

## Recent survey on fuzzy mapping based image contrast enhancement techniques

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### Abstract

*The principal objective of enhancement techniques is to process an image so that the result is more suitable than the original image for a specific application. So, the definition of image enhancement is a fairly broad concept that can encompass many applications such as forest mapping classification techniques, Project scope definition, scope verification, scope change control, Global and Indian Geoinformatics Market. In recent years, many researches have been done to enhancement on low contrast image by using the fuzzy image processing method. The main focus of this paper is to provide survey on image enhancement using fuzzy image processing techniques.*

### Keywords

*Contrast, Fuzzy logic, Image enhancement.*

### 1.Introduction

Image enhancement is a process of improving the quality of image by improving its feature. Image enhancement is a method of digital image processing which processes the digital image. Image enhancement includes contrast and edge enhancement, feature sharpening and noise filtering and so on. Among these technique contrast enhancement is important because human eyes are more sensitive to the luminance than to the chrominance/color component of an image. Principle of Contrast enhancement is to improve the visual appearance of the image without introducing unwanted effects and artefacts. Various images like medical images, aerial images, satellite images and even real life photographs may suffer from noise and poor contrast due to the inappropriate lighting during image acquisition and/or wrong setting of aperture size and shutter speed of a camera, so it is necessary to enhance the contrast and remove the noise to increase image quality. Application area of image enhancement ranges from medical images to real life photography. Contrast enhancement is one of the challenging and interesting areas of image processing [1].

Image enhancement processes consist of a collection of techniques that seek to improve the visual

appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. It is often used to increase the contrast in images that are substantially dark or light. Image enhancement entails operations that improve the appearance to a human viewer, or operations to convert an image to a format better suited to machine processing. Image enhancement refers to those image processing operations that improve the quality of input image in order to overcome the weakness of the human visual system [2].

To understand to concept of image enhancement let we denote a two-dimensional digital image of gray-level intensities by  $I$ . The image  $I$  is ordinarily represented in software accessible form as an  $M \times N$  matrix containing indexed elements  $I(i, j)$ , where  $0 \leq i \leq M - 1$ ,  $0 \leq j \leq N - 1$ . The elements  $I(i, j)$  represent samples of the image intensities, usually called pixels (picture elements). For simplicity, we assume that these come from a finite integer-valued range. This is not unreasonable, since a finite word length must be used to represent the intensities. Typically, the pixels represent optical intensity, but they may also represent other attributes of sensed radiation, such as radar, electron micrographs, x rays, or thermal imagery.

Image enhancement is applicable in every field where images are to be understood and analyzed like medical image analysis, satellites images analysis etc. we can say that Image enhancement simply means, transforming an image  $I$  into image  $J$  using  $T$  (see figure 1). Where  $T$  is the transformation. The values of pixels in images  $I$  and  $J$  are denoted by  $p$  and  $q$ , respectively. As said, the pixel values  $p$  and  $q$  are related by the expression [3-4],

$$q = T(p) \quad (1)$$

Where  $T$  is a transformation algorithm that maps a pixel value  $p$  into a pixel value  $q$ . The results of this transformation are mapped into the grey scale range or color image. if we are dealing with grey scale digital images. Then, the results are mapped back into the range  $[0, L-1]$ , where  $L=2k$ ,  $k$  being the number of bits in the image being considered. So, for

example, for an 8-bit image the range of pixel values will be [0, 255]. The same theory can be extended for the color images too [3-4].

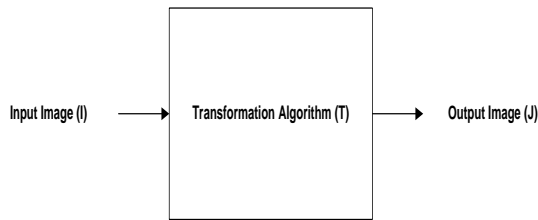


Figure 1 Image enhancement operation

## 2. Image enhancement techniques

There exist many techniques that can enhance a digital image without spoiling it. Image enhancement improves the quality (clarity) of images for human presentation. Eliminating blurring and noise, increasing contrast, and enlightening details are examples of enhancement operations. For example, an image might be chosen of an endothelial cell, which may be of low contrast and little blurred. Decrementing the noise and blurring and incrementing the contrast range could enhance the image.

