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Low Cost VLSI Implementation for Illumination Adjustment by Adaptive Modified Gamma Correction

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Abstract: For real-time surveillance and safety applications in intelligent transportation systems, high-speed process for image improvement is important and should be thought-about. In this paper, we propose a quick and economical illumination adjustment algorithmic program that is appropriate for affordable terribly massive scale integration implementation. Experimental results show that the projected technique needs the smallest range of operations and achieves comparable visual quality as compared with previous techniques. To additional meet the need of real-time image/video applications, the 16-stage pipelined hardware design of our technique is enforced as associate intellectual property core. In some inexpensive intelligent imaging systems, the process rate is slowed down, and our hardware core will run at terribly low power consumption.

I. Introduction

There is an increasing demand for cameras and intelligent surveillance systems aiming at monitoring private and public areas. For example, the camera-based advanced driver help system will inform drivers of the suitable speed or facilitate keep the vehicle between lane markers to enhance vehicle/road safety. In intelligent transportation systems (ITSs), the cameras keep track of the road and driving things to discover the traffic flow or to record data related to vehicle crashes or accidents mechanically. However, scant visibility as a result of the influence of weather or poor atmospherical light-weight can cause the intelligent system to be inoperative.

Many image preprocessing algorithms are integrated to extend the visibility of the system, like denoising, scaling, and illumination adjustment. In such a time period intelligent system, high-speed process for those enhancement algorithms is important and should be thought-about. A hardware implementation for the algorithms [1]–[4] could be a higher resolution, which might be enclosed in end-user camera instrumentation to satisfy the need. In this paper, we focus on the developmentof a fast and efficient illumination adjustment algorithm that issuitable for low-cost high-speed hardware implementation.

In this paper, we propose a low-complexity illumination adjustment algorithmic program based on the Retinex theory. The fastillumination estimation by using the concept of bidimensional empirical mode decomposition (FIEEMD) is presented. Then, a modified gamma correction is employed to adjust the illumination component to obtain a more pleasing image. The experimental results demonstrate that our method achieves farshorter execution time and comparable visual quality as compared with other enhancement methods [10]. Moreover, we also present a 16-stage pipelined hardware design enforced as an intellectual property (IP) core that may be integrated with different circuits within the system-on-chip (SoC). By using hardware sharing and data processing techniques, the planned IP core will efficiently operate to fulfill the necessity of period of time applications with lower price. In some inexpensive imaging systems, the process rate will be delayed, and our hardware core can run at terribly low power consumption.

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II. Related Works

In 1971, Land and Mccann [12] developed the Retinextheory as a simple and effective model of visual perception. The Retinex theory assumed that the intensity of visible lightreaching a camera and the observer's eyes depends on theproduct of two components: illumination, which represents the ray of light source from the sun or sky in the scene, and reflectance, which represents the illumination variation ofthe object surfaces. According to the assumption, an observed image can be expressed as

$$I(x, y) = L(x, y) \times R(x, y) \qquad (1)$$

Where I(x, y) is the pixel of an observed image located i the(x, y) coordinate, L(x, y) is the illumination of the scen andR(x, y) is the reflectance of the objects. Based on th Retinex theory, the image enhancement algorithm fir estimates the illumination denoted as ˆL(x, y) by some sign processing technique, and the estimated reflectance denote as ˆR(x, y) can be determined by (1). Then, the estimate illumination ˆL(x, y) can be adjusted by a nonlinear operat G (·) to enhance the visual quality of the image. Finally, th adjusted luminance data can be obtained as

$$I'(x, y) = R'(x, y) \times G(L'(x,y))$$

The image I' is an enhanced version of the input observed image. The main challenge of the Retinex method is how to estimate the illumination component L'(x, y) properly. Recently, a powerful signal analyzing technique called empirical modedecomposition (EMD) is proposed [12]. By extracting oscillation information of the data, EMD decomposes a signal into several frequency components, which are called character isticintrinsic mode functions (IMFs), and a last function that cannot be decomposed into any IMFs, which is called residue. The process of EMD required several iterations to obtain each IMF.

