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Review on Contrast Enhancement Techniques: Depth Perspective

Mr. Ashish B. Umredkar
Department of CSE
PIET
Nagpur, India
aumredkar.it@gmail.com

Prof. A. R. Mahajan
Department of CSE
PIET
Nagpur, India
armahajan@rediffmail.com

Abstract—Due to the advent of computer technology image-processing techniques have become increasingly important in a wide variety of applications. Poor images can be enhanced using various Image Contrast Enhancement technique. Contrast is the difference in intensity between highest and lowest intensity level in an image. When pixel in an image have high dynamic range then the image is high contrast. This paper presents the comparative study of different image contrast enhancement techniques based on Histogram modification techniques and depth images such as histogram equalization, histogram specification, Brightness preserving bi-histogram equalization, brightness-preserving histogram equalization with maximum entropy, flattest HS with accurate brightness preservation, Gaussian Mixture Modelling, sharpness enhancement of stereo image using BJND, enhancement of image and depth map using AJTF, image contrast enhancement using color and depth histogram. However the aforementioned histogram equalizations methods has some of the drawbacks that are overcome by subsequent methods.

Histogram based techniques are mainly based on equalizing the histogram of the image and modification framework. Such image creates side-effects such as over enhancement and washed out images. To overcome this drawbacks, we proposed image contrast enhancement using joint segmentation of color and depth images. Depth images are directly capture using specific depth sensor or can be generate using stereo matching techniques. For segmentation we used saliency maps algorithm to detect objects in an images.

Keywords*-Contrast enhancement, Histogram equalization, maximum entropy, Histogram modification, Gaussian mixture modeling (GMM), histogram partition, Adaptive bilateral filter, trilateral filter, Depth image*

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I. INTRODUCTION

Image contrast enhancement techniques have been extensively studied in the past decades. Among various contrast enhancement approaches, histogram modification based methods have received the greatest attention owing to their simplicity and effectiveness. In particular, since global histogram equalization (GHE) tends to over-enhance the image. To overcome the drawback of GHE, alternate method is to divide an image histogram into several sub-intervals and modifying each sub-interval separately used. The effectiveness of these sub-histogram based methods is highly dependent on how the image histogram is divided. The state-of-the-art algorithm models the image histogram using the Gaussian mixture model (GMM) [9] and divides the histogram using the intersection points of the Gaussian components. The divided sub-histograms are then separately stretched using the estimated Gaussian parameters.

In the last years, many different solutions have been proposed for the extraction of depth information relative to a real world scene. A depth map is an image or image channel that contains information relating to the distance of the surfaces of scene objects from a viewpoint. Various systems have been proposed in order to solve this task, each one with pros and cons. There are two main groups of methods, passive and active methods. Passive methods use only the information coming from two or more standard cameras to estimate the depth. Among them stereo vision systems [8], that exploit the localization of corresponding locations in the different images are most widely used. Stereo vision systems have been greatly improved in the last years but they cannot work on un-textured regions and the most effective methods are also very computational time consuming. Another possible solutions are the active methods such as structured light, laser scanners and Tof sensors. By projecting some form of light on the scene such methods can obtain better results than passive stereo vision systems, but they are also usually more expensive.

This paper gives the different methods or technology to improve the contrast of image in order to improve image quality. The combination of depth image with color image produce good result.Detail study of different method for enhancement is given in literature survey. The rest of the paper is organized as follows.Section II gives the literature survey followed by conclusion in section III.

II. LITERATURE SURVEY

Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME) [3] is used to preserve brightness of image. Early Brightness preserving Bi-Histogram Equalization (BPHE) is proposed. But BBHE can preserve the original brightness of input image to a certain extent when the histogram of input image has a quasi-symmetrical distribution around its mean.

This paper proposes a novel extension of histogram equalization to overcome the drawback of Histogram Equalization which can yield the optimal equalization in the sense of entropy maximization. To maximize the entropy it is required to make the histogram as flat as possible. Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME) find optimal histogram using variational approach which has the maximum differential entropy under the mean brightness constraint and then implements the histogram specification under the instruction of that desired histogram. The drawback of this paper is it do not stretched target histogram explicitly but maximize entropy instead. Also Maximum entropy doesn't means contrast enhancement but contrast stretching to some extent.

