Dynamic Image Contrast Enhancement using Pixel Value Dependent Multipliers*

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***Abstract*—In this paper an algorithm is proposed that enhances the contrast of an image similar to the "Auto-Contrast enhancement" feature by Adobe Photoshop 2015. The algorithm increases the contrast dynamically based on each pixel's value.**

I. Introduction

Contrast Enhancement is a popular method in Image processing software as objects in high contrast images are easier to detect for the Human Visual System (HVS). Also, slight contrast enhancements are often more pleasing to the eye, especially when dealing with low contrast images [1]. To implement a similar function Linear Transformation is used to increase pixel values of relatively lighter parts of the image and decrease pixel values of relatively lower parts. Additionally, contrast is enhanced less for already high or low pixel values based on a threshold. This ensures dynamic contrast enhancement to not lose too much detail on edge values.

II. Proposed Algorithm

To enhance the contrast of an image, the current contrast level should make a difference. Thus, before performing Linear Transformation, the pixel values first get adjusted by the overall mean pixel value. This leads to a new theoretical pixel value range of [-255;255]. Only the absolute value of the pixel value is relevant for the linear transformation for the following reason: The Linear Transformation used by this algorithm distinguishes 3 pixel value ranges: 1. [0;54], 2. [55;205], 3. [201;255]. Pixel values that are associated to the 1. or 3. interval are referred to edge pixels or edge pixel value from now on. The second value range is the largest and an average slope of the linear function is used to increase the contrast for values in this range. As the 1. and 3. value ranges represent the edge cases and may preserve important detail that should be distinguished from other edge pixel values, only x percent (x can be 50 for example) of the transformation slope is applied to these values. This means pixel values that are edge values are intensified less which leads to a more detailed and eye-pleasing image afterwards. In short, all pixel values above the mean get increased and all below get decreased, with for example 50 percent intensity on edge values. The following flowchart (Fig 1) illustrates the linear transformation that is performed on each absolute pixel values after mean adjustment when slope adjustment is 50 percent.

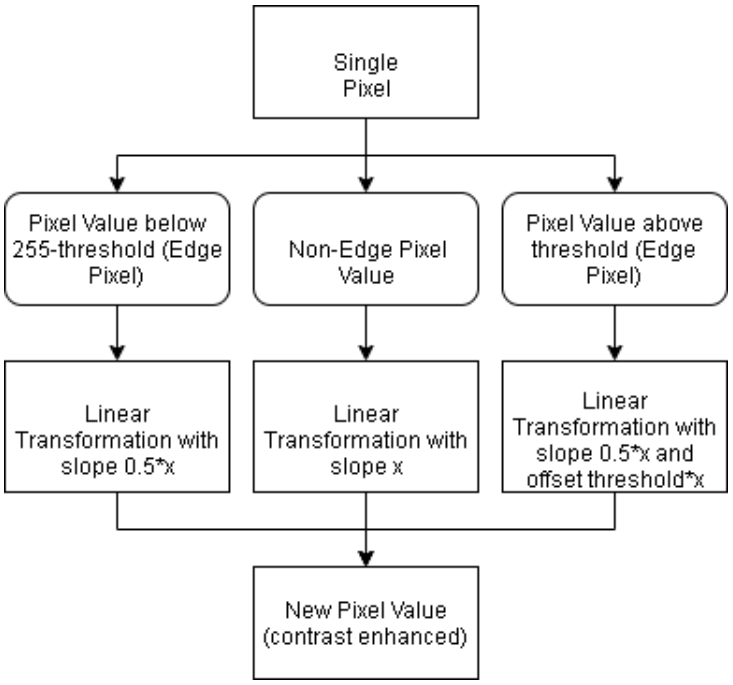

Fig. 1. Flowchart of performed Linear Transformation: Dynamic Contrast Enhancement with pixel value dependent multipliers and offset, 0.5 slope adjustment

III. Results

Figure 2 illustrates the difference between the original and the image processed by the proposed algorithm of this paper. When comparing image a) and b) of figure 2 the higher contrast of image b) is immediately visible, especially when inspecting coat, hair and skin color of the photographer in the image. The histogram of the enhanced image shown in c) clearly shows the high proportion of edge pixels (pixel values that are either close to 0 or 255) due to the performed contrast enhancement. When inspecting the linear transition in d) one can see the slight shift of each pixel value to a higher contrast. Also, one can see when the higher and lower thresholds are used to modify the linear transition on edge

pixels. According to the pixel value dependent multipliers introduced earlier in figure 1, pixels values below 55 or above 200 receive a different linear transition to allow for a more eye pleasing image. It is also noticeable that even with only a slight variation of pixel values towards higher contrast, the viewer can already see a noticeable difference on a greyscale image.

