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Enhanced Analysis on Image Enrichment Methods

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ABSTRACT—

The objective of Image enrichment is to process an image so that result is more suitable than original image for specific application. Digital image enrichment techniques provide a lot of choices for improving the visual quality of images. Appropriate choice of such techniques is very important. This paper will provide an overview and analysis of different techniques commonly used for image enhancement. Image enhancement plays a fundamental role in vision applications. Recently much work is completed in the field of images enhancement. Many techniques have previously been proposed up to now for enhancing the digital images.
Image enrichment is the task of applying certain alterations to an input image like as to obtain a more visually pleasing image. Many images such as medical images, remote sensing images, electron microscopy images and even real life photographic pictures, suffer from poor contrast. Therefore it is necessary to enhance the contrast. The purpose of image enhancement methods is to increase image visibility and details. Two major classifications of image enhancement techniques are spatial domain enhancement and frequency domain enhancement. However, these techniques bring about tonal changes in the images. Number of enhancement techniques available for sketches are very few in comparison with the techniques available for images. The scope of enhancement in case of composite sketches and forensic sketches is left out. Therefore, it would have been better if an in-depth research work is undertaken.

KEY WORDS- Image processing; Image enrichment; Unsharp Masking; Nonlinear filtering

I. INTRODUCTION:

Image contrast enhancement plays a vital role in almost any image-based application. Numerous contrast enhancement techniques have been proposed in the literature [1,2]. In one category of these techniques, the visual quality of digital image is improved by emphasizing its high frequency content, which corresponds to edges and discontinuities in the image, to enhance the fine details in the image. The underlying principle in such techniques is based on the sensitivity of the human visual system to discontinuities present in the scene. Thus, emphasizing the high frequency content would necessarily improve the image quality. One popular technique that adopts such approach is the classical linear unsharp masking (UM); in which contrast enhancement is achieved by adding the original image to a scaled highpass-filtered version of the image itself. The highpass-filtered version of the original image is either computed in the spatial domain using derivative masks or in the frequency domain using highpass filters [1,2].

Several approaches have been proposed to extend the basic UM technique by manipulating the edge image before it is added back to the original image. The simplest extension is based on scaling the edge image by a constant value [3]. However, there are no guidelines on how to specify the gain value. Additionally, this approach applies equally to all regions in the image without any consideration to the level of activity. This in turn results in noise amplification in smooth regions and ringing artifacts near edge regions. To address the ringing artifacts problem, the authors in [4] specify the gain scale values that are proportional to the local activity in the image regions. Basically, for a pixel in the edge image, the scale value is assumed to be inversely proportional to the local standard deviation (LSD) in a small neighborhood around that pixel. In this approach, ringing artifacts are significantly reduced since edge pixels are characterized with relatively high LSD values. However, amplification of noise in smooth regions is significantly increased since smooth regions are of low LSD values.
Alternatively, the technique proposed in [5] attempts to tackle noise amplification and edge ringing artifacts by using a nonlinear contrast gain function that is defined by deriving a transformation function that maps the LSD histogram into a desired histogram obtained through an extension Hunt's

produces better results in terms of enhanced image quality and reduced ringing and noise amplification. Nonetheless, defining the proper gain function for an image involves an iterative procedure that requires the user to specify three different parameters interactively.
Images that come from a variety of microscope technologies provide a wealth of information. The limited capacity of optical instruments combines with the noise inherent in optical imaging to make image enhancement desirable in many applications. Image enhancement is the process of altering the appearance of an image, or a subset of an image, for improved contrast or visualization of some features and to facilitate more accurate subsequent image analysis, such as classification. With image enhancement, the visibility of selected features in an image can be improved, but the inherent information content cannot be increased. The design of a good image enhancement algorithm should consider both the specific features of interest in the image and the imaging process itself. In microscopic imaging, the images are often acquired at different focal planes, different time intervals, and in different spectral channels. The design of an enhancement algorithm should therefore take full advantage of this multidimensional information.

A variety of image enhancement algorithms have previously been developed and utilized for microscopy applications. These algorithms can be classified into two categories: spatial domain and transform domain methods. The spatial domain methods include operations carried out on a whole image or on a local region selected on the basis of image statistics. Techniques that belong to this category include histogram equalization, image averaging, sharpening of important features such as edges or contours, and nonlinear filtering. The transform domain enhancement methods manipulate image information in a transform domain, such as Fourier and wavelet transform domains. In many cases, interesting image information that cannot be separated out in the spatial domain can be isolated in the transform domain. For example, one can often amplify certain Fourier coefficients and then return the image to the spatial domain to highlight interesting image content. The wavelet transform is another powerful tool that has been used for image enhancement.

