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# Controlled Bilateral Filter And Clahe Based Approach For Image Enhancement

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**Abstract:** ***Image enhancement is a region of improving the visual clarity of the image in digital image processing. In this paper, we propose a new algorithm using CLAHE and unsharp masking with bilateral filter. Enhancement of contrast and sharpness of an image is required in many applications. In applications like medical radiography enhancing movie features and observing the planets it is necessary to enhance the contrast and sharpness of an image. Unsharp masking is good tool for sharpness enhancement; it is an anti-blurring filter. By using unsharp masking algorithm for sharpness enhancement, the resultant image suffering with two problems, first one is a hallo is appear around the edges of an image, and second one is rescaling process is needed for the resultant image. The aim of this paper is to enhance the contrast and sharpness of an image simultaneously and to solve the problems. In the proposed algorithm, we can adjust the two parameters controlling the contrast and sharpness to produce the desired output.***

**Keywords**- Bilateral filter, Edge-preserving filter, Adaptive Gain Control, Image Enhancement, Unsharp Masking, CLAHE.

## 1. Introduction

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover, observer specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods. There exist many techniques that can enhance a digital image without spoiling it. The enhancement methods can broadly be divided in to the following two categories:

1. Spatial Domain Methods
2. Frequency Domain Methods

In spatial domain techniques [1], we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied on the input values.

Digital image processing allows the use of much more complex algorithms for image processing, and hence can offer more sophisticated performance at simple tasks. An image is defined as a two dimensional light intensity function (x, y), where x and y are spatial coordinates, and the value f at any pair of coordinates (x, y) is called intensity or grey level value of the image at that point.

We require simultaneous enhancement of sharpness and contrast in many applications. Based on this requirement a continuous research is going on to develop new algorithms. We are having deferent type sharpness enhancement techniques, among these unsharp masking will gives enhanced sharpness with original image as background. We find some unwanted details in the resultant image. To avoid these we used new algorithms. In this section firstly we discuss related works, which are sharpness enhancement techniques including unsharp masking, contrast enhancement and adaptive gain control.

## 2. Methodology

Image enhancement project is composed of three main techniques:

1. Unsharp masking using bilateral filter
2. CLAHE for Contrast enhancement
3. Adaptive Gain Control

The very first part is known as UNSHARP MASKING part. This is the first part of the proposed technique of image enhancement. In unsharp masking algorithm, often the resultant image is amplified to achieve better sharpness. However the signal contains

a) Details of the image

b) Noise

c) Over-shoots and under-shoots in area of sharp edges

While the enhancement of the noise is clearly undesirable, the enhancements of the Over-shoots and under-shoots creates halo effect. Ideally the algorithm should only enhance the details of the image. Due to this reason we require that the filter is not sensitive to noise and does not smooth sharp edges. The edge preserving filter, nonlinear filter [2, 3, 4] is used as it does not smooth sharp edges. To reduce halo effect, edge preserving filter called bilateral filter [9], [11] is used as it is relatively simple and advanced than median filter [3].

For contrast enhancement, we use Contrast Limited adaptive histogram equalization (CLAHE) was originally developed for medical imaging and has proven to be successful for enhancement of low-contrast images such as portal films. The CLAHE algorithm partitions the images into contextual regions and applies the histogram equalization to each one. This evens out the distribution of used grey values and thus makes hidden features of the image more visible. The full grey spectrum is used to express the image.

Contrast Limited Adaptive Histogram Equalization, (CLAHE) is an improved version of AHE, or Adaptive Histogram Equalization which was used in earlier work proposed[8] [9]. Both overcome the limitations of standard histogram equalization. A variety of adaptive contrast limited histogram equalization techniques (CLAHE) are provided. Sharp field edges can be maintained by selective enhancement within the field boundaries. Selective enhancement is accomplished by first detecting the field edge in a portal image and then only processing those regions of the image that lie inside the field edge. Noise can be reduced while maintaining the high spatial frequency content of the image by applying a combination of CLAHE, median filtration and edge sharpening. A variation of the contrast limited technique called adaptive histogram clip (AHC) can also be applied. AHC automatically adjusts clipping level and moderates over enhancement of background regions of portal images.

The expression of modified gray levels for standard CLAHE method with Uniform Distribution can be given as

$$g = [\, g_{max} - g_{min} \,] * P(f) + g_{min}$$

Where g $_{MAX}$ is Maximum pixel value, g $_{MIN}$ is Minimum pixel value and g is the computed pixel value.