To overcome the drawback of BPHEME methodFlattest histogram specification with accurate brightness preservation (FHSABP) is employed in [4], because the output of BPHEME is always maximize entropy which is corresponds to contrast stretching to some extent but not provide better result. In this paper, flattest histogram specification proposes to transform the histogram into a target flattest histogram, subject to a mean brightness constraint. FHSABP tries to find the optimal histogram, which is the flattest one with the mean brightness constraint. An exact histogram specification method is employed to ensure brightness preservation with the whole procedure.

The key idea of exact histogram specification method is to distinguish order of pixel with same intensity. For example, the two pixel P and Q with the same intensity, the human will perceive pixel P is brighter than pixel Q if the neighboring pixels of P is brighter than Q. For that set of low pass filter is designed. After filtering the image using this filter, 8 bit system description is constructed. This pixel values are sort and assign each pixel to new level. So we get new brightness preserver image. But, when the gray level of the input image are equally distributed, FHSABP behave similar as HE [4].

Paper [5] present adaptive bilateral filter (ABF) used for sharpness enhancement and noise removal. To remove noise, conventional filter are used. As the domain low pass Gaussian filter gives higher weights to center pixel and the range low pass Gaussian filter gives higher weights to pixels that are similar to the center pixel in gray value. Combining the range filter and the domain filter we get a bilateral filter. Previously, un-sharp masking (USM) algorithm is used for sharpening the edges. But the drawback of this method is produces halo around the edges and amplify noise if present in image. To address this problem adaptive bilateral filter is used. ABF outperforms the bilateral filter in noise removal. At the same time, it renders significantly sharper images. Compared with an USM based adaptive sharpening method, ABF stored edges are as sharp as the USM restored edges, but without the halo artifacts as produced by USM.

Histogram Modification Framework [6] present a general framework based on histogram equalization for image contrast enhancement which is posed as an optimization problem that minimizes a cost function. Histogram equalization is an effective technique for contrast enhancement. The output of conventional histogram equalization (HE) is always excessive contrast enhancement. Noise robustness, white-black stretching and mean-brightness preservation may easily be incorporated into the optimization. The contrast of the image or video can be improved without introducing visual artifacts that decrease the visual quality of an image and cause it to have an unnatural look.

Histogram Modification take advantage of available dynamic range, Histogram Equalization tries to create a uniformly distributed output histogram by using a cumulated histogram as its mapping function. But, HE often produces overly enhanced unnatural looking images. To overcome this problem, the input histogram can be modified without compromising its contrast enhancement potential. The modified histogram can then be accumulated to map input pixels to output pixel.

Binocular Just-Noticeable Difference (BJND) [8] provides a new sharpness enhancement algorithm for stereo images. They introduced a novel application of the BJND model for the sharpness enhancement of stereo images. An efficient solution for reducing the over enhancement problem in the sharpness enhancement of stereo images was proposed. The solution was found within an optimization framework with additional constraint terms to suppress the unnecessary increase in luminance values.

The concept of a just-noticeable difference has played an important role in understanding the human visual system. The JND implies a visibility threshold by which a human can perceive changes in pixel values which is not only depends on the luminance but also on the contrast of a local image region. Several studies have concentrated on finding a visibility threshold for a 3-D image, and two types of thresholds, i.e., the JND in depth (JNDD) and the binocular JND (BJND) were reported. The first threshold (JNDD) indicates that a human cannot perceive a depth difference smaller than the threshold. Therefore, the JNDD can be exploited when the depth data is lossy compressed without degrading the depth perception. The second threshold (BJND) is related to the inter difference between the left and right views that a human can recognize. As human cannot realize a distortion when viewing the stereo image if the distortion in one viewpoint image is less than the BJND. BJND-Aware Sharpness Enhancement Algorithm present a new sharpness enhancement technique based on the BJND for the stereo images. Instead of explicitly developing a sharpness enhancement algorithm, they process the enhanced image of each view in a way that the inter differences could not severely exceed the BJND.

A Gaussian Mixture Model (GMM) [9]is a parametric probability density function represented as a weighted sum of Gaussian component densities. This paperproposes an adaptive image equalization algorithm that automatically enhances the contrast in an input image. The algorithm uses the Gaussian mixture model to model the image gray-level distribution.

