Global Scientific JOURNALS

GSJ: Volume 7, Issue 8, August 2019, Online: ISSN 2320-9186
www.globalscientificjournal.com

COLORIMETRIC CORRECTION OF CFA IMAGES FOR FOOD ANALYSIS

OUSMAN BOUKAR[1, 2,*], Gamraïkréo DJAOWE[1], Alban NGATCHOU[1], and Laurent BITJOKA[1, 2]

1-Laboratory of energy, signal, imaging and automation (LESIA), The University of Ngaoundere, Cameroon
2-National School of Agro-Industrial Sciences, P. O. Box 455, Ngaoundere, Cameroon.
** Corresponding author. E-mail: boukarousman@gmail.com*

ABSTRACT

Our main objective was to implement a dynamic color correction method applicable to any type of CFA image. To achieve this objective, we developed a set of mathematical equations based on numerical models. The implementation of these mathematical equations allowed us, by taking a white background as a reference, to restore all the colors that make up our product to be imaged, and in a second time to correct the imperfections related to the acquisitions of images. We also note that the noise related to the acquisition conditions and the interaction between the light and the product to be imaged were eliminated more than 95%.

KeyWords
CFA images, denoising, colorimetric correction.

Introduction

The benefits of an image will not really be realized and reliable measurements can only be obtained at the cost of a good correction. Correction or pretreatment is an essential step in image analysis; these are the only truly essential treatments in the agri-food industry [1]. Before specifying the different impairments affecting a raw image, as well as their origins and their possible corrections, it is necessary to redefine two very different and yet frequently confused notions: the signal and the noise [2]. A signal is a measurable quantity related to a state of a given object or physical phenomenon: temperature, speed, intensity, number of photons. One of the fundamental characteristics of a signal is to be reproducible: ideally, one should find it identical to itself in a series of measurements. We can classify the signals in two categories: on the one hand the useful signals, the ones we are trying to measure (for example the photons coming from a food product), and on the other hand the useless signals (that is, undesirable) that come into it (for example photons from the bottom of a food product). Being reproducible, an undesirable signal can be known by taking a measurement under conditions such that this signal is isolated (or easily isolatable). Since we can know it, we can eliminate it. Unfortunately, in our real world nothing is perfect, and every signal is degraded by multiple causes: nature of the signal itself, variations of the state of the object to be measured, inaccuracy and defects of the measuring instrument, parasites. In the end, several measurements will give, in the current case, similar but not identical results. The variations of the measured signal compared to the “average” signal represent the noise. One of the most important (and annoying) features of noise is its random nature: it is not reproducible. Not being able to reproduce it, we can not know it. Not being able to know it, we can not find the 'real' signal [3]-[5].

The role of the correction proposed in this paper is to get rid of the raw CFA image of unwanted signals that are present and that prevent it from being exploitable.

Methodological approach of correction of a raw CFA image

The correction of a raw CFA image is done in the reverse order of the successive alterations it has undergone. First, the offset image is used, followed by the thermal image. The corresponding signals being added to the photon signal, the operation to be performed is a pixel to pixel subtraction. The degradation to be corrected here being of a multiplicative nature (it is a sort of ‘gain’ to be compensated), the operation to be performed is a pixel to pixel division. In order to maintain intensity levels close to those of the raw image, the division is in practice accompanied of a multiplication by the average value ($\tilde{I}^{PLU}$) of PLU (uniform light range) image. Let $\tilde{I}^{CFA}$ the corrected CFA image. The fundamental equation of correction developped by Yang *et al.* [6] =is defined asfollows:

$$\tilde{I}^{CFA} = \frac{I^{CFA} - I^{Ther}}{I^{PLU} - I^{Off}} \bar{I}^{PLU} \quad (1)$$

We propose an approach that further simplifies equation 1 by multiplying each component of the CFA image by a specific coefficient, which corresponds to the gain to be compensated for each component; which results in the following equation 2:

$$\begin{bmatrix} \tilde{R} \\ \tilde{G} \\ \tilde{B} \end{bmatrix} = \begin{bmatrix} a & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & c \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (2)$$

Where a, b and c represente the correction coefficients. The consequences of missing or defective pretreatment are generally disastrous. When the CFA image is incorrectly corrected, pixels that are too bright, or too dark, appear in the image. The use of such an image for the analysis is then strongly compromised.

In practice, the parameters a, b, c depend on the image in presence; In this case, it is necessary to carry out empirical tests to determine a, b, and c.

