CUMULATIVE CROSSTALK REDUCTION

Igor Shcherback<sup>1</sup>, Elad Gan<sup>1</sup>, Lior Blockstein<sup>2</sup>, Orly Yadid-Pecht<sup>1,2</sup>

1. Pixel-Scan, Ltd, 114 Midreshet Sde-Boker, 84990, Israel

[shcigor@gmail.com](mailto:shcigor@gmail.com)

[eladgan@gmail.com](mailto:eladgan@gmail.com)

Phone: 972-8-6255888/141

2. The VLSI Systems Center, Ben-Gurion University,

P.O.B 653, Beer-Sheva 84105, Israel

[blockstein@gmail.com](mailto:blockstein@gmail.com)

[oyp@ee.bgu.ac.il](mailto:oyp@ee.bgu.ac.il)

Phone: 972-8-6477257

Fax : 972-8-6477620

***Digest:*** The global distortion that occurs in CMOS Image Sensors (CIS) is manifested in information leakage from each and every physical pixel to its surroundings or crosstalk (CTK) that might be photonic (e.g., optical, chromatic), electronic or both. This leakage degrades the spatial frequency, reduces overall sensitivity, color separation, contrast, and leads to additional noise after the color correction procedure, which results in failed products. The problem becomes worse as the pixel pitch shrinks.

We have developed and present a generic technique for CIS cumulative CTK reduction which can be applied to any photosensors array situated on the common substrate.

In the proposed approach the captured signal is reoriented internally such that the photocarriers captured by the "wrong" pixels are "restored" to the pixel they initially originated from, and the "improved" image is re/constructed without additional signal loss. The developed generic technique suits both color and monochrome CISs inherently considering optical as well as electronic CTK in the array.

The developed methodology considers the CTK shares existing within the investigated pixel array as "known" (e.g., acquired by direct measurements by the spot light stimulation in three different wavelengths (e.g., red, green, and blue), covering the visible spectrum), and enables to improve the overall sensor performance, resolution and sensitivity, i.e., improve its color sensitivity (separation/tint), increase quantum efficiency, eliminate "green disparity" (the mutual disparity of the signals obtained from the "green" pixels situated adjacent to the "blue" and "red" pixels correspondingly), increase effective sensor resolution (enlarge effective pixel count, increase sharpness, contrast, reduce blooming, smear, etc). Moreover, the presented method does not amplify and/or add signal noise, while inherently reducing the imager system noise, it improves overall sensor SNR.

The proposed methodology was verified using a commercial advanced 2.2um pitch CIS camera, and is presented here as an example of the described technique applicability. Fig. 1 emphasizes the image quality and color rendering improvement achievable by the proposed method, as well as sensor SNR improvement. Fig. 2 and Fig. 3 show the significant effective resolution improvement, such that details (spatial frequencies) that are almost undistinguishable in the original pictures can be easily resolved after the cumulative CTK reduction. Fig. 2 also shows the improvement of the overall sensor sensitivity and contrast, blur reduction, etc. Fig.3 contains the evidence of the achievable color sensitivity improvement.

Note that current work is still in progress, and we intend to introduce additional results confirming the presented technology applicability.

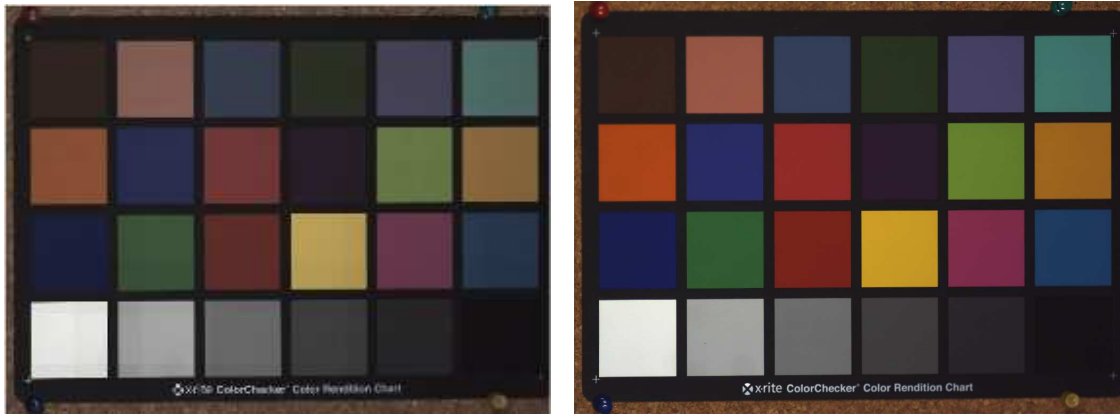


Fig. 1: Example of the proposed technology applicability; Color/Tint rendering Improvement: Left – image obtained from the sensor; Right - same image after the proposed crosstalk reduction. The same demosaicing method was used for both images. Note the reduction of the spatial noise viewable at the left (and caused mainly by the “green disparity”, which is eliminated). The relative  $\Delta E$  CIELab improvement (representing the improved color representation abilities of the sensor after CTK reduction) comes up to ~50% for certain colors.