Basically, Image enhancement is classified into two broad categories namely frequency domain, and spatial domain and fuzzy domain methods. In the frequency domain method, the enhancement is conducted by modifying the frequency transform of the image. Meanwhile in the latter method image pixels are directly modified to enhance the image. However, computing the enhancement in frequency domain is time consuming process even with fast transformation technique thus made it unsuitable for real time application [5]. One of the latest method that is gaining popularities to enhance the image is fuzzy technique which is based on gray level mapping into fuzzy membership function. In this technique fuzzy set rules is used to modify the membership function and finally defuzzification is applied to enhance image.

So we can say that Image enhancement techniques can be divided into three broad categories:

- Spatial domain methods.
- Frequency domain methods (DFT).
- Fuzzy Domain.

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 [6].

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.

Fuzzy image enhancement is based on gray level mapping into membership function. The aim is to generate an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image that are farther from the mean [7-8].

## 3. Application of image enhancement

Image enhancement (IE) has contributed to research advancement in a variety of fields [4]. Some of the areas in which IE has wide application are noted below.

1. In forensics, IE is used for identification, evidence gathering and surveillance. Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced to help in identification of culprits and protection of victims.
2. In atmospheric sciences, IE is used to reduce the effects of haze, fog, mist and turbulent weather for meteorological observations. It helps in detecting shape and structure of remote objects in environment sensing. Satellite images undergo image restoration and enhancement to remove noise
3. Astrophotography faces challenges due to light and noise pollution that can be minimized by IE. For real time sharpening and contrast enhancement several cameras have in-built IE functions. Moreover, numerous software, allow editing such images to provide better and vivid results.
4. In oceanography the study of images reveals interesting features of water flow, sediment concentration, geomorphology and bathymetric

patterns to name a few. These features are more clearly observable in images that are digitally enhanced to overcome the problem of moving targets, deficiency of light and obscure surroundings.

5. Medical imaging uses IE techniques for reducing noise and sharpening details to improve the visual representation of the image. Since minute details play a critical role in diagnosis and treatment of disease, it is essential to highlight important features while displaying medical images. This makes IE a necessary aiding tool for viewing anatomic areas in MRI, ultrasound and x-rays to name a few.

Numerous other fields including law enforcement, microbiology, biomedicine, bacteriology, etc., benefit from various IE techniques. These benefits are not limited to professional studies and businesses but extend to the common users who employ IE to cosmetically enhance and correct their images.

#### 4. Literature survey

Many contrast enhancement algorithms are existing, but development of new algorithm which would produce better images than the existing one is a challenging problem. Several algorithms have been proposed to overcome the uncertainties encountered during transmission and acquisition of the images. Sometimes these uncertainties or vagueness are caused by low contrast in the images. So it is necessary to represent and resolve uncertainty effectively to improve the contrast. Because of the ability to handle and manage the imprecision encountered with images effectively, applying fuzzy set theory becomes a strong in road image processing areas like contrast enhancement. Many research works are still going on in this area to make improvements in the existing techniques.

##### A. Fuzzy Inference System based Contrast Enhancement

In 2011, Balasubramaniam Jayaram, Kakarla V. V. D. L. Narayana and V. Vetrivel [9], proposed a method of contrast enhancement based on fuzzy inference system. In this approach a method of generating if then rules specific to an image based on the local image statistics is performed. In this method they generated only a partial histogram instead of a complete histogram thus saving computational cost and compared with those algorithms that used histogram equalization for contrast enhancement. The term used are partial histogram, fuzzy partitions of input and output domains, dynamic minimum and maximum, concentrated minimum and maximum.

Partial histogram is obtained by taking the pixel values only from random paths in the image pixel matrix that is used four paths 1-horizontal, 1-vertical, and 2-along diagonals. They found that partial histogram still contains sufficient information about the pixel intensities of the original image.

Dynamic minimum and maximum are minimum and maximum value among all pixel intensities in the partial histogram.

Concentrated minimum and maximum are minimum and maximum values among all the pixel intensities in the concentrated range of the partial histogram.

This algorithm enhance the image by using fuzzy sets whose membership functions triangular function (piece-wise linear function) and employ Mamdani Fuzzy system for generating the rule base using the local image information.

##### B. Enhancement of the Low Contrast Image Using Fuzzy Set Theory

In 2012, Khairunnisa Hasikin et al.[10] proposed a fuzzy grey scale image enhancement technique by maximizing fuzzy measures contained in the image. For fuzzification they used S- membership function, parameters of S-function are calculated depends on the membership factors  $\alpha$ ,  $\beta$  and  $\gamma$ . Three parameters are calculated as:

$$\begin{aligned} a &= \alpha E_{max} \\ b &= \beta |IOF_{max} - E_{max}| \\ c &= \gamma IOF_{max} \end{aligned}$$

Where  $\alpha$ ,  $\beta$  and  $\gamma$  are chosen to obtain optimum S-membership function. After fuzzification they used power law and saturation operator for modification of fuzzified values in property domain. They used low contrast 400×264 size image for evaluating the performance of the proposed approach. For comparison they used PSNR, IOF, Contrast and processing performance metric. Contrast is used to distinguish between the object and background of the image. They achieved 22.039 dB which cause under-enhancement of the proposed approach.

