IMAGE DEHAZING: BBHE-DSIHE METHOD IN MEDICAL X-RAY IMAGES

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by

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I Rahul Singh, Roll No – 2K22/SPD/07 student of M.Tech (Signal Processing and Digital Design) hereby certify that the work which is being presented in the thesis entitled **"IMAGE DEHAZING: BBHE-DSIHE METHOD IN MEDICAL X-RAY IMAGES"** in partial fulfillment of the requirements for the award of the Degree of Master of Technology, submitted in the Department of Electronics and Communication Engineering , Delhi Technological University is an authentic record of my own work carried out during the period from 2022 to 2024 under the supervision of Dr. M S Choudhary.

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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CERTIFICATE BY THE SUPERVISOR

I certified that RAHUL SINGH (2K22/SPD/07) has carried out their search work presented in this thesis **"IMAGE DEHAZING: BBHE-DSIHE METHOD IN MEDICAL X-RAY IMAGES"** entitled for the award of **Master of Technology** from Department of Electronics and Communication Engineering, Delhi Technological University, Delhi, under my supervision. The thesis embodies results of original work, and studies are carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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ABSTRACT

Medical X-ray images are widely used for clinical diagnosis, providing crucial information for healthcare professionals. However, the quality of these images can be compromised due to factors such as human body structure, equipment limitations, and environmental interferences. This study focuses on enhancing the quality of X-ray images using various techniques. In this research, we suggest a novel approach BBHE-DSIHE method aimed at improving the quality of chest X-ray. It is a two-step approach for enhancing medical X-ray images, specifically focusing on dehazing techniques. The effectiveness of these techniques is evaluated through experiments conducted with different parameter settings. The BBHE-DSIHE method aims to improve image clarity and contrast, facilitating better diagnostic accuracy. The efficiency of the suggested approach is evaluated using the NIH Chest X-ray dataset. Our objective is to identify the most optimal methods for chest X-ray image. After analysing the experimental results, we found that our method demonstrates superior performance for PSNR parameter falling within the range of 30-50dB. Our method has slightly less Structural Similarity Index (SSIM) value as compared to DSIHE but it compensates that loss for the reduction in Mean Square Error (MSE) value. By employing this technique, we aim to improve the standard of medical X-rays images, thereby assisting healthcare professionals in accurate diagnosis and treatment planning.

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TABLE OF CONTENTS

List Of Tables

List Of Figures

List of Abbreviations

HE:	Histogram Equalization
BBHE:	Brightness Preserving Bi-Histogram Equalization
DSIHE:	Dualistic Sub-Image Histogram Equalization
DCP:	Dark Channel Prior
CAP:	Color Attenuation Prior
FVR:	Fast visibility Restoration
BCCR:	Boundary Constraint and Contextual Regularization
NIH:	National Institutes of Health
PSNR:	Peak Signal-to-Noise Ratio
MSE:	Mean Square Error
SSIM:	Structural Similarity Index Measure

CHAPTER 1

INTRODUCTION

In the domain of X-ray imaging, the issue of image dehazing assumes utmost significance. X-ray images are considered essential instruments in the medical domain, serving as crucial components in the identification and assessment of diverse medical disorders, encompassing bone fractures and dental ailments. The success of medical diagnosis and subsequent treatment strategies is directly influenced by the clarity and accuracy of X-ray pictures.

The importance of obtaining clear X-ray images in the field of medical diagnosis cannot be emphasised. Misunderstandings arising from ambiguity or distortions might result in incorrect diagnosis and potentially jeopardise the well-being of patients. Hence, the endeavour to improve the quality of Xray images by means of dehazing holds significant significance within the medical domain.

Image dehazing is a specific area within the field of image restoration that focuses on the restoration of images that have been degraded because of various atmospheric factors such as dust, smoke, haze, and similar phenomena. These features diminish the visibility of images. In the context of transportation applications, it is imperative to acknowledge that inadequate visibility has the potential to result in substantial accidents. Haze has a dual impact on the acquired image, manifesting as a reduction in the signal of the observed scene and the introduction of supplementary elements referred to as ambient light or airlight [1].

The degradation of image quality due to haziness is shown to intensify as the distance between the camera and the scene rises. This phenomenon can be attributed to the decrease in scene brightness and the concurrent increase in the magnitude of airlight. The degradation of the image results in a reduction of visibility [2].

X-ray is a widely employed imaging technology applied for the analysis of luggage in order to identify prohibited items like as weapons and explosives [3]. It is also employed for the detection of structural flaws in metal materials. In the medical field, X-ray imaging is extensively employed for the identification of bone fractures, while in dentistry, it is utilised for dental imaging purposes.

X-ray imaging is preferred over CT scan imaging due to the time-consuming nature of CT scans in comparison to Xray scans. The standard X-ray images exhibited suboptimal quality, and once they were generated, their quality could not be further enhanced. This limitation may present challenges in terms of storage, management, and communication [4].

The utilisation of image processing techniques has the potential to enhance the overall quality of photos [5]. The quality of X-ray images is compromised by various factors such as the intricate structure and composition of the human body, limitations in imaging equipment, environmental conditions, and other relevant elements [6]. Consequently, the resulting image quality is often suboptimal. Dehazing is a technique that mitigates the challenges encountered in various computer vision and image processing applications by enhancing the visibility of scenes. The process of haze removal in an image is employed to eliminate undesired visual distortions, and is often regarded as a technique for boosting the quality of an image [4], [7].