To analyze 2-D data such as a 2-D image and to overcome the exhaustive computation, Bhuiyan*et al.* [11] proposed the fast and adaptive bidimensional empirical mode decomposition (FABEMD). The process of FABEMD for extracting bidimensionalIMFs (BIMFs) is shown as in Fig. 1, where the solidarrow means the step flow of the algorithm, and the dashedarrow represents the important data flow for the step block. Formore detailed description, the reader can refer to [11].In the image application, some existing research [11]–[12]found that each BIMF and the residue contain different informationof an image such as color variety, edge, noise, andillumination. The first BIMF contains the majority of colorvariation, and the residue contains the illumination trend. Withthis assumption, we treat the residue as the illumination planeL'(*x*, *y*) in the Retinex theory for adjusting the uneven illumination.According to the FABEMD process, the residue isincluded in the average envelope ofeach *i*thdecomposition.To reduce the computational load, we only calculate the firstaverage envelope as the illumination plane L'(*x*, *y*).Then, an adaptive gamma correction is developed to adjust L'(x, y) to enhance the illumination contrast without oversaturation.

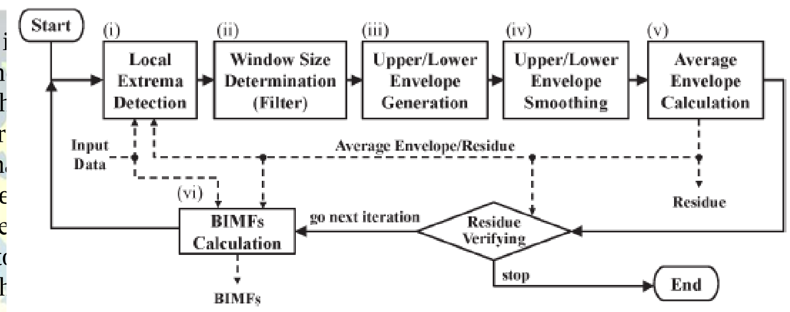

Figure 1 Flow diagram of the FABEMD.

III. Implementation

The flow diagram of the proposed illumination adjustment algorithm is shown as in Fig. 2. First, the color image is mapped from the RGB domain into the HSV color area. The HSV domain is a perfect approach for color descriptions that are natural and intuitive to humans. Second, the first average envelopeis extracted as the illumination plane *L* by using FIEEMD only from the intensity layer *V* of the *HSV* domain. Third, a novel gamma correction is employed to adjust the illumination component to improve the visual quality of the details in low- and high-luminance regions. Finally, the enhanced image represented in the *HSV* color space is converted into the RGB domain. The details of FIEEMD and modified gamma correction are described as follows.

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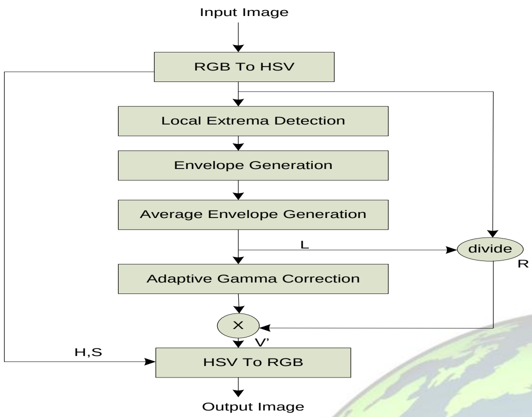

Figure 2. Proposed Illumnation Adjustment algorithm

a) Fast Illumination Estimation by Using the Concept of Bidimensional Empirical Mode Decomposition (FIEEMD)

The three processing steps of the FIEEMD are described as follows. Find the local maximum and local median points of the intensity layer V of the input image

i) Finding the local maximum and minimum points from the original image is an important step in the process of FABEMD. In this illumination adjustment application, these extreme points not only determine the trend of illumination L but also affect the reflectance R.

