# Parameterization of filters to correct light exposure in images

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***Abstract*—This article presents a methodology for developing an Image Signal Processing (ISP) pipeline specifically designed to correct exposure levels in images, addressing issues of overexposure (bright images) and underexposure (dark images). Our pipeline was developed and validated through extensive testing using advanced image analysis methods such as BRISQUE (Blind/Referenceless Image Spatial Quality Evaluator). The results demonstrate the effectiveness of the pipeline in improving image quality by adjusting exposure levels, making it a valuable tool for applications that require image corrections. This study contributes to the growing body of research on image enhancement techniques and highlights the potential of ISP in improving visual quality across multiple domains.**

***Keywords*—** Light exposure; Image enhancement; Neural networks

## I. INTRODUCTION

Photography is a mechanism developed by humans to capture and record images. Previously performed out through artistic representations, the recording of images and moments began to be performed out using photosensitive films, resulting in analog images and, currently, with the use of photosensitive electronic sensors, resulting in digital images. When capturing an image, there is a possibility of problems occurring at the time of recording, either due to physical problems with the camera or poor configuration when taking photos. One of these problems, for example, could be in relation to the degree of exposure related to the amount of light that the camera sensor captures, which, due to some error, would not have an adequate configuration when capturing the scene. These exposure problems can be classified in two ways: overexposure is the result of excessive light capture, making images "blown out" and underexposure is the result of insufficient light promoting dark areas [1].

This project aims to develop an application using filters to correct photos with overexposure and underexposure based on the analysis of BrisQue quality metrics. Also having the following specific objectives:

- Implement filters to highlight images;
- Perform image quality analysis;
- Find an ideal order for applying the filters.

Image improvement is achieved through to Image Signal Processing (ISP), which optimizes the image, giving it greater clarity and visual appeal. In addition to visual enhancement, this approach has a broader impact by contributing to the community through a set of techniques and approaches, enriching the field of image processing, offering new perspectives for improving images and expanding knowledge in the field. [2].

## II. IMAGE QUALITY ANALYSIS TECHNIQUES

This topic aims to evaluate the effectiveness of histogram techniques for classifying the degree of image exposure and Image Quality Analysis (AQI) for correcting exposure problems in images, ensuring that image quality is preserved and improved during the process of correction.

### A. Histogram

The histogram is a very important tool used in both statistics and computational photography. This tool is a form of graphical representation to visualize and distribute the frequency of a set of data, as show Figure 1. In the case of an image, the histogram is used to represent the frequency distribution of the pixels that make it up, corresponding, in a specific way, to the individual channels of their colors. In the case of a monochromatic image (a distribution in shades of gray) it has a variation in pixel intensity from 0 to 255, and the histogram of this image consists of the frequency of occurrence of each intensity value [3] [4].

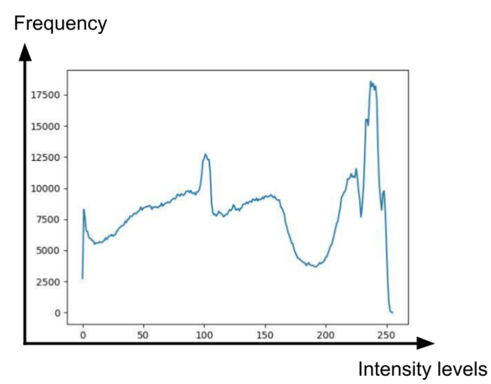


Fig. 1. Histogram representation of an image.

Using the histogram, it is possible to check the light exposure present in an image, in addition to having knowledge about the contrast level, color distribution and being able to perform equalization using histogram. When there is a concentration of pixels in the fourth quadrant of the histogram, high frequencies, it can be classified as an overexposed image. The opposite, when there is a concentration of pixels in the first quadrant of the histogram, low frequencies, it can be classified as an underexposed image [5].

### B. BRISQUE

Image quality analysis is an essential process for evaluating the fidelity and visual appeal of a captured or processed image. Image quality assessment covers a wide range of characteristics, from sharpness and colors to details and textures. It unfolds into two main aspects: subjective and objective. This article uses BRISQUE (Blind/No-reference Image Quality Evaluator), an innovative objective image quality analysis technique that does not require a reference image. The metric generated by BRISQUE represents a "score" that reflects the perceived quality of the input image. The higher the score, the better the image quality in relation to aspects such as sharpness, contrast and noise. [6].

## III. Image Correction Techniques

In this topic will be analyzed the CLAHE equalization, gamma correction and saturation techniques to correct images with incoherent exposure.

### A. Equalization CLAHE

Image equalization or histogram equalization analyzes the image in general, changing the contrast attribute, in which its functionality is to redistribute gray levels, expanding the range of pixels, resulting in increased contrast. However, in RGB images that contain three color channels, histogram equalization does not operate effectively, distorting the colors belonging to the image, resulting in visually excessive contrast. [7] [8].