Determination of parameters a, b, and c

To determine the parameters a, b, and c, we will choose a zone L of the CFA image I^{CFA} representing the white background. L is defined by:

$$L = \{ p(x, y) \in I^{CFA} / x \in [x_{min}, x_{max}], y \in [y_{min}, y_{max}] \} \quad (3)$$

With $\begin{cases} x_{max} - x_{min} = 19 \\ y_{max} - y_{min} = 19 \end{cases}$

The zone L designates a white zone of the background of the image I^{CFA} of which we have:

$$I^{CFA}(p) = I^{CFA}(q) = 255 \; \forall \, p, q \in L \quad (4)$$

Let $\bar{R}^L$ the means levels of the red colors levels of I^{CFA}, $\bar{G}^L$ the means levels of the green colors levels of I^{CFA}, and $\bar{B}^L$ the means levels of the blue colors levels of I^{CFA}. Theses means levels are defined as follow:

$$\bar{R}^L = \frac{1}{Card(R \cap L)} \sum_{p \in R \cap L} I^{CFA}(p)$$
$$\bar{G}^L = \frac{1}{Card(G \cap L)} \sum_{p \in G \cap L} I^{CFA}(p) \qquad (5)$$
$$\bar{B}^L = \frac{1}{Card(B \cap L)} \sum_{p \in B \cap L} I^{CFA}(p)$$

Let Rf the reference value. This reference value Rf is defined by:

$$R^f = \max\{\bar{R}^L, \bar{G}^L, \bar{B}^L\} \qquad (6)$$

The CFA image corrected as follows:

$$\begin{cases} \tilde{I}^{CFA}(p) = a.I^{CFA}(p)\ \forall\ p \in R \\ \tilde{I}^{CFA}(p) = b.I^{CFA}(p)\ \forall\ p \in G \\ \tilde{I}^{CFA}(p) = c.I^{CFA}(p)\ \forall\ p \in B \end{cases} \quad \text{with} \quad \begin{cases} a = \frac{\bar{G}_L}{\bar{R}^L} \\ b = \frac{\bar{G}_k^L}{\bar{G}^L} \\ c = \frac{\bar{G}_k^L}{\bar{B}^L} \end{cases} \qquad (7)$$

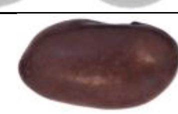
The CFA image corrected $\tilde{I}^{CFA}$ and the CFA image before correction I^{CFA} will have he respective coordinates as follow:

$$\tilde{I}^{CFA} = \begin{bmatrix} \tilde{R} \\ \tilde{G} \\ \tilde{B} \end{bmatrix} \text{ and } I^{CFA} = \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Biologicals Material used for CFA images acquisition

Two varieties of beans have been used for the acquisition images, and theses are presented in table 1.

Table 1. Bean samples used for our study.

Samples	Varieties	Captured images
Red beans	DOR701	
Speckled beans	MAC55	

Results and Discussion

The histograms of means levels of pixels of the white background before correction and after correction, for the different varieties of beans, are shown in Figures 1, 2, 3 and 4 below.

The histograms of the pixels levels of the white background before correction of CFA images, shown in figures 1 and 2, show that the levels of the pixels of the neutral zone are not uniform. The means pixels levels are well very less than the value of the white reference which is 255. These non-uniform values of white background pixels confirm the results reported by Pérez *et al.* [7]; the results reported by these authors show that the interactions between light and the objet capture degrade the quality of the image, therefore it affects the pixel levels. However, the green pixels levels are higher than the red and blue pixels levels. Blue pixels have the lowest levels. These differences in white background pixels levels also show that the green electromagnetic spectrum remains better at noise compared to red and blue spectrum. This result shows that the green color component is less sensitive to noise compared to the red and blue components. The high insensitivity to the noise of the green color component was similarly reported by [8]-[10]. We also note that the noise levels in the images of the varieties DOR701 and MAC55 are similar; which confirms the results reported by [2] and [3], which stipulate that the presence of noise in an image depends in part on the conditions of acquisition of the image and the interaction between the light source and the product to be imaged.