The intersection points of the Gaussian components in the model are used to partition the dynamic range of the image into input gray-level intervals. The contrast equalized image is generated by transforming the pixels gray levels in each input interval to the appropriate output gray-level interval according to the dominant Gaussian component and the cumulative distribution function of the input interval

For homogeneous region, Gaussian components with small variances are weighted with smaller values than the Gaussian components with larger variances, and the gray-level distribution is also used to weight the components in the mapping of the input interval to the output interval. This algorithm is free of parameter setting for a given dynamic range of the enhanced image and can be applied to a wide range of image types.

The input image P having dynamic range is converted into enhanced image Q within the range using three steps. This are modeling, portioning and mapping. In modeling step, the histogram of the input image is modelled using GMM. As GMM can model any data distribution in terms of linear mixture of different Gaussian distributions with different parameters.

Each Gaussian component has a standard deviation, different mean and weight in the mixture model. FJ algorithm is used for estimating the parameters of GMM. After the estimation of best model from the modeling section, the histogram is partitioning to get the input intervals. The intersection points of the Gaussian components are used for partitioning the dynamic range of the input image into several input gray-level intervals. Finally enhanced image is obtained by mapping each input interval to corresponding output interval by adding weight which depends on the rate of the total number of pixels that fall into interval and the standard deviation of the dominant Gaussian component.

A new algorithm that can jointly enhance the sharpness of the depth map and image is present in paper [10]. For that, the Adaptive Bilateral Filter is modified to obtain an adaptive joint trilateral filter (AJTF) for which the parameters are determined according to the accuracy of the depth map and image. As the image or depth map alone cannot provide accurate AJTF parameters for the joint enhancement, pattern classification technique used in block truncation coding is adopted as parameter selection method. By comparing the similarity between depth map and image patches, different levels of enhancement are performed to enhance the sharpness of the depth map as well as visual quality of the image.

In this paper, presents an adaptive joint trilateral filter (AJTF), which consists of domain, range and depth filters which is used for the joint enhancement of images and depth maps, achieved by suppressing the noise and sharpening the edges. For improving the sharpness of the image and depth map, the AJTF parameters such as the offsets and the standard deviations of the range and depth filters are determined in such a way that image edges that match well with depth edges are considered.

The overall quality of the degraded image was significantly improved by the AJTF, which not only remove noise but also sharpen edges simultaneously. In addition, it was also demonstrated that the AJTF successfully performed joint enhancement when both the image as well as depth map had poor quality. The AJTF showed better performance compared to conventional depth enhancement algorithms in terms of both subjective and objective quality. But the computational complexity of the AJTF is high.

Image enhancement based on nonlinear transfer function is discuss in paper [11], color image is converted from RGB color space to HSV color space. The image enhancement technique is applied to the V (Luminance value) component of the image and the S (saturation) component is enhanced by stretching its dynamic range. The H (hue) component has been kept constant to avoid color distortion. V component of HSV is enhanced in two steps. In first step the V component was divided into overlapping and non-overlapping blocks and for each pixel inside the block the luminance enhancement was carried out using non-linear transfer function. In the second step, 2-D Gaussian filter is used for contrast enhancement. The modified V value is combined with enhanced S component and unchanged H component in order to obtain enhanced HSV image. And finally HSV color space is converted back into RGB color space.

A new method for enhancement of image using color and depth image is introduced in [12].A pair of color and depth images is take as input. The proposed algorithm modifies the histogram of the color image using the histogram of the depth image as side information.

To represent histogram of color image, they transform the color space from the RGB space to the hue-saturation-intensity (HSI) space and use only the intensity channel. Thus histogram modification is applied to the intensity channel only and the resultant color image is obtained by transforming the color space back to the RGB space.

The significant intersection point then used to partition the histogram sub-intervals. For partitioning Gaussian Mixture Modeling based portioning method is used. In histogram partitioning-based contrast enhancement algorithms, the mapping function for each layer is estimated exclusively such that image details in each layer can be effectively enhanced. However, histogram partitioning using only the intensity channel can assign different labels to the neighboring pixels that have similar intensity as well as depth values. The color layer labeling is guided to be spatially overlapped with the depth layer labeling such that the neighboring pixels with the similar color and depth values are likely to be merged together.

III. CONCLUSION

In this paper we introduced the different methods or algorithm used for contrast enhancement of image. For better enhancement of image, a depth map/ image is required to provide deep information. GMM algorithm can provide the better result but with the help of depth image it produced more enhanced image and solve the problem of over enhancement.

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