##### C. Image Contrast Enhancement using Fuzzy Technique

In 2013, Reshmalakshmi C. And Sasikumar M.[11] proposed a method that deals with contrast enhancement using fuzzy technique. Fuzzy technique converts elements from pixel plane to membership plane i.e. fuzzy plane using suitable either linear membership functions or non-linear membership function. Membership functions are used for converting pixel elements from large grey scale range

to a fuzzy domain value i.e. values between zero to one. They proposed an alternative log membership function defined over the crossover point of the fuzzy set. Contrast enhancement is done using intensity transformation. They used contrast intensification operator (INT) with trigonometric series to enhance the image contrast. To implement transformation function, they grouped the pixels according to their intensities, algorithm adaptively increases the detail in the image, if relative pixel needs to be darkened, sharpen, and smoothen while preserving the other characteristics of an image. Finally, different intensity channels in the modified fuzzy plane are reconstructed to the spatial plane using defuzzification method. Here they used inverse transformation formula for reconstructing the pixel value in spatial plane.

They compared the various contrast enhancement method with the proposed method using some evaluation criteria. Performance evaluation parameters are measure of enhancement by entropy (EMEE), Measure of entropy (ME), Measure of luminance index (MLI), Peak enhanced to original image ratio (PEOIR) and Mean squared difference (MSD). They obtained PEIOR upto 11.37 dB.

D. Membership function modification for image enhancement using fuzzy logic

In March 2013, Preethi S.J. and K. Rajeshwari [12], have proposed a method using ramp membership function. In this approach the modification of the membership function is done using square and cubic operator for enhancing the quality of digital image. The proposed technique has been used in various areas such as medical imaging to make diagnosis easy, color photograph etc. And they considered whole image as a set of dark pixels and bright pixels. Using fuzzy approach uncertainty of image is calculated i.e. pixels which are fully out of the set has membership degree zero and one which are fully in to the set have membership degree one, and rest have partial membership degree. After image enhancement they applied brightness enhancement techniques.

E. Fuzzy Contrast Mapping for Image Enhancement

In 2015, Anita Thakur and Deepak [13] propose a fuzzy based contrast enhancement of gray level images. They extend the work done by [dhawan and Jiuxian] and propose a fuzzy contrast mapping to enhance the contrast of gray scale image. Proposed fuzzy image enhancement is based on gray level mapping into membership function. The aim is to generate an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image those are farther from the mean. In the last few years,

nonlinear filters based on fuzzy models have been shown to be very effective in contrast enhancement without destroying the useful information contained in the image data. In this work the proposed algorithm works on fuzzy contrast mapping and a rule based enhancement. The image quality of the system has been evaluated based on visual appearance, peak signal to noise ratio and entropy.

F. A Combined Effect of Local and Global Method for Contrast Image Enhancement

In 2015, Sampada S Pathak et.al. [14] suggests a combination of local and global method for contrast image enhancement. With the help of global contrast image enhancement we can improve low contrast of image but it avoids noises within the image. Besides this when high contrast occurs in image, it causes under enhancement and over enhancement on some part of an image. It has good advantage but it lacks the local detail of an image. When we use local image enhancement, it only enhances local detail of an image. Also it increases noise of an image when high contrast gain occurs. When we use combination of local and global method it gives us much better results for certain images, compare to local or global image enhancement. In this paper authors used global contrast stretching method for global contrast image enhancement. They used unsharp masking technique for local contrast image enhancement to enhance the local detail of an image. Proposed method preserve the brightness of an image when contrast image enhancement is done.

## 5. Conclusion

Many contrast algorithms are developed but the existing algorithms do not handle the uncertainties or vagueness caused by the low contrast in the image. These uncertainties can be encountered during the transmission or acquisition of image. In many cases these uncertainties are caused by the low contrast of the image. Therefore, it is necessary to represent and resolve the uncertainty present in the images. In addition to these, shortcomings of the existing contrast enhancement techniques also suffer from over-enhancement and under-enhancement. Fuzzy set theory has been applied for contrast enhancement because of their ability to handle and manage the uncertainties encountered with the images effectively and rectifies over-enhancement and under-enhancement problem.

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