The primary focus of this work is to create and assess picture dehazing approaches that are specifically designed for X-ray images. Our objective is to enhance the diagnostic usefulness of X-ray pictures by improving their clarity and accuracy. The findings of this study have substantial consequences for healthcare professionals, since the enhanced clarity of X-ray pictures has the potential to facilitate more accurate diagnoses and enhance the quality of patient care [8].

CHAPTER 2

LITERATURE SURVEY

The research discussed here presents a novel approach for enhancing medical X-ray images. This study applies the dark channel prior approach to medical X-ray pictures, demonstrating its effectiveness in enhancing image dissimilarity and efficiently emphasising features. The determination of an image's quality is assessed through the computation of its entropy value [4].

This study presents a proposed methodology for improving the quality of X-ray images. The methodology involves the utilisation of multiscale transform and Contrast Limited Adaptive Histogram Equalisation (CLAHE) based enhancement techniques. The Laplacian pyramid decomposes the input image into multiple scales and extracts the inherent features of a multiscale image. The application of CLAHE is employed to enhance the contrast of X-ray pictures. The restoration of the image is achieved through the utilisation of an inverse Laplacian pyramid technique, resulting in the acquisition of an enhanced image. The efficacy of the proposed methodology is afterwards evaluated through the utilisation of contrast assessment parameters for image analysis and information entropy [7].

This study proposed a real-time approach for mitigating haze using histogram processing techniques. The researchers applied the dark-channel-prior and Haar Wavelet techniques to each individual colour component of the image in order to extract several sub-bands. Subsequently, histogram equalisation was applied to each LL sub-band. Ultimately, a haze-free image is acquired by employing the technique of inverting a haze-free image across various colour components. The performance measurements achieved included Entropy, Peak Signal-to-Noise Ratio (PSNR), and Standard Deviation [9].

The proposed approach demonstrated enhanced outcomes in terms of both efficiency and the quality of restoration. The utilisation of this particular approach is deemed to be highly advantageous when dealing with high-resolution photographs and the processing of real-time video content [10].

The categorization of the various methods can be achieved by breaking them into three distinct components, namely image enhancement, fusion, and restoration. The concepts and qualities of these methods were subject to examination [11].

This study investigated image dehazing algorithms that are based on the dark channel prior. This study aimed to enhance comprehension regarding the efficacy of each stage of the dehazing process [12].

The review paper examines traditional dehazing methods utilised for the purpose of removing haze from photographs and enhancing the quality of haze-free images [13].

This paper proposed HE for image processing. It is an image processing technique commonly employed for contrast enhancement. It is a technique that improves the quality of an image without compromising the integrity of its information [4], [14].

This paper proposed BBHE for image processing. It is a method that enhances the contrast of an image without significantly affecting its brightness. This algorithm divides the histogram of original image into two sub-histogram and then pixel values in sub-histograms are evenly redistributed [15].

This paper explains DSIHE for the image processing. The algorithm divides the histogram of original image into two equal sub-images. Then the sub-images are processed independently and it takes spatial distribution of pixels into account [16].

This paper explains DCP for the image processing. It is based on observation that even in a haze-free image at least one of the pixel values closes to zero. The dark channel is minimum value of pixels in a channel. The DCP method uses this observation to find the amount of haze in an image [12], [17].

This paper proposed CAP for the image processing. It uses a model of how color attenuates in a scene to improve the quality of an image. The mentioned technique revolves around a method called the "color attenuation method." This approach addresses the challenge of haze detection and removal in computer vision for single images. It takes advantage of an observation regarding the behaviour of brightness and saturation in hazy images. In hazy regions, the brightness tends to increase while the saturation decreases. This phenomenon is influenced by two factors: direct attenuation and airlight. Direct attenuation results in lower brightness due to a reduction in reflected energy, whereas airlight enhances brightness and reduces saturation. The purpose of the color attenuation method is to estimate haze concentration by examining the variations in brightness and saturation. By comprehending these associations, it becomes feasible to devise algorithms that address image dehazing and enhance visibility under hazy conditions [18].

This paper explains Fast Visibility Restoration (FVR) for the image processing. It is used to restore that have been obscured from some sort of interference. This method first estimates visibility of each pixel in a image and then use this information to reconstruct the image. This method is used to restore the images that have degraded due to noise or some sort of corruption. Its objective is to eliminate the adverse effects of haze and restore clarity and color accuracy to the image. The fast visibility restoration algorithm is designed to prioritize computational efficiency, enabling real-time or near real-time dehazing of images. Its goal is to strike a balance between swift processing and effective haze removal [19].

This paper proposed Boundary Constraint and Contextual Regularization (BCCR) for the image processing. This algorithm is a technique employed in image dehazing to enhance the quality of dehazed images. It incorporates boundary constraints and contextual information to achieve this improvement. The Boundary Constraint and Contextual Regularization algorithm combines boundary constraints and contextual information to produce dehazed images with enhanced quality. By considering local and global image properties, it achieves better preservation of edge details and coherence, resulting in improved visual quality and reduced artifacts [16].

This paper explains DehazeNet algorithm for image processing. The DehazeNet algorithm is an advanced technique used for image dehazing. DehazeNet is an advanced algorithm that exploits the power of deep learning to automatically learn the mapping between hazy and haze-free images. It offers a solution for image dehazing, capable of handling different levels of haze and generating visually pleasing dehazed images [20], [21].

