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Survey on Image Contrast Enhancement Techniques

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Abstract: *Image enhancement is a processing on an image in order to make it more effective for computer to process. Enhancement is, used to improve the visual effects and the clarity of image. Contrast is the visual difference that makes an object distinguishable from background and other objects. Contrast enhancement, changing the pixels intensity of the input image to utilize maximum possible bins. It has been active research topic since early days of computer vision and digital image processing. The three general phases that all types of data have to undergo while using digital technique are Pre- processing, enhancement and display, information extraction. In this paper, various image contrast enhancement techniques for low contrast images are reviewed. We need to study and review the different image contrast enhancement techniques because contrast losses the brightness in enhancement of image. This paper focuses on the comparative study of contrast enhancement techniques and various techniques are analyzed for effective contrast enhancement.*

Keywords: *Image Processing, Contrast Enhancement, Histogram Equalization, Spatial Domain, Frequency Domain.*

1. INTRODUCTION

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. Digital Processing techniques help in manipulation of the digital images by using computers. As raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are Pre- processing, enhancement and display, information extraction.

Therefore, since every early days of image processing many contrast enhancement techniques have been proposed and used. Image enhancement means as the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals.

It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too.

This paper is organized into 6 sections. Section 1 gives an overview of the paper. It describes the importance of contrast enhancement in image processing. Section 2 describes the related work done by different authors. Section 3 describes domain of contrast enhancement. Section 4 gives a comparative analysis of the different contrast enhancement technique. Section 5 offer comparison and observations of various enhancement techniques. Conclusion is made in section 6.

2. LITRETURE SURVEY

In this section, we mention the relevant past literature that utilizes the various techniques for contrast enhancement. Most of the researchers focus on histogram based contrast enhancement techniques.

Agarwal.[1], proposed a new method named "Modified Histogram Based Contrast Enhancement using Homomorphic Filtering" (MH-FIL) for medical images. Histogram based techniques are used to enhance low contrast of all type of medical images. This method uses two step procedures, in first step global contrast of image is enhanced and then in the second step homomorphic filtering is used for image sharpening. And this filtering is followed by image normalization. This algorithm is proved as a flexible and efficient for medical image enhancement and can be closed a pre-processing step for medical image understanding and analysis.

S.S.Chong [2], proposed a modified version of hyperbolic algorithm contrast enhancement technique suitable for magnetic resonance imaging(MRI).In this technique contrast enhancement image obtained by controlled fashion of the gray level stretching on

structure. From the experimental result, it is examined that this technique get better the contrast of granular tissues and fatty tissues in addition to prevents over enhancement of the image by preserving the brightness of the overall image.

Tarun Mahashwari [3], presents a method for enhancement of contrast of an image based on Fuzzy system. Fuzzy techniques can manage the uncertainty and imperfectness of an image. Fuzzy method for contrast enhancement is divided into three stages: image fuzzification, modification of membership values, and image defuzzification.

ZhiYu Chen [4], describes a new automatic method for contrast enhancement. By grouping the histogram components of a low-contrast image into a proper number of bins according to a selected criterion, then redistribute these bins uniformly over the grayscale. And finally ungroup the previously grouped gray-levels. The technique is known as gray-level grouping (GLG).

Andrea Polesel [5], introduces a variation of the basic UM (Unsharp Masking) scheme that uses an adaptive filter. Adaptive filter is used to underline the medium contras details in the input image more than large contrast details. The adaptive ansharp masking technique that achives two objectives of avoiding noise amplification and excessive overshoot in the details areas is a novel approach to image enhancement.

Yeong-Taeg Kim [6], proposes extension of histogram equalization. The proposed algorithm is to utilize independent histogram equalizations separately over two sub images found by decomposing the input image based on its mean value. Resulting equalized subimages are bounded by each other around the input mean. The proposed algorithm maintain the mean brightness of a given image significantly and provides a natural enhancement.

Manvi[7], present that histogram equalization is a more general class of histogram remapping methods. This method adjust the image to make it easier to analyze or to improve visual quality. The contrast of the image can be improve without introducing visual artifacts that decrease the visual quality of an image and cause it to have an unnatural look. Algorithm uses the input histogram, which does not change significantly within the same scene, as the primary source of information. If the histogram equalization function is known, then the original histogram can be recovered by inverse of transformation function.

3. IMAGE ENHANCEMENT TECHNIQUE

Image enhancement technique can be divided into two broad categories:

1. Spatial based domain image enhancement :-

Spatial based domain image enhancement works directly on pixels. The main advantage of spatial based domain technique is that they are simple to understand and the complexity of these techniques is low which favours real time implementations.