Literature Survey

Pietro P., and Malik J. [3] proposed a new scale-space and edge detection algorithm using anisotropic diffusion method. In their technique, the diffusion coefficient is used in such a way to support the intra-region smoothing as comparative to inter-region smoothing, so as to extract the global information after removing the noise from the image. Bilateral filter is introduced by Tomasi, C., and Manduchi, R.[4] for gray and color images. Bilateral filter is non-linear and non-iterative filter that preserve the edges by mean of combining the nearby pixels values in image. They used the technique to combine the gray levels or color based on their geometric closeness and their photometric similarity in both range and domain .F. Durand and J. Dorsey[6] presented a technique for the display of high- dynamic-range images, which reduces the contrast while preserving detail. It is based on a two-scale decomposition of the image into a base layer, encoding large-scale variations, and a detail layer. Only the base layer has its contrast reduced, thereby preserving detail.
Xu, L., Lu, C.et al. [8] have proposed the technique of image smoothing with L0 gradient minimization method. This method is based on the spatial changes in which a restriction is placed upon the total number of non-zero gradients between pixels so that to globally enhancing the prominent edges, even if the boundaries of objects are much contract. An unsharp masking algorithm is presented by GuandDeng[9] by using exploratory data model as a unified framework. The proposed algorithm is designed to address three issues: 1) simultaneously enhancing contrast and sharpness by means of individual treatment of the model component and the residual, 2) reducing the halo effect by means of an edge-preserving filter, and 3) solving the out-of-range problem by means of log-ratio and tangent operations. M. Son,Y. Lee,et al.[12] presented a novel method for enhancing details in a digital photograph, inspired by the principle of art photography. Their technique provides a flexible tone transform model that consists of two operators: shifting and scaling. This model permits shifting of the tonal range in each image region to enable significant detail boosting regardless of the original tone.
The total variation filter [7] uses an L1 norm based regularization term to remove noises in images ,which is also considered as an edge-preserving decomposition algorithm. Weighted Least Squares (WLS)[13] based multi-scale decomposition algorithm decomposes an image to two layers by

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solving a weighted least square optimization problem. In [11] , H. Badri, H. Yahia et al. proposed an accelerated iterative shrinkage algorithm to decompose and enhance image. In [14], the L0 norm based smoothing algorithm is introduced to a detail enhancement scheme for fusion of differently exposed images by F. Kou, Z. Li, C. Wen. In [15], it is used in a visual enhancement algorithm for low backlight displays.

Enrichment Methods

Image enrichment is the process of modifying digital photos so that the desired info is far better pertaining to show or maybe for further image analysis. Image enrichment techniques can be divided into two broad categories :-

Spatial domain methods

Spatial domain techniques directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. Spatial domain techniques like the logarithmic transforms, power law transforms, histogram equalization are based on the direct manipulation of the pixels in the image. Spatial techniques are particularly useful for directly altering the gray level values of individual pixels and hence the overall contrast of the entire image. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results .It is not possible to selectively enhance edges or other required information effectively. Techniques like histogram equalization are effective in many images.

The approaches can be classified into two categories:

Point Processing operation (Intensity transformation function).

Spatial filter operations.

Point processing operations (Intensity transformation function) is the simplest spatial domain operation as operations are performed on single pixel only. Pixel values of the processed image depend on pixel values of original image. It can be given by the expression $g(x,y) = T[f(x,y)]$, where T is gray level transformation in point processing. They are especially useful for bringing out detail in Fourier transforms.

Direct methods define a contrast measure and try to improve it. Indirect methods on the other hand, improve the contrast through exploiting the underutilized regions or the dynamic range without defining a specific contrast term. Contrast enhancement techniques can be broadly categorized into groups: Histogram Equalization (HE),Tone Mapping.

Histogram Equalization is one of the most commonly used methods for contrast enhancement. It attempts to alter the spatial histogram of an image to closely match a uniform distribution. The main objective of this method is to achieve a uniform distributed histogram by using the cumulative density function of the input image. The advantages of the HE include it suffers from the problem of being poorly suited for retaining local detail due to its global treatment of the image small- scale details that are often associated with the small bins of the histogram are eliminated. The disadvantage is that it is not a suitable property in some applications such as consumer electronic products, where brightness preservation is necessary to avoid annoying artifacts.

Tone Mapping is another approach of contrast enhancement techniques. In this method if we want to output high dynamic range (HDR) image on paper or on a display. We must somehow convert the wide intensity range in the image to the lower range supported by the display. This technique used in image processing and computer graphics to map a set of colours to another, often approximate the appearance of high dynamic range images in media with a more limited dynamic range. Tone mapping is done in the luminance channel only and in logarithmic scale. It is used to convert floating point radiance map into 8-bit representation for rendering applications. The two main aims of tone mapping algorithm: Preserving image details and providing enough absolute brightness information in low dynamic range tone mapped image.

Frequency domain systems

Transformation or frequency domain techniques are based on the manipulation of the orthogonal transform of the image rather than the image itself. Frequency domain techniques are suited for processing the image according to the frequency content . The principle behind the frequency domain methods of image enhancement consists of computing a 2-D discrete unitary transform of the image, for instance the 2-D DFT, manipulating the transform coefficients by an operator M, and then performing the inverse transform.

The orthogonal transform of the image has two components magnitude and phase. The magnitude consists of the frequency content of the image. The phase is used to restore the image back to the spatial domain. The usual orthogonal transforms are discrete cosine transform, discrete Fourier

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transform, Hartley Transform etc. The transform domain enables operation on the frequency content of the image, and therefore high frequency content such as edges and other subtle information can easily be enhanced.