An improved aspect of histogram equalization and widely used in image processing is Contrast-Limited Adaptive Histogram Equalization (CLAHE). CLAHE is an extension of conventional histogram equalization that aims to adaptively improve local contrast in images. Unlike the histogram equalization, mentioned previously, its application is performed out locally. The CLAHE procedure consists of partitioning an image into sub-images and then applying equalization to each of these subdivisions, generating more significant and effective results compared to traditional histogram equalization (HE). The result of applying this filter is greater enhancement of the image, making contours and other elements more visible [9].

The image is divided into cells of specified size. A histogram is calculated for each cell. This involves counting the frequency of each pixel intensity value in the cell. The histogram of each cell is then equalized, but with a restriction according to the contrast threshold. After the cells are equalized, they are recombined to form the final image. Two parameters for using the filter: Window size (tile size) and Contrast limit (clip limit). The window size divides the image into a grid of cells or blocks, and this parameter determines the size of those cells. The window size affects the granularity of the equalization. The Contrast Threshold parameter controls the maximum amount of equalization that can be applied to each cell [10].

### B. Gamma Correction

Gamma correction or power transformation is a fundamental technique in the area of image processing, widely used to adjust the relationship between input and output values of image capture, printing and display devices. This approach aims to correct the nonlinearities inherent to these systems, ensuring accurate and visually pleasing reproduction of images. [4]. In the scenario where the image acquires a whitish appearance, as shown in the Figure 2, applying gamma correction proves crucial to improving contrast. In case of a clear image, applying values greater than 1 (Figure2) they make it possible to expand the values of the brightest pixels and highlight details in the bright areas of the image.

Similarly, when faced with an excessively dark image, Figure 3 , manipulating the gamma correction also becomes essential to achieve a visually balanced exposure. Applying values less than 1 makes it possible to expand the values of the darkest pixels and improve contrast in dark areas of the image, seen in Figure 3.

Fig. 2. A) Input image B)Image with gamma parameter greater than one($\gamma > 1$).

Fig. 3. A) Input image B)Image with gamma parameter less than one($\gamma < 1$).

### C. Saturation

Image processing around color manipulation, specifically saturation in the HSV (Hue, Saturation, Value) color space, is a area of research significant and constantly evolving. A common approach to manipulating saturation in images is to work in the HSV color space, where saturation represents the purity of the color. Separating color channels in HSV space allows you to adjust saturation independently of hue and value, which is critical for many image processing applications [11]

## IV. Filter Parameterization Methodology

### A. Architecture

This work aims to explore the methodology of image signal processing (ISP), as it is a crucial step in the image production chain, aiming to improve the visual quality of captures. The ISP is approached in this study as a sequence of carefully ordered filters, forming a pipeline that aims to produce improved images [12]. The approach used in this study is based on creating of a pipeline based on image classification. The filters present in the pipeline were obtained after a series of tests carried out empirically. The Figure 4 exemplifies how the empirical image correction process was carried out.

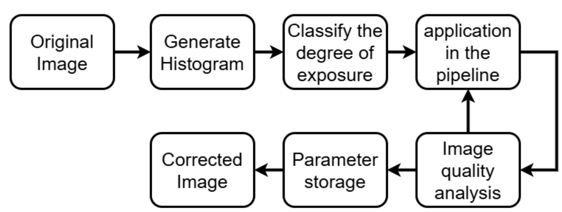


Fig. 4. Architecture representation.

Given an input image with an incoherent degree of exposure, its histogram was generated to extract its classification. After that, this image is applied to one of the pipelines corresponding to its classification. This rectified image is subjected to image quality analysis, in which, if the image obtains significant metrics, it can go to the next step, which would be the storage of the parameters used in the filters and the corrected image. If the values obtained by the metrics are not significant, it goes through the pipeline application stage again, modifying the filters or parameters. The aim is to obtain satisfactory visual results using the ISP method.

### B. Image Classification

To obtain the classification of the image, its histogram is analyzed, in which, through statistical means (II-A) get its classification, which can are: Overexposed or Underexposed. For the Overexposed classification, the histogram must be concentrated to the right, indicating a predominance of high pixels, close to 255, which characterizes an overexposed image. On the other hand, in the Underexposed classification, the histogram should be concentrated to the left, reflecting a predominance of low pixels, close to 0, indicating an underexposed image.

### C. Application in the pipeline

After several tests performed, it was observed that each image with its proper classification has a certain sequence of filters to be used. The final result of this analysis was the optimized composition of the ISP of three filters that proved to be efficient in correcting images with exposure problems, which can be seen in the Figure 5. The filters were applied using the average values of the BrisQue.

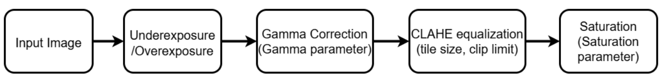


Fig. 5. Pipeline application representation.

### D. Image Analysis

The tests were conducted systematically, with each filter tested individually, with variations in the parameters in each experiment and also the variation in the order of the filters. The selection of images for these tests was made using objective methods of the image quality analysis (BRISQUE), using as an evaluation parameter, in which a score is generated for the image.

