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Image Enhancement Using Linear Programming Method for High Dynamic Range Image

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Abstract
Now a days in Telecommunication areas the contrast gain is considered as a major constraints. For the enhancement purpose, the technique called Histogram Equalization is involved, but due to over enhancement and not such gain is been obtained. So that for the OCTM is been proposed, where the constraints of HE is been rectified. OCTM gives better efficiency and it is been solved by Linear programming. In this paper the enhancement of HDR Image using linear Programming is done. According to it HDR Image is constructed using the multiple exposures and its contrast is enhanced using the OCTM method using Linear Programming.
Keywords: HE, Dynamic Range, OCTM, Contrast Enhancement, Linear programming

I. Introduction

In most image and video applications it is human viewers that make the ultimate judgement of visual quality. They typicallyassociate high image contrast with good image quality. Indeed, a noticeable progress in image display and generation (both acquisition and synthetic rendering) technologies is the increase of dynamic range and associated image enhancement techniques. The contrast of a raw image can be far less than ideal, due to various causes such as poor illumination conditions, low quality inexpensive imaging sensors, user operation errors, media deterioration (e.g., old faded prints and films), etc. For improved human interpretation of image semantics and higher perceptual quality, contrast enhancement is often performed and it has been an active research topic since early days of digital image processing, consumer electronics and computer vision.

Contrast enhancement techniques can be classified into two approaches: context-sensitive (point-wise operators) and context-free (point operators). In context-sensitive approach the contrast is defined in terms of the rate of change in intensity between neighboring pixels. The contrast is increased by directly altering the local waveform on a pixel by pixel basis. For instance, edge enhancement and high-boost filtering belong to the context-sensitive approach. Although intuitively appealing, the context-sensitive techniques are prone to artifacts such as ringing and magnified noises, and they cannot preserve the rank consistency of the altered intensity levels. The context-free contrast enhancement approach, on the other hand, does not adjust the local waveform on a pixel by pixel basis. Instead, the class of context-free contrast enhancement techniques adopts a statistical approach. They manipulate the histogram

of the input image to separate the gray levels of higher probability further apart from the neighboring gray levels. In other words, the context-free techniques aim to increase the average difference between any two altered input gray levels. Compared with its context-sensitive counterpart, the context-free approach does not suffer from the ringing artifacts and it can preserve the relative ordering of altered gray levels. For the purpose of automatic processing, histogram equalization (HE) was derived and has received great attention since early days of image processing due to its simplicity and easy implementation. HE tends to spread the histogram of the input image so that the levels of the histogram-equalized image will span a fuller range of the gray scale. In addition, HE has the additional advantage that it is fully automatic, and the computation involved is fairly simple. However, HE can be detrimental to image interpretation if carried out mechanically without care. In lack of proper constraints HE can over shoot the gradient amplitude in some narrow intensity range(s), flatten subtle smooth shades in other ranges. In addition, it can bring unacceptable distortions to image statistics such as average intensity, energy, and covariances, generating unnatural and incoherent 2D waveforms. In order to overcome the constraints by HE optimal contrast-tone mapping (OCTM) to balance high contrast and subtle tone reproduction is used. Since it is computationally difficult to find the optimal one among all feasible solutions, we instead formulate the problem as one of maximizing the contrast gain subject to limits on tone distortion. Such a contrast-tone optimization problem can be converted to a linear programming, and hence can be solved efficiently in practice. In addition, our linear programming technique offers a greater and more precise control of visual effects than existing techniques of contrast enhancement. Common side effects of contrast enhancement, such as contours, shift of average intensity, over exaggerated gradient, etc., can be effectively suppressed by imposing appropriate constraints in the linear programming framework. In the new framework, Gamma correction can be unified with contrast-tone optimization.

II. Contrast and Tone

Consider a gray scale image I of b bits with a histogram h of K non-zero entries, $x_0 < x_1 < \ldots < x_{K-1}$, $0 < K \leq L = 2^b$. Let p_k be the probability of gray level x_k, 0 _ k < K. We define the expected context-free contrast of I by

$$C(p)=p_0(x_1-x_0) + \sum_{1 \leq k < K} p_k (x_k - x_{k-1}) \quad .. (1)$$

By the definition, the maximum contrast C_{max} = L-1 and it is achieved by a binary black-and-white image $x_0 = 0$, x_1=L - 1; the minimum contrast C_{min} = 0 when the image is a constant. As long as the histogram of I is full without holes, i.e., K = L, x_k-x_k-1 = 1, 0 ≤k < L, C(p) = 1 regardless the intensity distribution (p_0, p_1,…, p_{L-1}). Likewise, if x_k-x_{k-1} = d > 1, 0 ≤ k < K < L, then C(p) = d.

