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Various Image Enhancement Methods – A Survey

Akash Kumar Bhagat[1], S. P. Deshpande[2]
[1](ECE, GIT, India)
[2](ECE, GIT, India)

Abstract: *This paper focuses on the different image enhancement techniques. Image enhancement has found to be one of the most important vision applications because it has ability to enhance the visibility of images. It enhances the perceivability of poor pictures. Distinctive procedures have been proposed so far for improving the quality of the digital images. To enhance picture quality image enhancement can specifically improve and limit some data presented in the input picture.*
Image processing typically relies on accurate, simple, and tractable model. Usually, digital images acquired from optical or electronic cameras tend to suffer interference. These spots degrade the articulation of images. As one of important image processing techniques, image enhancement can transform one image to another to improve the perception of information for human viewers.
The quality of images is often influenced by external factors such as illumination, equipment and so on in the process of image acquisition and transmission. Image enhancement is an image processing technology which processes images through methods such as adjusting tone to improve images' contrast and enhance details in dark areas.
The goal of image enhancement techniques is to improve a characteristic or quality of an image, such that the resulting image is better than the original, when compared against a specific criterion. The main objective of this paper is to discover the limitations of the existing image enhancement strategies.
Keywords: *Wiener filter, spatial domain, Wavelet transform, Gabor filter, ANN.*

I. Introduction

Digital image processing is the use of computer algorithms to perform image processing on digital images. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. One of the first applications of digital images was in the newspaper industry, when pictures where first sent by submarine cable between London and New York.

An image is two dimensional picture that gives appearance to a subject usually a physical object or a person. It is digitally represented by a rectangular matrix of dots arranged in rows and columns. Digital images are often corrupted by noises during acquisition, transmission and storage processes. Such noises will severely affect image processing such as image segmentation, edge detection, and object recognition.

The principal objective of enhancement technique is to process an image so that the result is more suitable than the original image for a specific application (very much problem-oriented) or to bring out specific features of an image or to highlight certain characteristics of an image. Therefore, many well-known digital noise filters have been presented in the past years for all kinds of image processing systems, such as average filter, Wiener filter, Median filter, Discrete Fourier transform, Discrete cosine transform, Discrete wavelet transform and so on. For example, as a typical linear filtering, the Wiener filtering can smooth Gaussian noise effectively but it makes image blurry and has little effect on removing other noises such as impulse noises and Salt & Pepper noises. Nonlinear filter, like Median filtering, due to its good effect on processing impulse noise and Salt & Pepper noise, has been often used in image processing.

Two major classifications of image enhancement techniques can be defined:
(i) Spatial domain enhancement (ii) Transform domain enhancement.

Image enhancement attempts to emphasize details or edges. As a commonly used technique, mask convolution is hard to selectively enhance details at different scales in the spatial domain. Of course, applying different mask techniques may yield different enhancement results in the spatial domain. Transform domain enhancement techniques involve mapping the image intensity data into a given transform domain by using transforms such as the 2-D discrete cosine transform (DCT), Fourier transform etc. The basic idea in using this technique is to enhance the image by manipulating the transform coefficients. Recently, many transform-based enhancement techniques have been proposed.

II. Literature survey on Image Enhancement techniques

1.1. Image Enhancement in Spatial Domain

Spatial domain enhancement techniques deal with the image's direct intensity values.

2.1.1 The image histogram

Histogram is a given number of pixels have given a list of values in the image. For each gray level histogram corresponds to the number of pixels in the gray level, if the gray level corresponding to the pixel sum will be the number of pixels of the image. Then the histogram of the image is then normalized, normalized all add up to 1.