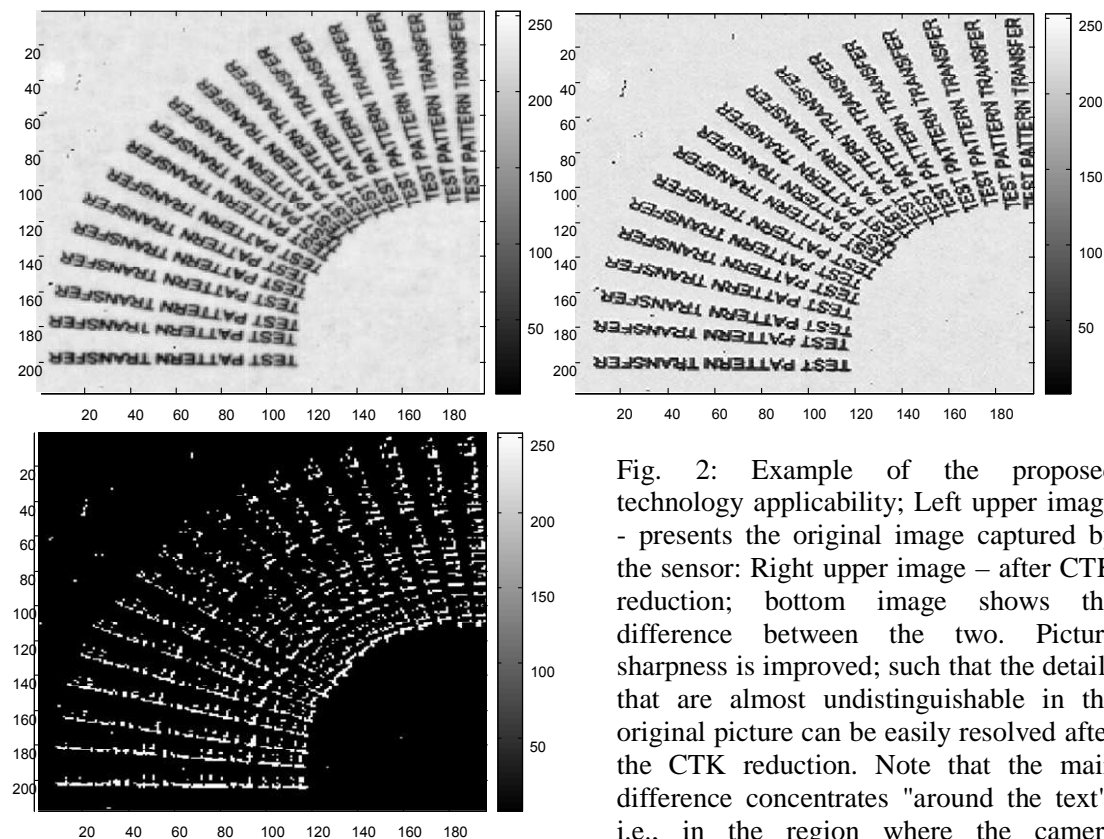


Fig. 2: Example of the proposed technology applicability; Left upper image - presents the original image captured by the sensor; Right upper image – after CTK reduction; bottom image shows the difference between the two. Picture sharpness is improved; such that the details that are almost undistinguishable in the original picture can be easily resolved after the CTK reduction. Note that the main difference concentrates "around the text", i.e., in the region where the camera resolution is damaged by CTK for the relatively high spatial frequencies range. Picture sharpness and contrast are also improved.

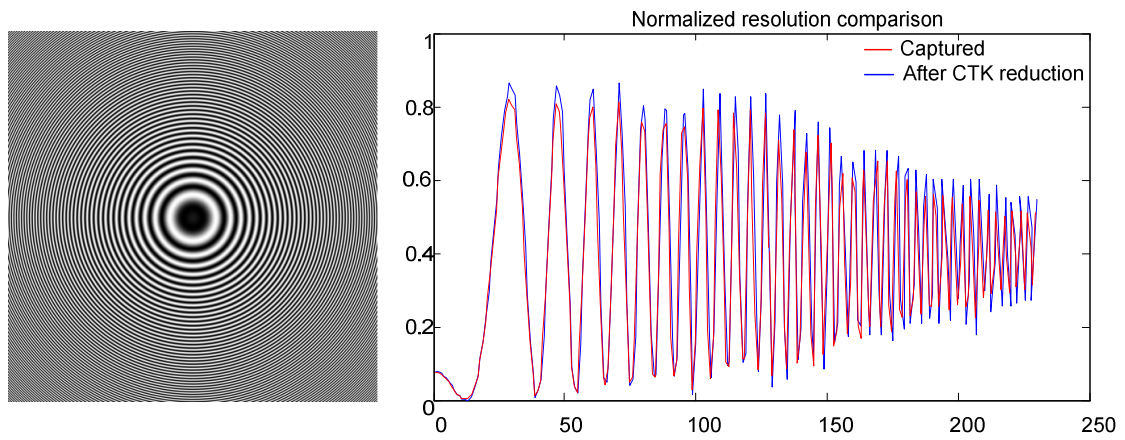


Fig. 3: Example of the proposed technology applicability: Left – circular diffractive-like image used for the sensor resolution checkup (aliasing is caused by the image shrink); Right - the normalized cross-sections comparison, i.e., from the captured image, and after CTK reduction. The intensity attenuation caused by the resolution fall with the spatial frequency (i.e., MTF) improvement after crosstalk reduction is evident especially for the higher frequencies range. Without loss of generality, the current example introduces the sensitivity and resolution improvement only for the RED color plane (i.e., after the same demosaic process was applied for both original and crosstalk-reduced images), such that higher signal obtained after CTK reduction correlates to the improved RED response. Similar results were obtained also for the Green and Blue sensor responses.