CHAPTER 3

METHODS AND TECHNIQUES

3.1 Histogram Equalization (HE)

Histogram Equalisation is an image processing technique commonly employed for contrast control. Histogram equalisation (HE) is a technique that improves the quality of an image while maintaining the integrity of its information [4], [14]. This algorithm follows a series of steps to accomplish its task:

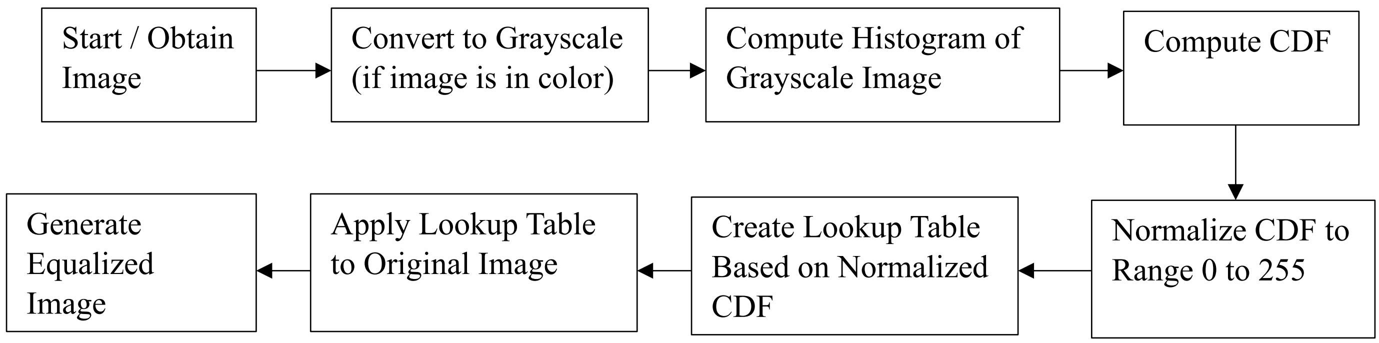

Fig 3.1 Block Schematic of Histogram Equalization Method

3.1.1 Algorithm

1. Obtain the input image.
2. If the image contains colour, convert it to grayscale.
3. The histogram of the grayscale image can be computed by tallying the occurrence of each intensity level within the range of 0 to 255.
4. The task at hand involves calculating the cumulative distribution function (CDF) for a given histogram. The CDF is obtained by summing up the frequencies of intensity levels in a cumulative manner.
5. Normalize the CDF to the range of 0 to 255 to ensure even distribution of intensity values.
6. Create a lookup table to map the original intensity values to the equalized values based on the normalized CDF.

7. Apply the lookup table to the original image, replacing each intensity value with the corresponding equalized value.
8. Generate the equalized image.

3.1.2 Advantages

1. Histogram equalization can be used to improve the contrast of the images that have low contrast.
2. It can improve the visibility of the edges in images.
3. It is relatively simple and easy to implement technique.

3.1.3 Limitations

1. It can introduce artifacts into images, such as increased noise or blurring.
2. It can be ineffective on images that already have high contrast.
3. It can change overall tone of an image.

3.2 BBHE

This algorithm divides the image into lower half and upper half sections based on histogram analysis, calculates scaling factors, maps intensity values, and generates an output image. The BBHE algorithm initially performs a decomposition of an input picture into two subimages by utilising the mean value of the input image [15]. This algorithm follows a series of steps to accomplish its task:

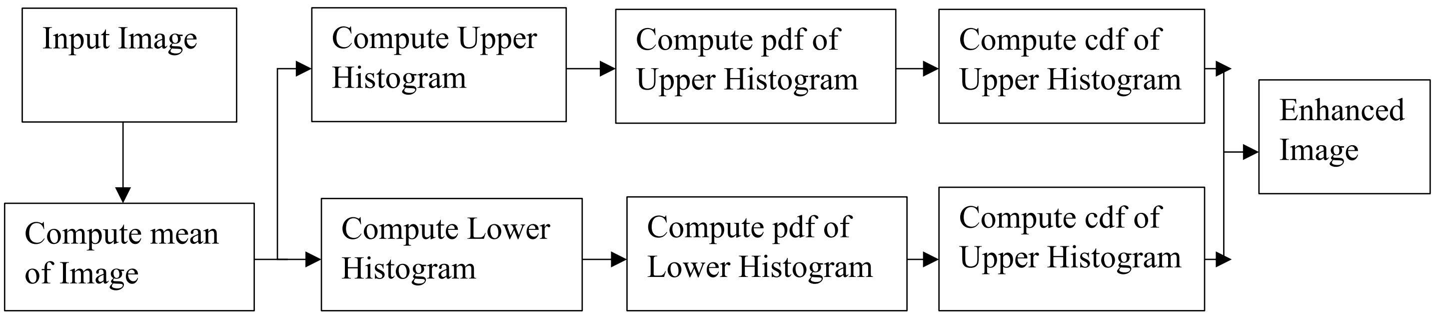

Fig 3.2 Block Schematic of BBHE

3.2.1 Algorithm

1. Examine the grayscale image.
2. Compute the histogram of the given input image.
3. The histogram can be partitioned into two equal sections, namely the lower half (LH) and upper half (UH), by utilising the cumulative histogram.
4. Compute the CDF for both LH and UH.
5. Determine the scaling factors for LH and UH using the formula:

$$Scaling\ factor\ for\ LH\ = ((maximum\ gray\ level\ /\ 2))maximum\ CDF\ value\ of\ LH \quad (3.1)$$

$$Scaling\ factor\ for\ UH\ = (maximum\ gray\ level\ /\ 2)\ /\ maximum\ CDF\ value\ of\ UH \quad (3.2)$$