ii) Estimate the upper and lower envelopes by using local maximum and local median points, respectively. Once obtaining the local maximum and local median points, thendevelop the upper and lower envelopes.

iii) Calculate the first average envelope $E'A$ by averaging the upper and lower envelopes obtained from Step (ii). The obtained $E'A$ is just the estimated illumination plane L and will be further processed for illumination adjustment.

b) Adaptive gamma correction

The AGC method can gradually increase the low intensity and prevent the major decrement of the high intensity. The proposed AGC process mechanically calculates the gamma parameter via probability density. The proposed adaptive gamma correction (AGC) is formulated as follows:

$$T(l) = l\max(l/l\max)^{\gamma} = l\max(l/l\max)^{1-cdf(l)}$$

The AGC method can progressively increase the low intensity and avoid the significant decrement of the high intensity. Finally, the gamma parameter based on $cd\ f$ is formulated as follows,

$$\gamma = 1 - cdf_w(l)$$

IV. EXPERIMENTAL RESULTS

The design utilization for the Illumination adjustment is shown in figure 3.

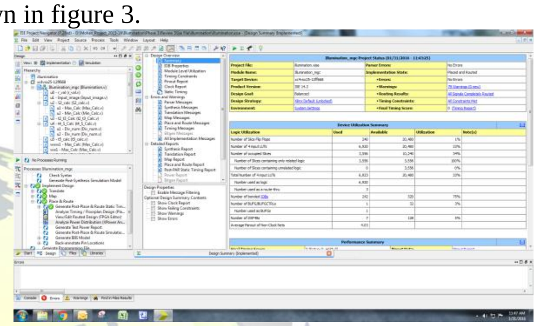

Figure 3 Design Utilization

The power analysis for the illumination is shown in figure 4. The total power consumed is 0.290Wat the junction temperature of 20°C.

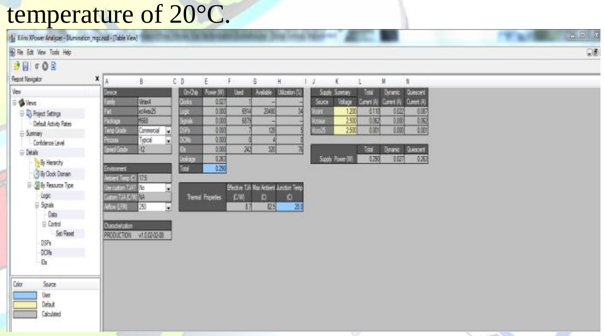

Figure 4 Power Analysis

The illumination output for is shown in figure 5a and 5b.

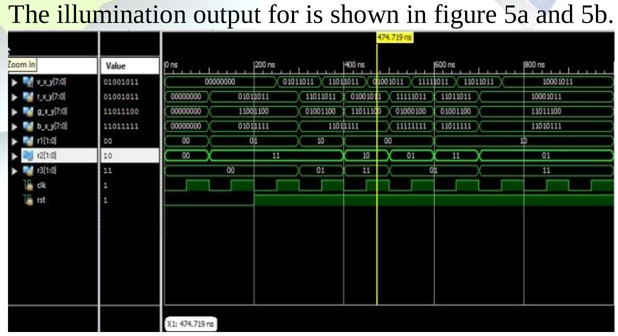

Figure 5 a. Output phase

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Figure 5 b. Output phase

V. Conclusion

In this proposed algorithm we use the concept of adaptive Gamma correction technique instead of modified gamma correction is used, so that the processing of the image mapping takes place in dynamic way instead of some static, so that the processing speed is quite improved in this design. The adaptive technique uses the PDF of the various Values of RGB by doing it in cumulative nature that results in correctness of the final values obtained, thus reducing the steps used in the adaptive gamma correction technique.

In Further work, the proposed system can be done to automate the recursion value according to the image, so that an appropriate value of recursion level can be used to segment histogram. The work can also be done to apply this technique over videos.

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