Spatial domain methods can again be classified into two broad categories:

- Point Processing operation:

  The simplest spatial domain operations occur when the neighborhood is simply the pixel itself. Used primarily for contrast enhancement.

- Spatial filter operations:

  Filtering is used to modify or enhance an image. Spatial domain operation or filtering in which the processed value for the current pixel processed value for the current pixel depends on both itself and surrounding pixels. Hence Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the input pixel.

2. Frequency based domain image enhancement:-

Frequency based domain image enhancement is a term used to describe the analysis of mathematical functions with respect to frequency and operate directly on the transform coefficients of the image, such as Fourier transform, and discrete cosine transform (DCT). The basic idea in using this technique is to enhance the image by manipulating the transform coefficients.

Frequency domain methods can again be classified into three categories:

- Image Smoothing
- Image Sharpening
- Periodic Noise reduction by frequency domain filtering.

Advantages and Disadvantages of Enhancement Techniques

Techniques	Advantages	Disadvantages
Spatial based domain image enhancement	The main advantage of spatial based domain technique is that they conceptually simple to understand and the complexity of these techniques is low which favours real time implementations.	These techniques generally lacks in providing adequate and robustness requirements.

Frequency based domain image enhancement	The advantages of frequency based image enhancement includes low complexity of computations, ease of viewing and manipulating the frequency composition of the image and the easy applicability of special transformed domain properties.	The basic limitations including are it cannot simultaneously enhance all parts of image very well and it is also difficult to automate the image enhancement procedure

4. VARIOUS CONTRAST ENHANCEMENT TECHNIQUES

A. Histogram Equalization (HE):

Enhancement of an image can be implemented by using different operations of brightness increment, sharpening, blurring or noise removal. One of the most popular global contrast enhancement techniques is histogram equalization (HE). The histogram of image is the operation by which the occurrence of each intensity value in the image is shown.

Histogram equalization is the technique by which the dynamic range of the histogram of an image is increased. HE assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. It improves contrast and the goal of HE is to obtain a uniform histogram. This technique can be used on a whole image or just on a part of an image.

This usually results in an enhanced image, with an increase in the dynamic range of pixel values.

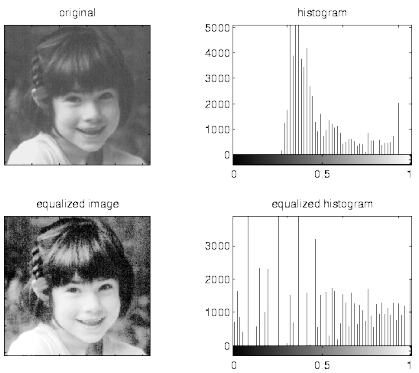

Figure 5.1: *Histogram Equalization of an image*

B. Bi-Histogram Equalization

In order to overcome the drawback introduced by the HE method described in the previous subsection, a brightness preserving Bi-HE method was proposed. BBHE method is used to decompose the original image into two sub-images, by using the image mean gray-level, and then apply the HE method on each of the sub images.

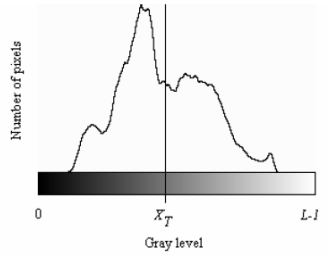

Figure 5.2: *Bi – histogram equalization*

In bi-histogram equalization the histogram of the image is separated into two sub histograms based on the mean value of the histogram of the original image, the sub-histograms are equalized independently using refined histogram equalization, which gives flatter histogram.

C. Gray Level Grouping (GLG)

In Gray Level Grouping (GLG) , the basic procedure is to first group the histogram components of a low-contrast image into a proper number of bins according to a selected criterion, then redistribute these bins over the grayscale uniformly, and finally ungroup the previously grouped gray-levels.

GLG not only produces results superior to conventional contrast enhancement techniques, but is also fully automatic in most circumstances, and is applicable to a broad variety of images.