During experiments with multiple images the following parameters turned out to be reasonable and led to a good balance between preserving detail, enhancing contrast and achieving an eye-pleasing result: The threshold for determining if a pixel is an edge pixel was set to 200, which means that pixel values above 200 and below 55 are receiving a different multiplier to the linear transformation slope to preserve more detail. The overall linear transformation slope was set to 1.2. This means that a non-edge pixel value gets increased or decreased by 20 percent to enhance contrast. This turned out to be a good balance between a noticeable enhanced contrast but not overly enhanced image.

In figure 3 one can see the difference between the resulting image of performing the "Auto-Contrast enhancement" feature of Adobe Photoshop 2015 and the Enhanced Image processed by the proposed algorithm with x = 1.2, slope adjustment for edge pixels of 1.15 and a threshold of 200. The images are very similar both on a visual level as well as the histograms shown in c) and d) of the of 3. Both images noticeably enhance the contrast while Adobe Photoshop seems to enhance the contrast a bit less as compared to the proposed algorithm. Interestingly, at the same time the histograms in c) and d) show a higher value of edge pixels on the Photoshop image which would suggest a higher contrast enhancement as the proposed algorithm. However, as one can see the Photoshop image enhances the contrast of non-edge pixels slightly less which leads to a lower contrast enhancement of the proposed algorithm in this case. Overall, it can be concluded however, that the resulted images and histograms by both methods are highly similar and only with a detailed analysis separable from another.

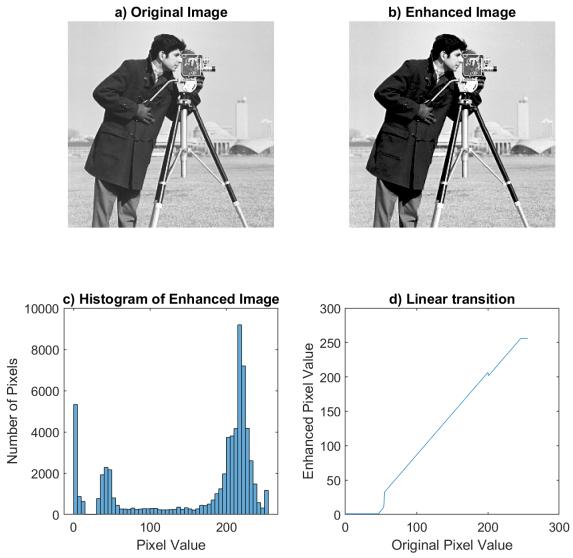

Fig. 2. Comparison, Enhanced Image vs Originial Image

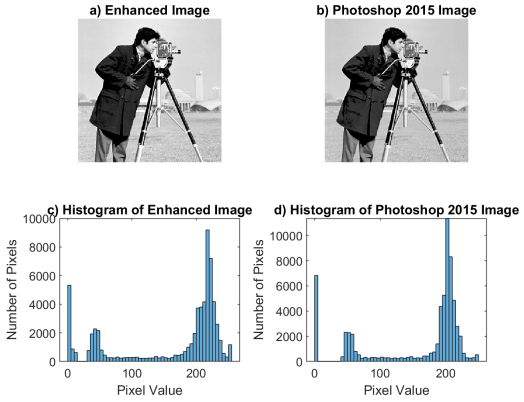

Fig. 3. Comparison, Enhanced Image vs Photoshop Image

REFERENCES

[1] W. S. Geisler and M. S. Banks, "Visual performance," in Hand- book of Optics (M. Bass, ed.), McGraw-Hill, 1995.

Fig. 4. ”Auto-Contrast enhancement”, Photoshop 2015

Fig. 5. Contrast enhancement, proposed algorithm