2.1.2. Histogram modification

In order to make the original image, gray distribution is more uniform, the detail of the image is more prominent, generally use the histogram modification. Assuming that the gray level variable 'r' of original image has been normalized,i.e. $0\leq r \leq 1$. r=0 represents the black; r=1 stands for white. Set the variable's' represents the gray level image, then the relationship between the variable s and variable r: s=T(r). Assume that T(r) to satisfies the conditions: (i) T(r): single-valued, monotonically increasing (the order from black to white in gray scale); preserve the order from black to white. (ii) $0\leq T(r) \leq 1$ for $0\leq r \leq 1$; [2]

An image, each pixel gray level R can be regarded as the random variables on the interval of (0, 1). Let r be a continuous variable, the probability density function Pr(r) expresses image gray distribution $F(r) = \int P(w)dw$, indicates that the Image gray level is less than the number of pixels r. assuming the transformation of gray level image is represented as a Probability Density Function Ps(s). According to the theory of probability, the relationship between Pr(r) and Ps(s) is: Ps(s) = $[\mathrm{Pr}\ (\mathrm{r})\ \mathrm{dr}\ /\mathrm{ds}]\ \mathrm{r} = \mathrm{T}\hat{}(-1)(\mathrm{S})(1)$. By changing the T(r) can control the shape of the Ps(s). Because Pr(r) and Ps(s) relative gray level distribution, so in order to change the image appearance, you should choose the appropriate T(.).Therefore, in order to get a new image with gray level distribution Ps(s), the transformation function T(r) is suitable to correct the image grey level probability density function Pr(r). This is the essence of the technology of image enhancement using gray level transformation.

2.1.3. Histogram Equalization algorithm

The HE algorithm requires the formula (1) Ps(s)= constant, namely the image information is equal to the amount of all the gray levels in the image, the amount of information contained in the largest, so choose according to T(r). To obtain the amount of information as much as possible from the image, the image entropy as large as possible, the following is the process of the implementation of HE algorithm. Let T(r) in previous section turn into: s=T(r) $=\int \mathrm{P}\ (\mathrm{w})\mathrm{dw}$, $0\leq\ r\ \leq\ 1(2)\ \ \mathrm{ds}/\ \mathrm{dr}$ =Pr(r)(3)Ps(S)=[Pr(r) dr/ds],=[Pr(r)/pr(r)]=1 (4) .Thus, Ps(s)=l is a set of uniform distribution of Probability Density Function. In the enhancement of the sense of comparison and contrast, but also increase with the increase of the dynamic range of the pixel gray level. Gray level r takes discrete values $\{rk;\ k = 0, 1, \ldots L-1\}$. L is the number of gray levels, then continuous function Pr(r) into $\{\mathrm{Pr}\ (\mathrm{rk});\ \mathrm{k} = 0, 1, \ldots, \mathrm{L}-1\}$. Where $\mathrm{Pr}\ (\mathrm{rk}) = \mathrm{nk}/\mathrm{n}$; nk is the number of pixel gray level appearing in that image. n is the total number of pixels in the image. To change s= T(r) into Sk = T(rk) = $\sum ni/n$ = $\sum \mathrm{Pr}(\mathrm{r})\mathrm{k}\ =\ 0,1,\ldots, \mathrm{L}-\mathrm{l}$ (5) The final value of gray transform is S k = (L - 1) x S k.(6)[2]

2.1.4. *Dynamic histogram specification*

Dynamic Histogram Specification [3] algorithms based on the Histogram Specification (HS) methods have been proposed to enhance the contrast without losing the genuine histogram characteristics. In order to keep genuine histogram features, the DHS extracts the differential information from the input histogram. On the other hand, it also applies extra parameters to control the overall processing, such as frame direct current and gain control value.

2.2. *Image Enhancement in Wavelet Domain*

A famous method, the fast Fourier transform algorithm is well suited for analysis stationary signal where all frequencies have infinite coherence time. However, this method fails to exactly determine when a particular frequency component occurred. Then a short time Fourier transform with a fixed sized window was proposed by Gabor to overcome the problems of Fourier transform. But it does not describe local changes in frequency content which prompted the use of Wavelet transform for the purpose of signal analysis. The wavelet transform offers a multi-scale and time-frequency-localized image representation. Similar to sine function and cosines function in Fourier domain, wavelets are used as the basis function for representing signals and images in wavelet transform. For the wavelet transform provides multiple resolution representations of a given image, researchers can enhance the image where high-pass component and low pass component are kept separately if a frame image can be decomposed into several components in multiple resolution levels . Originally, wavelet

coefficients were considered to be independent. Later, it was realized that there are strong dependencies within a sub-band both across scales and between neighboring coefficients in wavelet coefficients of natural images, especially around image edges [1].
The wavelet transform is a time-frequency analysis tool developed in the 1980s, which has been successfully applied in the image processing domain after Mallat [4] presented the fast decomposition algorithm.