6. Calculate the new intensity mapping for LH and UH using the formula:

$New\ intensity\ for\ LH\ =\ rounded\ (original\ intensity\ *\ scale\ factor\ for\ LH)$ (3.3)

$New\ intensity\ for\ UH = rounded(original\ intensity * scale\ factor\ for\ UH) + (maximum\ gray\ level/2)$ (3.4)

7. Generate an output image that possesses identical dimensions to the original image.
8. Perform an iteration through every individual pixel present in the input image.
9. When the pixel intensity is within the LH range, the associated pixel in the output image should be assigned using the updated intensity mapping for LH.
10. When the pixel intensity is within the UH range, the associated pixel in the output image should be assigned based on the new intensity mapping for UH.
11. The process outlined in steps 8-10 should be repeated for each individual pixel inside the input image.
12. The generated image can be either displayed or saved.

3.2.3 Advantages

1. BBHE can increase the contrast of an image without significantly changing its brightness. This can make it easier to see the details in images that are otherwise too dark or too bright.
2. The original image is not modified.
3. Simple to implement.

3.2.3 Limitations

1. This method can introduce artifacts in the image such as holes or false edges.
2. This method is not always effective.

3.3 DSIHE

The grayscale probability density function is employed to divide the image into two sub-images of equal size [22]. This algorithm follows a series of steps to accomplish its task:

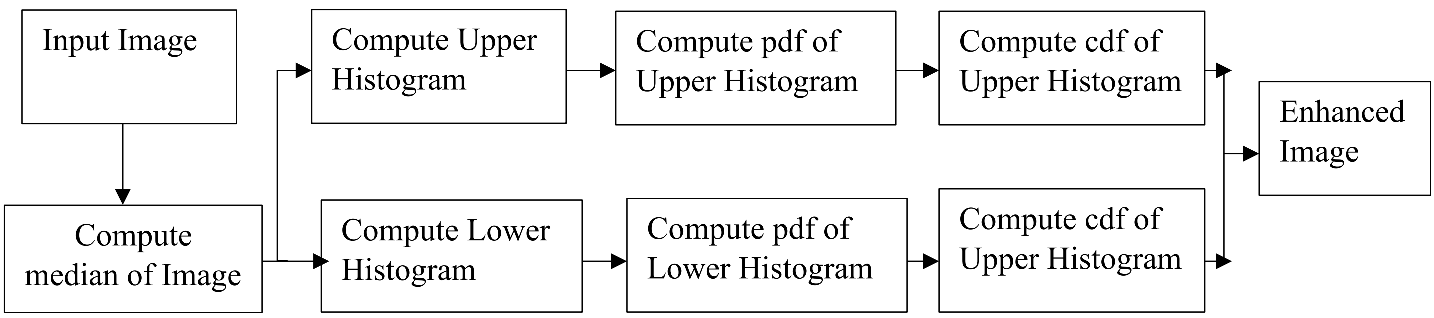

Fig 3.3 Block Schematic of DSIHE

3.3.1 Algorithm

1. Obtain the original image as input.
2. The image should be partitioned into non-overlapping sub-images.
3. For each and every sub-image:
   i) Compute the histogram of the sub-image.
   ii) Calculate the CDF for the histogram of the sub-image.
   iii) The average grey level of the sub-image can be determined by dividing the sum of all grey levels by the total number of pixels.
   iv) The CDF can be divided into two distinct sections, namely, the section pertaining to grey levels that are below the average, and the section pertaining to grey levels that are above the average.
   v) Independently apply histogram equalization to both sections of the CDF.
   vi) Combine the equalized parts of the CDF
   vii) Map the original sub-image pixels to the equalized CDF to generate the equalized sub-image.
4. The process of combining all sub-images that have been equalised is undertaken in order to generate the improved image.

3.3.2 Advantages

1. This method preserves the mean better than BBHE in some cases.

3.3.3 Disadvantages

1. Enhancement achieved by using this method is not satisfactory.
2. If parameters are not set correctly, DSIHE can actually degrade the quality of an image.

3.4 DCP

The Dark Channel Prior (DCP) is a very efficient technique utilised for the purpose of image dehazing, specifically designed to enhance the visual clarity of photographs that have been adversely affected by atmospheric haze or fog. The DCP approach encompasses a series of steps, which are as follows:

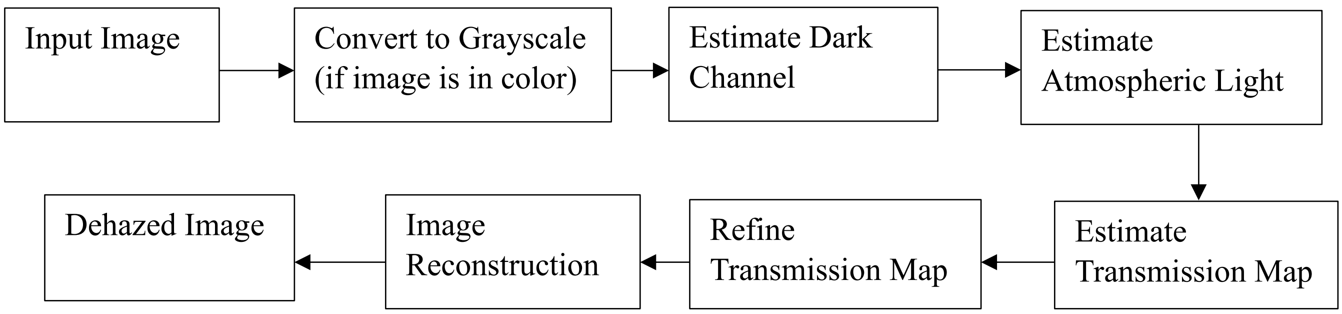

Fig 3.4 Block Schematic of DCP

3.4.1 Algorithm

1. Input Image: Commence with a visually obscured or mist-laden input image that necessitates dehazing.
2. Transformation to Grayscale: Perform a conversion on the input image to obtain a grayscale representation. The simplification of the processing is achieved while still preserving essential features [18].
3. Estimation of the Dark Channel: Compute the dark channel of the given grayscale image. The dark channel is defined as the minimum intensity value of pixels within a local 12 window. This procedure aids in the identification of the most indistinct areas within the image, typically distinguished by diminished pixel intensities.
4. Estimation of Atmospheric Light: The objective is to estimate the atmospheric light, which corresponds to the light that is either scattered or absorbed by haze present in the picture. The estimation is commonly derived from the pixels with the highest intensity in the dark channel. It is postulated that these luminous pixels are indicative of the non-hazy areas within the observed image [12].
5. Estimation of Transmission Map: The objective is to compute the transmission map, which characterises the proportion of light that has effectively propagated through the atmospheric haze. The estimation is conducted through the utilisation of the dark channel and ambient light. The transmission map is a valuable tool for determining the level of haze density present in a given scene.
6. Refinement of the Transmission Map: Improve the quality of the transmission map. One potential approach is to enhance the transmission map in order to minimise artefacts and provide a seamless transition between areas with haze and areas without haze.
7. Image Reconstruction: Ultimately, the dehazed image can be reconstructed by employing the transmission map in conjunction with the atmospheric light. According to a study conducted by researchers [12], this particular process effectively eliminates the presence of haze in the image, hence enhancing vision and rendering distinct details.

The Dark Channel Prior technique is highly efficient in enhancing the visual quality of images affected by haze and is extensively employed in diverse domains such as image dehazing and computer vision.

3.4.2 Advantages

1. The Dark Channel Prior technique is highly efficient in enhancing the visual quality of images affected by haze and is extensively employed in diverse domains such as image dehazing and computer vision.
2. It is simple and easy to implement.
3. It is fast and efficient. It can produce good results in many cases.

3.4.3 Disadvantages

1. It can produce artifacts in some cases such as halos around the bright lights.
2. It is not as effective on images with lot of hazes.
3. It can be sensitive to choice of parameters.

3.5 Color Attenuation Prior (CAP)

The mentioned technique revolves around a method called the" color attenuation method." This approach addresses the challenge of haze detection and removal in computer vision for single images. It takes advantage of an observation regarding the behaviour of brightness and saturation in hazy images.

In hazy regions, the brightness tends to increase while the saturation decreases. This phenomenon is influenced by two factors: direct attenuation and airlight. Direct attenuation results in lower brightness due to a reduction in reflected energy, whereas airlight enhances brightness and reduces saturation. The prevalence of airlight results in increased brightness and decreased saturation in areas affected by haze.

The colour attenuation approach establishes a statistical correlation, represented by Equation, among the depth of the scene, concentration of haze, brightness, and saturation. The equation presented in this context implies that an increase in scene depth leads to an elevation in brightness and a decrease in saturation, ultimately culminating in a greater discrepancy between brightness and saturation.

$$depth(x) \propto conc(x) \propto brightness(x) - sat(x) \quad (3.5)$$

The purpose of the color attenuation method is to estimate haze concentration by examining the variations in brightness and saturation. By comprehending these associations, it becomes feasible to devise algorithms that address image dehazing and enhance visibility under hazy conditions [18].

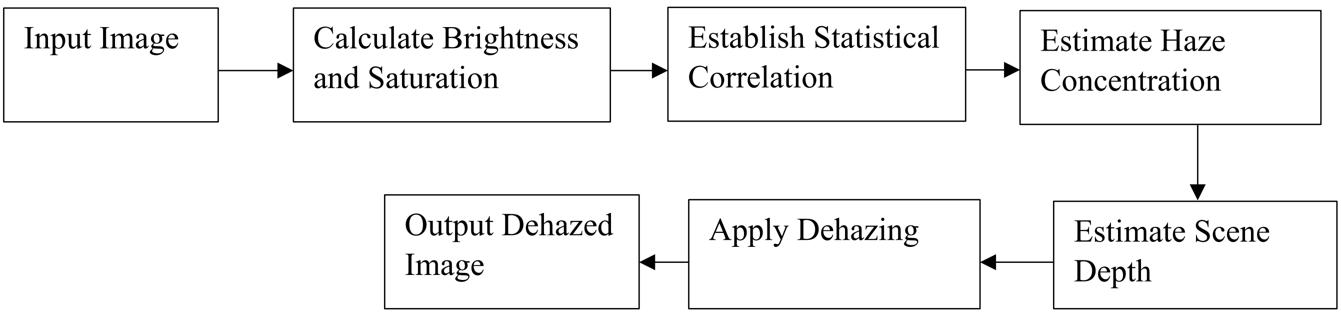

Fig 3.5 Block Schematic of CAP

3.5.1 Advantages

1. It improves the quality of image by desaturating the colors of pixels that are further away.
2. It increases the contrast of the image.
3. It also reduces the noise. It desaturates the pixels that are further away helps to smooth out the image.