D. Histogram Specification/ Modification

Here we want to convert the image so that it has a particular histogram that can be arbitrarily specified. Such a mapping function can be found in three steps:

- Equalize the histogram of the input image
- Equalize the specified histogram
- Relate the two equalized histograms

Here are the specific steps of the algorithm:

Step 1: Find histogram of input image and find its cumulative the histogram equalization mapping function:

$$H_x[j] = \sum_{i=0}^{j} h_x[i]$$

Step 2: Specify the desired histogram and find its cumulative the histogram equalization mapping function:

$$H_z[j] = \sum_{i=0}^{j} h_z[i]$$

Step 3: Relate the two mapping above to build a lookup table for the overall mapping. Specifically, for each input level i, find an output level j so that best matches :

$$|H_x[i] - H_z[j]| = min_k|H_x[i] - H_z[k]|$$

and then we setup a lookup entry $lookup[i] = j$

E. Dynamic Histogram Equalization (DHE)

In DHE method the original image is decomposed into multiple sub images according to their local maxima, then the dynamic histogram equalization is applied to each sub image and finally, the sub Images are combined.

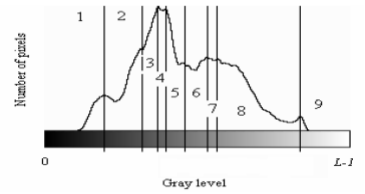

Figure 5.3: *Histogram of two or more sub sections*

DHE technique consists of five steps:

1. Smooth the histogram with filter.

2. Detection of the location of local maximums from the histogram.

3. Map each partition into a new dynamic range.

4. Equalize each partition independently.

5. Normalize the image brightness.

Map each partition into a new dynamic range

Let $m_0, m_1, \ldots\ldots, m_n$ are (n+1) gray levels correspond to the local maximums detected in the previous step. If the original histogram before the smoothing is in range of $[I_{min}, I_{max}]$, then, the first sub-histogram is in range of $[I_{min}, m_0]$, the second sub histogram in the range of $[m_0 + 1, m_l]$, the third one $[m_l + 1, m_2]$, and so on until the last sub histogram $[m_n + 1, I_{max}]$.

However, the equalized version of these sub histograms does not assure a very good enhancement, because sub histograms with small range will not be enhanced significantly by HE. Hence, following the same concept as DHE, BPDHE spans each sub-histogram first before the equalizations are taking place. The spanning function used is based on the total number of pixels contained in the sub-histogram. This function is described by the equations given below,

$$span_i = high_i - low_i$$

$$factor_i = span_i * \log_{10} M$$

$$range_i = (L-1) * factor / \sum_{k=1}^{n+1} factor_k$$

Where $high_i$ is the highest intensity value contained in the sub-histogram *i*, low_i is the lowest intensity value in that section, and M is the total pixels contained in that section. The dynamic range used by the sub-histogram *i* in input image is given by $span_i$, while the dynamic range used by in output image is $range_i$.

Let the range of the output sub-histogram *i, is* $[start_i, end_i]$. If we set the first sub-histogram of the output image is in the range of $[0, range_i]$, then the $start_i$ and end_i (for i> 1) can be calculated as follow:

$$start_i = \sum_{k=1}^{i-1} range_k + 1$$

$$end_i = \sum_{k=1}^{i} range_k$$

F. Adaptive Histogram Equalization(AHE)

Adaptive histogram equalization (AHE) is an image processing technique used to improve contrast of images. It differs from simple histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. It is more suitable for improving the local contrast .

5. COMPARISON OF TECHNIQUES

Sr. No	Technique	Concept	Advantage	Disadvantage
1	Histogram Equalization	Uniform distribution of gray values over scale.	Simple, effective and low complexity.	Brightness of an image is changed after HE.
2	Bi-Histogram Equalization	Decomposion of image using mean value.	Preserve the brightness of an image.	Gives an artificial look to image.
3	Dynamic Histogram Equalization	Decomposion of image using local minima or maxima.	Enhances the images without making any loss of information	Required more computation time i.e. more complex.
4	Gray Scale Grouping	Formation of bin of grey values.	Applicable to a broad variety of images.	More Complex
5	Histogram Modification	Uses specified image histogram	Simple and works well in many applications.	System is sensitive to noise.

6	Adaptive Histogram Equalization		AHE has a tendency to over amplify noise in relatively homogeneous regions of an image.	Complex and enhances high contrast area much more.

6. CONCLUSION

This flattering causes the overall enhancement of contrast of the input image. Image Enhancement (IE) transforms images to provide better representation of the information present in image. Image contrast enhancement plays an important role in image enhancement. In this paper, the different image contrast enhancement techniques are analyzed. The major goal of image contrast enhancement is to produce images without severe side effects at the same time maintain input mean brightness. In this Paper, work for image contrast enhancement based on prior knowledge on the Histogram Equalization has been presented.

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