There are many image enhancement methods based on wavelet transform, such as Lu et al. [5], Yang and Hansell [6], Fang and Qi [7],Zhou et al. [8], Wu and Shi [9], etc. In these papers, methods of image enhancement based on wavelet transform were proposed.

2.3. Image Enhancement Method Based on ANN

Now a day Artificial Neural Network (ANN) has become one of the most fashionable concepts in the field of image enhancement. The information processing ability of an ANN system mostly comes from its architecture, so designing a suitable ANN algorithm to enhance all kinds of images is a terrible question. Ideal ANN architecture may be larger-sized network, can be trained quickly, easily avoid local minima, and accurately fit the training data. However, this system may be low efficiency because of its high computational complexity and will be poor performance in generalization due to over-fitting. On the other hand, if researchers cut down the size of the ANN, the computational costs will be saved, but there is a chance to be trapped in local minima. There have been many ways to design ANN architectures automatically such as evolutionary algorithms, constructive and pruning. At last the experience of the researchers may decide the quality of the ANN image enhancement algorithm.

III. Critical Analysis Of Various Techniques

The objective of the literature review is to find and explore the benefits of image enhancement algorithms and also to find the short comings in existing algorithms and techniques. The main goal of this literature review is to find the gaps in existing research and techniques and possible solutions to overcome these gaps.

IV. Possible Solutions

Global histogram equalization is suitable for overall enhancement. It is often necessary to enhance details over small areas. The number of pixels in these areas may have negligible influence on the computation of a global transformation, so the use of this type of transformation does not necessarily guarantee the desired local enhancement. The solution is to devise transformation functions based on the grey level distribution – or other properties – in the neighborhood of every pixel in the image. The histogram processing technique previously described is easily adaptable to local enhancement. The procedure is to define a square or rectangular neighborhood and move the centre of this area from pixel to pixel. At each location the histogram of the points in the neighborhood is computed and a histogram equalization transformation function is obtained. This function is finally used to map the grey level of the pixel centered in the neighborhood. The centre of the neighborhood region is then moved to an adjacent pixel location and the procedure is repeated. Since only one new row or column of the neighborhood changes during a pixel-to-pixel translation of the region, updating the histogram obtained in the previous location with the new data introduced at each motion step is possible quite easily. This approach has obvious advantages over repeatedly computing the histogram over all pixels in the neighborhood region each time the region is moved one pixel location. Another approach often used to reduce computation is to utilize non overlapping regions, but this method usually produces an undesirable checkerboard effect.

V. Conclusion

In this paper, we have surveyed various techniques for enhancing images degraded by additive noise during acquisition, transmission and storage processes. Though it has many encouraging results in image analysis and processing applications, recent studies turn up their own weaknesses too.

Histogram equalization suffers from the problem of being poorly suited for retaining local detail due to its global treatment of the image. It is also common that the equalization will over enhance the image, resulting in an undesired loss of visual data, of quality, and of intensity scale.

The main shortcoming of Median filtering is changing all pixel value of the image and blurring the details of the image such as points, lines and textures. Moreover, Median filtering blurs the boundaries of the image when the width of window is less than half of the selected width of window.

The basic limitations of the transform-based image enhancement methods are: i) they introduce certain artifacts which are "objectionable blocking effects"; ii) they cannot simultaneously enhance all parts of the image very well; iii) it is difficult to automate the image enhancement procedure.

The main drawback found with two-dimensional wavelets is the limited ability in capturing directional information, thus it is not capable of efficiently decomposing the complex shapes into more meaningful forms.

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