3.5.2 Disadvantages

1. This method can be computationally expensive.
2. It may not be suitable for all images.
3. It can introduce artifacts in the image.

3.6 Fast visibility restoration (FVR)

The fast visibility restoration algorithm is a method utilised in the field of image dehazing to efficiently improve the visibility of images that are affected by haze. The primary goal of this process is to mitigate the negative impacts caused by haze and to enhance the visual clarity and colour fidelity of the image. This algorithm follows a series of steps to accomplish its task:

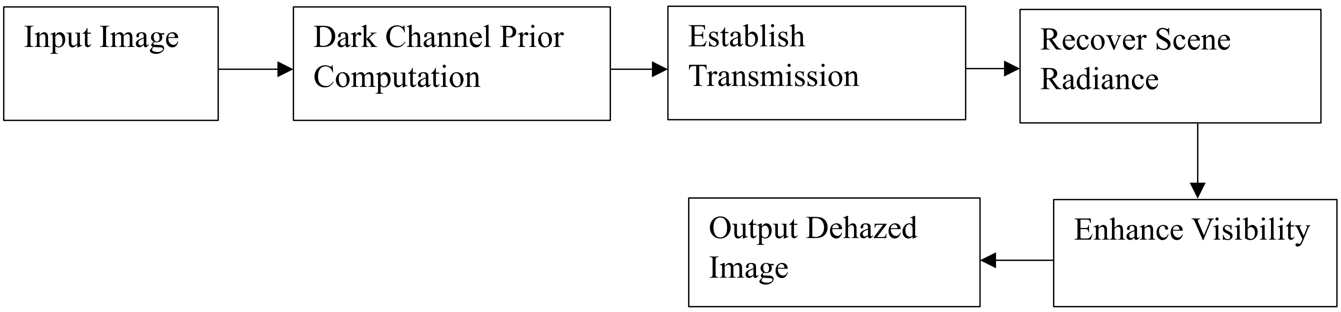

Fig 3.6 Block Schematic of FVR

3.6.1 Algorithm

1. Initial processing: The algorithm initiates with pre-processing steps, like converting the color space and enhancing the image. These steps help prepare the image for further analysis.
2. Haze estimation: The algorithm estimates the haze present in the image by analyzing color and intensity information. Statistical models or heuristic methods are employed to estimate the haze parameters, including the atmospheric light and transmission map.
3. Transmission map estimation: It involves determining the level of haziness for every individual pixel inside the image. The programme derives the map by analysing the correlation between the initial scene and the hazy image that is detected. Techniques such as dark channel prior and colour attenuation prior are commonly utilised for the purpose of estimating this phenomenon.
4. Haze removal: The algorithm proceeds to eliminate the haze from the image using the predicted transmission map. The algorithm implements a dehazing technique that addresses the reduction in light intensity resulting from atmospheric haze, with the objective of restoring the original radiance of the captured scene. The aforementioned function commonly encompasses activities that are reciprocally related to the process of haze production, such as the application of a dehazing model or an atmospheric scattering model.

5. Post-processing: Finally, the algorithm performs postprocessing operations to refine the dehazed image. This may include tasks like enhancing contrast, reducing noise, and correcting colors, all aimed at further improving the visual quality and restoring the original details of the scene.

The fast visibility restoration algorithm is designed to prioritize computational efficiency, enabling real-time or near real-time dehazing of images. The objective of this algorithm is to achieve a harmonious equilibrium between efficient processing and successful haze removal. This characteristic renders it well-suited for scenarios that demand prompt visibility improvement, such as surveillance systems, autonomous vehicles, and real-time video processing [19].

3.6.2 Advantages

1. It is relatively simple and efficient method.
2. It is used to restore the images that have been partially obscured.
3. It can be used to restore the images that have been degraded by noise or other form of corruption.

3.6.3 Disadvantages

1. It may not be able to restore images that have been completely obscured.
2. It introduces artifacts into restored image.
3. It may not be able to restore image that have degraded by severe noise or corruption.