GSJ: Volume 7, Issue 8, August 2019
ISSN 2320-9186

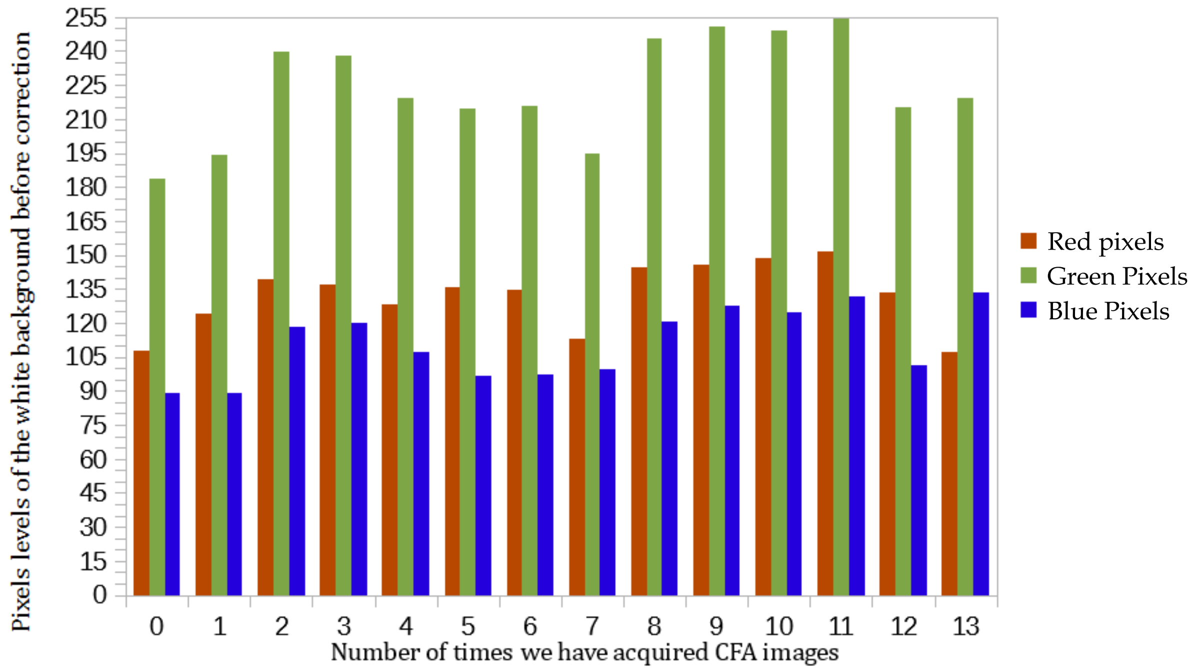


Figure 1. Histogram of the means pixels Levels of the white background before correction: case of the variety DOR701

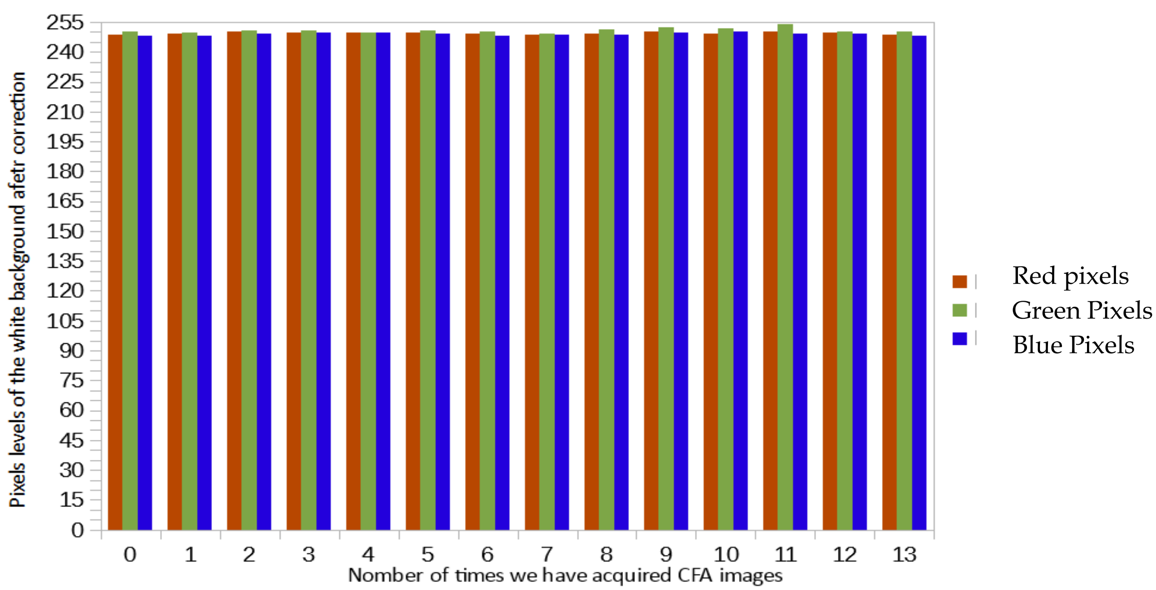


Figure 2. Histogram of the means pixels Levels of the white background after correction: case of the variety DOR701