## V. Experimental Evaluation

### A. Environment Setting

To implement the algorithms, the Legion 5 15IMH05H notebook was used, whith 16GB of RAM, Intel Core i7 - 10750H 2.60Hz processor, and a video card RTX 2060 of the 4GB. These implementations were made in PyCharm Professional version 2022.2, an integrated development environment for Python version 3.7.8. In addition to using the Opencv, Numpy, mathplotlib, Brisque and Tkinter libraries.

### B. Image Database

During the study, 50 images were used, acquired through the database freely available on the internet, available through the MIT-Adobe FiveK dataset [13].

### C. Results (Images, tables and graphs)

As a result of the work performed, processed images were obtained for each classification. These processed images were obtained by varying the input parameters. Starting with image classification, given an input image, we seek to identify the region of pixel concentration within the histogram.

Analyzing the Figure 6 as a reference, the concentration of pixels in the left region is observed, classifying it as an underexposed image. After that, we can use the underexposure filter pipeline, as described in Figure 5. First, we apply some gamma values to change the input image, so we will have images with diverse values of the gamma. These images are applied to evaluate the BrisQue method. The results obtained for the range application were these:

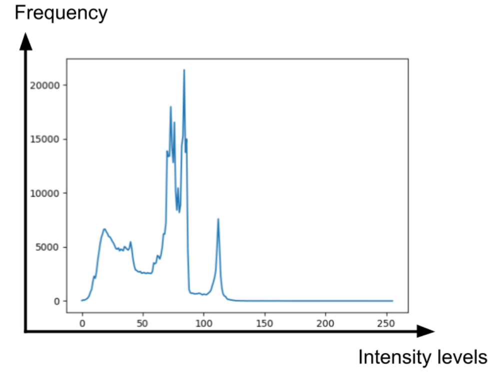


Fig. 6. Histogram of the image used as an example.

TABLE I
BrisQue results in relation to gamma

| GAMMA | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | AVG |
|---|---|---|---|---|---|---|
| BRISQUE | 27.46 | 27.87 | 27.80 | 28.71 | 29.58 | 28.28 |

When analyzing the average value of the images that were subjected to BrisQue analysis, it is obtained that the image closest to BrisQue is the image submitted to the gamma factor of 0.5, which has a value of 27.87. Following the pipeline, this image with gamma factor 0.5 is subjected to CLAHE equalization. The results obtained for the range application were these:

TABLE II
BrisQue results in relation to CLAHE

| CLAHE | 1x2 | 1x6 | 1x10 | 2x2 | 2x6 | 2x10 | AVG |
|---|---|---|---|---|---|---|---|
| BRISQUE | 26.21 | 19.50 | 16.75 | 24.56 | 16.82 | 15.98 | 19.97 |

When analyzing the average value of the images that were subjected to BrisQue analysis, it is obtained that the image closest to BrisQue is the image submitted to the CLAHE factor of 1x6, which has a value of 19.50. Following the pipeline, this 1x6 CLAHE fact image is subjected to saturation. The results obtained for applying saturation were these:

TABLE III
BrisQue results in relation to saturation

| SATURATION | 1.2 | 1.5 | 1.7 | 2.0 | 2.2 | AVG |
|---|---|---|---|---|---|---|
| BRISQUE | 19.455 | 19.301 | 19.194 | 19.306 | 19.375 | 19.326 |

When analyzing the average value of the images that were subjected to BrisQue analysis, it is obtained that the image closest to BrisQue is the image submitted to the saturation factor 2.0, which has a value of 19.306. After applying the pipeline, the corrected image is obtained. Observe the input image on the left of Figure 7 and the corrected image on the right.

Taking the image above as an example, we extract your classification through the graph. Through statistical analysis, the concentration of pixels with high values is noticeable, making it an overexposed image. This means that high ranges are used to reverse the high exposure of the image, to extract the first parameter, to move the pipeline forward. We use the MSE metric as a comparison.

## VI. Conclusion

This article addressed the issue of images with exposure problems, exploring methods to correct these defects and improve the visual

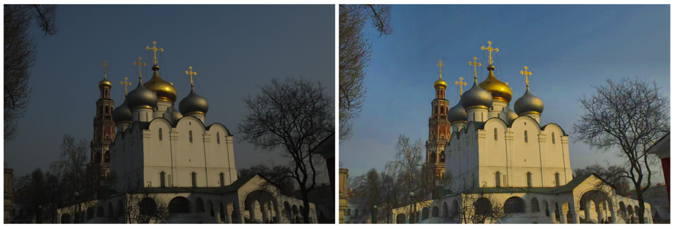

Fig. 7. Comparison of the input image with the image corrected by the pipeline.

quality of images. After a series of tests and parameter adjustments, three main filters were selected: gamma, CLAHE and saturation. To determine the ideal filter parameters, the BRISQUE objective image quality analysis method was used. This method made it possible to quantitatively evaluate the resulting images and identify those with better visual quality after applying the filters. The developed pipeline proved to be efficient in correcting exposure problems, with BRISQUE playing a crucial role in selecting the best images tested. During testing, it was observed that some images had a yellowish or bluish appearance. As a suggestion for future work, it is recommended to implement a white balance algorithm, aiming to obtain images with a more neutral white balance and, consequently, better color fidelity.

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