3.7 BCCR

The BCCR algorithm is a technique employed in image dehazing to enhance the quality of dehazed images. It incorporates boundary constraints and contextual information to achieve this improvement. This algorithm follows a series of steps:

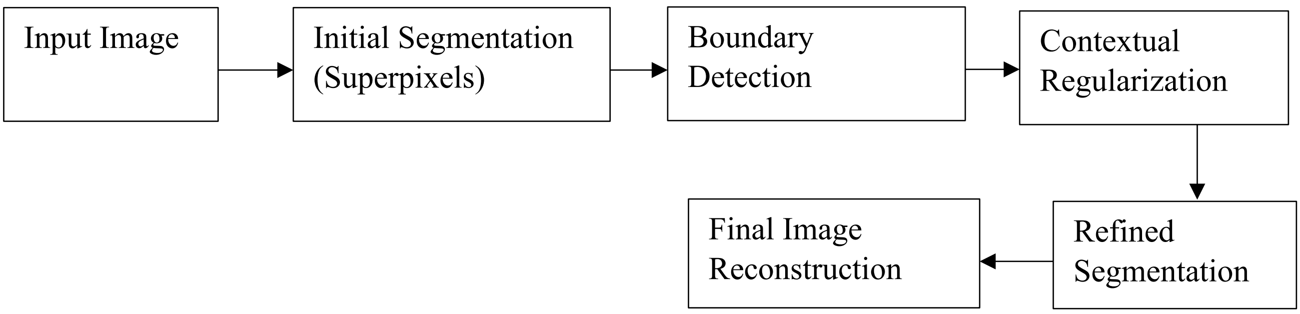

Fig 3.7 Block Schematic of BCCR

3.7.1 Algorithm

1. Haze estimation: The method initiates by making estimations of haze characteristics, such as atmospheric light and the transmission map. The estimation employed in this

study employs statistical methods that are based on the qualities of haze present in the image.

2. Boundary constraint: To preserve object boundaries, the algorithm applies a boundary constraint. It ensures that the dehazing process does not introduce blurring or distortion to important edge details. The aforementioned limitation ensures that there is coherence between the initial image with haze and the resulting image after dehazing, particularly at the edges of objects.
3. Contextual regularization: Alongside the boundary constraint, the algorithm utilizes contextual regularization to enhance the dehazing outcome. By considering relationships among neighbouring pixels, it promotes smoothness and coherence in the dehazed image. This regularization helps to reduce artifacts and enhance visual quality.
4. Optimization: The algorithm formulates an optimization problem that combines boundary constraint, contextual regularization, and other image priors. It seeks to minimize an objective function that balances fidelity to the data (preserving details and colors) and regularization (ensuring smoothness and coherence). Various optimization techniques can be used to solve this problem and obtain the optimal dehazed image.
5. Post-processing: Finally, the algorithm may apply postprocessing operations to further refine the dehazed image. These operations can include contrast enhancement, noise reduction, and color correction, all aimed at improving the overall visual quality and making the dehazed image more appealing.

The Boundary Constraint and Contextual Regularization algorithm combines boundary constraints and contextual information to produce dehazed images with enhanced quality. By considering local and global image properties, it achieves better preservation of edge details and coherence, resulting in improved visual quality and reduced artifacts [16].

3.7.2 Advantages

1. It is effective for preserving details such as edges or textures.
2. Simple to implement.
3. It is computationally efficient.

3.7.3 Disadvantages

1. Sometimes, produces blurry results.
2. It is not efficient as some other dehazing methods at removing hazes from images with a lot of noise.

3.8 DehazeNet Algorithm

The DehazeNet algorithm is an advanced technique used for image dehazing. The proposed method utilises CNNs, which are a class of deep learning models, to acquire knowledge about the association between hazy images and their matching haze-free counterparts. The algorithm progresses through multiple stages.

3.8.1 Algorithm

1. Dataset preparation: A substantial compilation of paired images, consisting of both hazy and haze-free versions, has been gathered. The haze-free images are utilised as

reference material for the purpose of training the network. The dataset has been partitioned into separate training and validation sets.

2. Network architecture: DehazeNet consists of various layers, including convolutional, pooling, and activation layers. The inclusion of these layers facilitates the network's ability to extract distinctive characteristics from the input images and subsequently rebuild the dehazed output. The architectural design may vary based on the individual implementation.
3. Training: The network undergoes training by utilising a dataset consisting of paired photos, one being hazy and the other being haze-free. During the training process, the neural network undergoes adjustments to its internal parameters in order to minimise the disparity between its anticipated dehazed image and the haze-free image that corresponds 15 to it inside the training dataset. This adjustment is achieved through a process called backpropagation and optimization techniques such as stochastic gradient descent.
4. Loss function: The utilisation of a loss function is necessary to measure the discrepancy between the expected dehazed image and the haze-free image that serves as the ground truth. Typical options for the loss function encompass MSE or perceptual loss, which effectively captures perceptual disparities across images.
5. Optimization: The network parameters are optimized using the training set and the chosen loss function. This optimization process fine-tunes the weights and biases of the network, enhancing its ability to generate accurate dehazing predictions.
6. Inference: Once the network is trained, it can be deployed to dehaze new and unseen hazy images. The obscured image is inputted into the trained neural network, which then generates the equivalent dehazed image as the resulting output. The process of inference is generally characterised by its rapidity, enabling the timely or very timely removal of haze from images.

DehazeNet is a sophisticated system that leverages the capabilities of deep learning to autonomously acquire knowledge about the relationship between hazy and haze-free images. It provides a comprehensive solution for the task of image dehazing, effectively addressing varying degrees of haze and producing visually appealing dehazed images [20], [21].