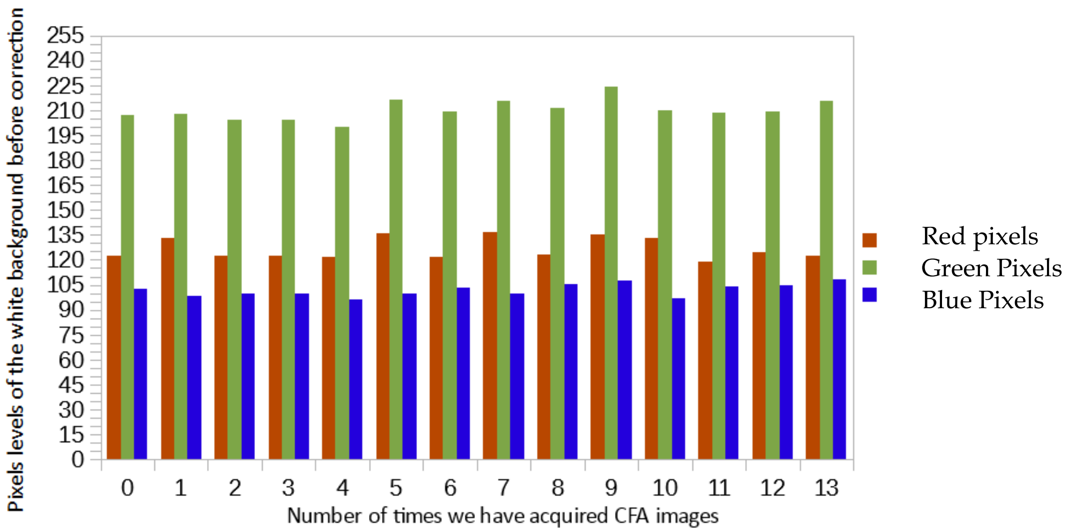


Figure 3. Histogram of the means pixels Levels of the white background before correction: case of the variety MAC55