Challenges and Future Directions

1.Image enhancement is the process of enhancing the appearance of an image, or a subset of the image, to improve contrast or visualization of image features of interest or to facilitate more accurate subsequent image analysis.
2.Image enhancement can be achieved using computational methods either in the spatial domain or in the transform domain.
3.Spatial domain methods accomplish image enhancement using either global operations on the whole image, or local operations acting on a neighborhood of each pixel.
4.The operations used to increase contrast in the image include contrast stretching, clipping and thresholding, image subtraction and averaging, and histogram equalization and specification.
5.The operations used to sharpen image features and reduce noise include spatial band-pass filtering, directional and steerable filtering, and median filtering.
6.If image noise is a stationary random process, variants of the Wiener filter can be used to reduce the noise.
7.Nonlinear filters, such as the median filter, can reduce noise without blurring edges.
8.Transform domain methods accomplish image enhancement based on computations performed in a transform domain, such as the Fourier or wavelet transform domain. Often salient image features can be more easily isolated and extracted in the transform domain than in the spatial domain.
9.Commonly used Fourier domain image enhancement methods include Wiener filtering, least-squares deconvolution, and band-pass filtering. The Wiener filter is optimal for noise removal in the sense of minimum mean square error.
10.Wavelet domain image enhancement methods leverage the advantages of multiscale image representation and nonlinear filtering. Since image edges tend to correlate spatially across multiple scales, whereas noise does not, one can exploit this property and use nonlinear filtering to accentuate edge structures while suppressing noise in an image.
11.Essentially all of the techniques developed for the enhancement of monochrome images can be applied to enhance color images by performing the operations on their multiple intensity components or on their luminance component, where image detail and edge information are encoded.

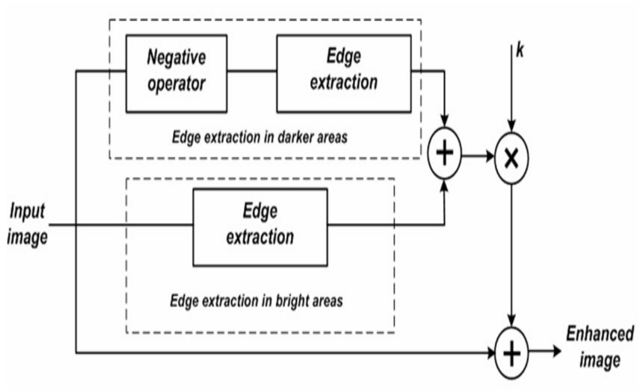

Figure 1. The developed unsharp masking enhancement process

Unsharp masking enhancement process

Unsharp masking enhancement process [1] is one of the most widespread algorithms used for image enhancement. This technique is usually implemented using Laplacian operator. Recently, non linear operator (i.e. QV filter) has been used for image enhancement based on unsharp masking technique [2]. The non linear operator presents an apparent problem appearing in the extraction of features from dark areas. Thus, these areas are not well enhanced as brighter regions. Too, the noise is well amplified due to the sum combination of quadratic terms for QV systems. The developed unsharp masking technique, presented here, is composed by two branches. The first branch extracts the edge from the input image. In the second branch we compute the negative of the input image followed by the extraction of the result. The developed unsharp masking scheme is illustrated by Figure 2.

In this paper the edge extraction block in Fig 1 is implemented using mean weighted high pass filter [5]. We choose the filter in order to reduce the noise amplification due to the quadratic terms in equation 2. Also, the filter extracts thinner edges from images. In Fig 2, the top branch of the developed approach the edges of the negative image are extracted. In the down branch, we extract the edge from the input image. In both branches the mean weighted high pass filter is used for edge extraction.

RESULTS

This paper surveys some of the areas where image enhancement is done. This paper presents the most important techniques for image enhancement in digital image processing. Although this paper did not discuss the computational cost of enhancement techniques it may play a critical role in choosing a technique for real time applications. Despite the effectiveness of each of these algorithms when applied separately, in practice one must devise a combination of such methods to achieve more effective image enhancement.

CONCLUSION

In summary, Image enhancement, one of the most popular ongoing topics in image processing, is reviewed and discussed in this survey. We first introduced previous reviews of image enhancement methods and discover that most of them are only for one aspect. We also figure out that the performance of existing image enhancement methods has never been qualitatively and quantitatively evaluated in an appropriate way. All these issues motivate us to frame this survey. Second, we introduced the existing classification of image enhancement methods as well as our proposed new classification. Then, many commonly used image enhancement methods are reviewed based on the proposed classification followed by a survey of image quality metrics and databases for enhanced images. After the comprehensive literature study, we present the challenges and their potential directions of image enhancement techniques. Before we draw the final conclusion, several future perspectives for image enhancement and its evaluation are discussed. In conclusion, universal image quality metrics and databases that can be used for the performance evaluation of image enhancement approaches are necessarily desired.

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