P(f)=CPD

(Cumulative probability distribution)

For exponential distribution gray level can be adapted as

$$g = g_{min} - \left(\frac{1}{\alpha}\right) * \ln[1 - P(f)\,]$$

## 3. Adaptive Gain Control

In the enhancement of the detail signal we require gain factor to yield good results, it be must be greater than one. Using a same gain for the entire image does not lead to good results, because to enhance the small details a relatively large gain is required. This large gain can lead to the saturation of the detailed signal whose values are larger than a certain threshold. Saturation is undesirable because different amplitudes of the detail signal are mapped to the same amplitude of either -1 or 1. This leads to loss of information. Therefore, the gain must be controlled adaptively.

We describe the following below gain control algorithm using tangent operations [22]. To control the gain, we first perform a linear mapping of the detail signal d to a new signal c, c=2d-1, such that the dynamic range of c is (-1,1). A simple idea is to set the gain as a function of the signal c and to gradually decrease the gain from its maximum value $\gamma_{MAX}$ when |c| < T to its minimum value $\gamma_{MIN}$ when $|c| \rightarrow 1$.

More specifically, we use the following adaptive gain control function:

$$\gamma(c) = \alpha + \beta e^{(-|c|^{\eta})} \quad (1)$$

where η is a parameter that controls the rate of decreasing. The two parameters α and β are obtained by solving the equations: $\gamma(-1) = \gamma_{MAX}$ and $\gamma(1) = \gamma_{MIN}$. For a fixed η, we can easily determine the two parameters as follows:

$$\gamma(c) = {(\gamma_{MAX} - \gamma_{MIN})}/{(1 - e^{-1})} \quad (2)$$

And

$$\alpha = \gamma_{MAX} - \beta \quad (3)$$

Although both $\gamma_{MAX}$ and $\gamma_{MIN}$ could be chosen based upon each individual image processing task, in general it is reasonable to set $\gamma(1) = \gamma_{MIN}$.

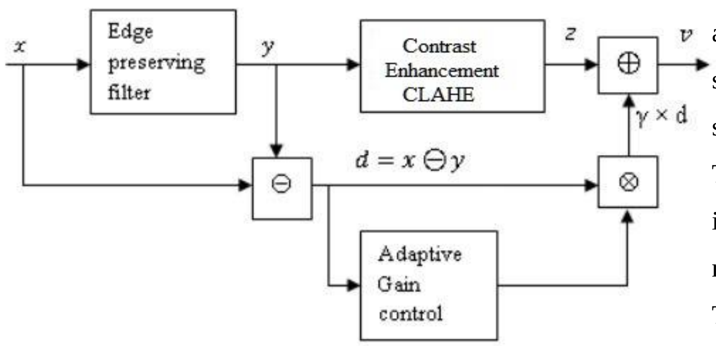


**Figure 3.1:** Proposed Algorithm for Image Enhancement

## 4. The proposed algorithm

Step 1: Load the image to be enhanced.

Step 2: Split the image in to Y, Cb, and Cr color planes.

Step 3: Use DCT for block wise splitting of each plane.

Step 4: Unsharp Masking is implemented using Bilateral filter.

Step 5: The resultant image is processed for contrast Enhancement using Contrast Limited adaptive histogram equalization (CLAHE) instead of the previously used Adaptive histogram equalization (AHE).

Step 6: The resultant after the step 5 is added up with the Adaptive Gain Control which is multiplied with difference calculated after Step 4.

Step 7: Final output image is saved and PSNR and MSE are calculated.

## 5. Results

**Table 5.1:** Results– Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE)

| Serial no. | Image Name | PSNR | MSE |
|---|---|---|---|
| 1 | Cargirl.jpg | 20.3132 | 633.9695 |
| 2 | Wallpaper_20 | 20.6080 | 538.7126 |
| 3 | Big-one | 19.2646 | 808.7033 |
| 4 | Tree-autumn-river | 19.8985 | 859.0651 |

## 6. Conclusion and Future Work

The results acquired show that the proposed approach is more beneficial in image enhancement uniformly. The combined approach of Bilateral Edge preserving filter along with Uniform contrast enhancement with CLAHE and adaptive gain control returns high PSNR value. Therefore, the high frequency and the low frequency content can be equalized to get significant image quality. Such an equalized enhancement scheme causes further reduction in the noise or distortion.

The future work of this approach provides better clarity of the image and provides exposure to the content of the image which remains hidden due to improper contrast and gain distribution. The technique can yield better results in medical imaging for diagnoses or armed forces for the use in night vision equipment. Also the skills of photography and human identification can achieve great boost. The enhancement technique can be optimized to work for other color schemes and graphics formats in high definition devices.

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