Contrast enhancement is to increase the difference between two adjacent gray levels and it is achieved by a remapping of input gray levels to output gray levels. Such a remapping is also necessary when reproducing a digital image of L gray levels by a device of Ł gray levels, L≠Ł. This process is an integer-to-integer transfer function

$$T : \{0,1, \ldots,L - 1\} \rightarrow \{0, 1, \ldots, Ł - 1\} \quad \ldots (2)$$

In order not to violate physical and psycho visual common sense, the transfer function T should be monotonically non decreasing such that T does not reverse the order of intensities. 1 In other words, we must have T(j) ≥T(i) if j > i, and hence any transfer function T has the form

$$T(i) = \sum_{0 \leq j \leq i} s_j \quad 0 \leq i < L$$

$$S_j \in \{0,1 \ldots Ł - 1\} \quad \ldots(3)$$

$$\sum_{0 \leq j < L} S_j < Ł$$

where sj is the increment in output intensity versus a unit step up in input level j (i.e., x_j-x_{j-1} = 1), and the last inequality ensures the output dynamic range not exceeded by T(i). In (3), s_j can be interpreted as context-free contrast at level j, which is the rate of change in output intensity without considering the pixel context. Note that a transfer function is completely determined by the vector s = (s_0, s_1,… , s_{L-1}), namely the set of contrasts at all L input gray levels. Having associated the transfer function T with context-free contrasts s_j 's at different levels, we induce from (3) and definition (1)
a natural measure of expected contrast gain made by T:

$$G(s) = \sum_{0 \leq j < L} p_j S_j \quad \ldots(4)$$

where p_j is the probability that a pixel in I has input gray level j. The above measure conveys the colloquial meaning of contrast enhancement. This is all about the contrast and tone of the gray scale image. In next section we see about the OCTM.

III. Contrast-Tone Optimization By Linear Programming with OCTM

To motivate the development of an algorithm for solving frequency details and tone subtlety of smooth shades, it is useful to view contrast enhancement as an optimal resource allocation problem with constraint. The resource is the output dynamic range and the constraint is tone distortion. The achievable contrast gain G(s) and tone distortion D(s) are physically confined by the output dynamic range Ł of the output device. In (4) the optimization variables (s_0, s_1,..,$s_{L-1)}$represent an allocation of Ł available output intensity levels, each competing for a larger piece of dynamic range. While contrast enhancement necessarily invokes a competition for dynamic range (an insufficient resource), a highly skewed allocation of Ł output levels to L input levels can derive some input gray levels of necessary representations, incurring tone distortion. This causes unwanted side effects, such as flattened subtle shades, unnatural contour bands, shifted average intensity, and etc. Such artifacts were noticed as drawbacks of the original histogram equalization algorithm, and proposed a number of ad hoc. techniques to alleviate these artifacts by reshaping the original histogram prior to the equalization process. In OCTM, however, the control of undesired side effects of contrast enhancement is realized by the use of constraints when maximizing contrast gain G(s).Hence the equations are re written in OCTM

$$\max_{s} \sum_{0 \leq j < L} p_j S_j$$

subject to (a) $\sum_{0 \leq j < L} S_j < Ł$

(b) Sj ≥0 , 0≤ j < L;

(c) $\sum_{j \leq i < j+d} S_i \geq 1, 0 \leq j < L-d$

IV. Experimental Results

Fig. 1 through Fig. 3 present some sample images that are enhanced by the OCTM technique in comparison with those produced by conventional histogram equalization (HE). The transfer functions of both enhancement techniques are also plotted in accompany with the corresponding input histograms to show different behaviors of the two techniques in different image statistics.

In image house (Fig. 1), the output of histogram equalization is too dark in overall appearance because the original histogram is skewed toward the bright range. But the OCTM method enhances the original image without introducing unacceptable distortion in average intensity. This is partially because of the constraint in linear programming that bounds the relative difference (< 20% in this instance) between the average intensities of the input and output images.

Fig. 2 compares the results of histogram equalization and the OCTM method when they are applied to a common portrait image. In this example histogram equalization overexposes the input image, causing an opposite side effect as in image House, whereas the OCTM method obtains high contrast, tone continuity and small distortion in average intensity at the same time.

Fig. 3 shows the improvement of OCTM over histogram equalization for video imaging.

Fig 1

Fig 2

Fig 3

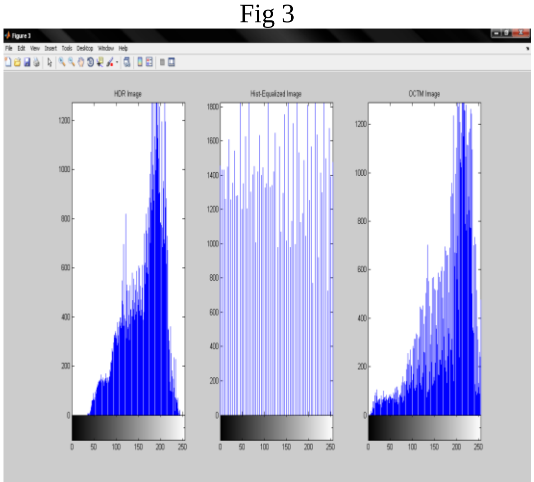

Fig 4

(Fig. 1 the original; Fig 2 the output of histogram equalization; Fig 3 the output of the proposed OCTM method; Fig 4 the transfer functions and the original)

V. Conclusion

A image enhancement technique of Optimal Contrast-Tone Mapping is proposed. The resulting OCTM problem can also be solved efficiently by linear programming. The OCTM solution can increase image contrast while preserving tone continuity, two conflicting quality criteria that were not handled and balanced as well in the past the optimization framework is general, and the constraints that are imposed by practical applications can be added to achieve desired visual effects.

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