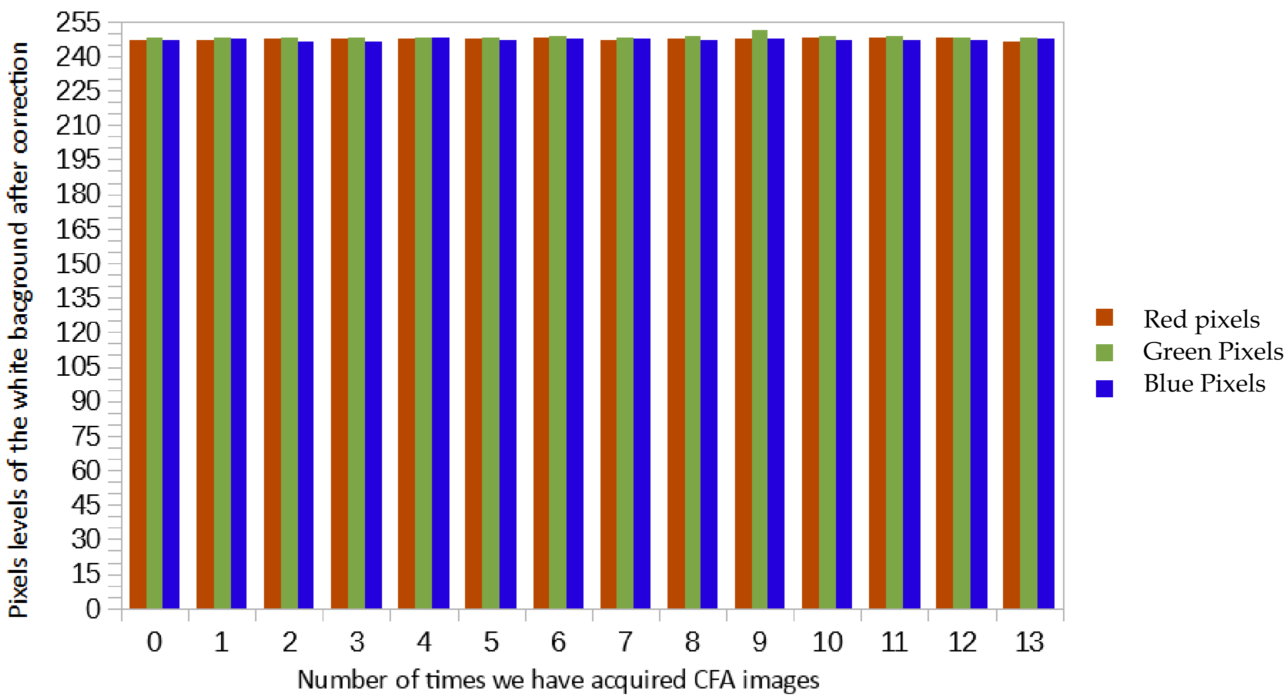


Figure 4. Histogram of the means pixels Levels of the white background after correction: case of the variety MAC55

The results presented in figues 2 and 4 show that the levels of the white background pixels of the corrected images are similar to each other; the average levels of the red, green and blue pixels are comparable from one image to another with levels substantially close to the reference value which is 255. Taking as the reference threshold for the correction the highest average value of the green component, it is possible to eliminate more than 95% the noise present in the different CFA images. This result obtained confirms the thesis according to which a CFA image is made up of a large number of noises, which must imperatively be eliminated before any other form of use of said CFA image.

Conclusion

The work presented in this paper focused on the implementation of a method for the efficient correction of CFA images in order to eliminate any noise that could affect their quality. To achieve the expected results, we have developed a numerical method based on the determination of a correction coefficient specific to each component color component of each CFA image. By taking a white background as a reference, the results obtained show that our proposed method of colorimetric correction, allowed in a first to restore the corresponding white color effective to our white background, and in a second time to reduce more than 95% the noises present in the CFA images.

Acknowledgment

At the end of our work, we would like to express our gratitude to the State of Cameroon, which is funding our work through the university research modernization bonus. Our profound thanks to the National School of Agro-Industrial Sciences, which fully funded the purchase of our research equipment.

References

[1] C. J. Du and D. W. Sun, "Recent developments in the applications of image processing techniques for food quality evaluation: a review", *Trends in Food Science & Technology*, 15, 230–249, 2004.

[2] M. S. Lee, S. W. Park, and M. G. Kang, "Denoising algorithm for CFA image sensors considering inter-channel correlation", *Sensors*, 17, 1236; 2017, doi: 10.3390/s17061236.

[3] A. Bosco, S. Battiato, A. Bruna, and R. Rizzo "Noise reduction for CFA image sensors exploiting HVS behavior", *Sensors*, 9, 1692-1713, 2009.

[4] L. Zhang, R. Lukac, X. Wu, and D. Zhang, "PCA-Based spatially adaptive denoising of CFA images for single-sensor digital cameras", *IEEE Tranactions on Image Processing*, 18(4), 2009.

[5] E. G. Fernández, A. L. S. Orozco, L. J. G. Villalba, and J. Hernandez-Castro, "Digital image tamper detection technique based on spectrum analysis of CFA rrtifacts", *Sensors* 18, 2804; 2018, doi: 10.3390/s18092804.

[6] Y. Yang, "Contribution to the objective evaluation of the quality of color images estimated by demosaicing", *PhD thesis*, The University of Lille 1, Sciences and Technologies, October 2009.

[7] M. A. Pérez, O. González, and J. R. Arias, "Optical fiber sensors for chemical and biological measurements", in Current developments in optical fiber technology, *IntechOpen*, Malaya, Malaysia, June 2013.

[8] L. Bitjoka, O. Boukar, D. Tenin, M. F. C. Mbofung, and E. Tonye, "Digital camera images processing of hard-to-cook beans", *Journal of Engineering and Technology Research*, 2(9), 177–188, 2010.

[9] G. Djaowé, L. Bitjoka, O. Boukar, D. G. Libouga, and B. Waldogo, "Measurement of the rennet clotting time of milk by digital sequence images (2d+t) processing", *Journal of Food Engineering*, 114 (2), 235–241, 2013.

[10] O. Boukar, L. Bitjoka, G. Djaowé, "Nondestructive Determination of Beans Water Absorption Capacity Using CFA Images Analysis for Hard-To-Cook Evaluation", International Journal of Electrical and Computer Engineering, 3 (3), 317–328, 2013.