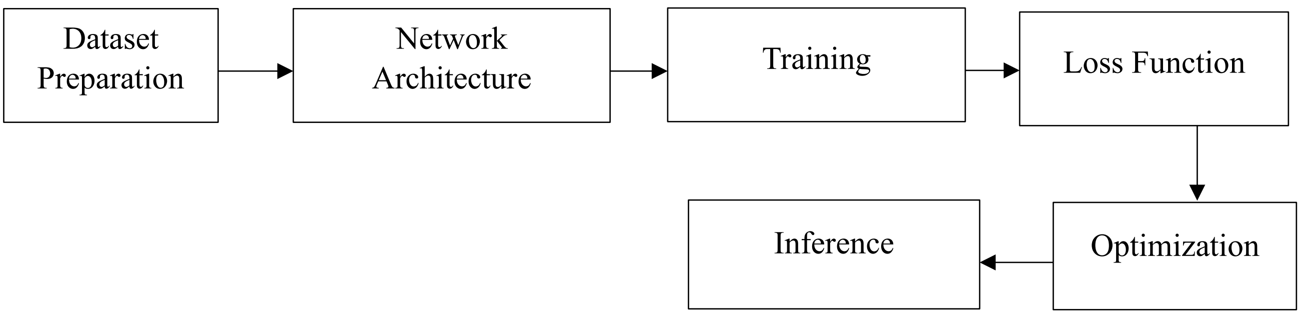

Fig 3.8 Block Schematic of DehazeNet

3.8.2 Advantages

1. It is more efficient than the traditional dehazing methods.
2. It dehazes the image without introducing the artifacts or distortions in the image.
3. It is able to dehaze images with different level of hazes in the images.

3.8.3 Disadvantages

1. This method is computationally expensive.
2. It requires large dataset to train the model.
3. It may not be able to dehaze images with very severe hazes.

CHAPTER 4

PROPOSED METHODOLOGY

4.1 BBHE-DSIHE METHOD

We proposed BBHE-DSIHE method which is a two-step approach for enhancing medical X-ray images, specifically focusing on dehazing techniques as shown if figure 4.1. The method involves the sequential application of two image enhancement algorithms: BBHE followed by DSIHE.

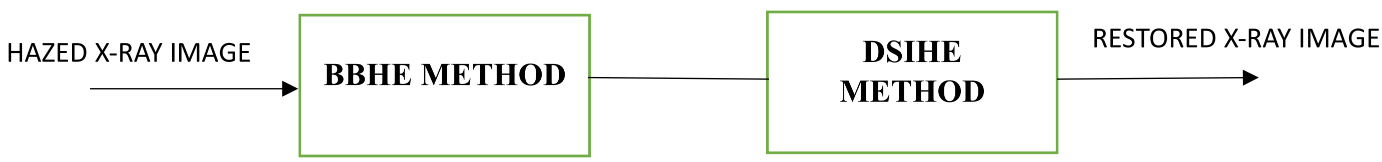

Fig 4.1 Block Schematic BBHE-DSIHE Method

4.2 Algorithm

1. Obtain the input X-Ray image.
2. Image Pre-processing: The algorithm initiates with pre-processing steps, we use BBHE Method for the pre-processing of the input image. BBHE method can increase the contrast of our input image without significantly changing its brightness.
3. The second step involves applying DSIHE to the pre-processed image obtained from the previous step.

4.3 Advantage

In addition to increasing PSNR, our suggested approach lowers MSE at the expense of a minor decrease in SSIM.

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CHAPTER 5

EXPERIMENTAL RESULTS

This section is a discussion of the dataset used in experiments and the corresponding quantative and qualitative results.

5.1 Dataset

The utilisation of the NIH Chest X-ray dataset has significant value for scholars engaged in medical image analysis, rendering it a commendable selection for a conference paper centred on the enhancement of medical x-ray images through the process of dehazing [23]. The dataset is accessible in multiple forms and comprises a significant compilation of chest X-ray pictures. The following is a summary of the dataset:

The NIH Chest X-ray dataset is a comprehensive compilation of chest X-ray pictures, rendering it a valuable asset for the field of medical image analysis. The utilisation of these images is crucial for a range of functions, encompassing lung segmentation, disease identification, and dehazing.

5.2 Quantative Results

Methods	PSNR	MSE	SSIM
BBHE-DSIHE	30.0621	64.1016	0.972542
HE	29.1601	78.8989	0.96667
BBHE	29.112	79.777	0.97735
DSIHE	29.5012	72.9391	0.98111
DCP	22.5697	359.8391	0.80824
CAP	9.8744	0.10293	0.22687
FVR	14.4223	0.036122	0.66221
BCCR	-10.7642	11.9241	0.14669
DehazeNet	11.6125	0.068984	0.4644

Table 5.1 Comparison of parameters for the chest X-ray image based on our method and other methods

As shown in Table 5.1, Our Method exhibits the highest value for the PSNR metric, falling within the range of 30-50dB [24]. This range is considered optimal for human visualisation. DSIHE is the most optimal approach for chest X-ray picture based on the SSIM parameter. FVR exhibits the lowest value for the MSE parameter. But SSIM parameter is not optimal. So, despite having minimum MSE it is not very good method for image dehazing for medical X-ray images. Our method has slightly less SSIM value i.e., 0.972542 as compared to DSIHE but it compensates that loss by reducing the MSE value.

5.3 Qualitative Results

The purpose of this qualitative analysis is to offer a thorough comprehension of the visual enhancements attained by the dehazing algorithm. This analysis strengthens the quantitative results by presenting concrete examples and providing insights into the algorithm's practical usability in a medical setting.

a) Original Image

b) Our Method

c) HE Method

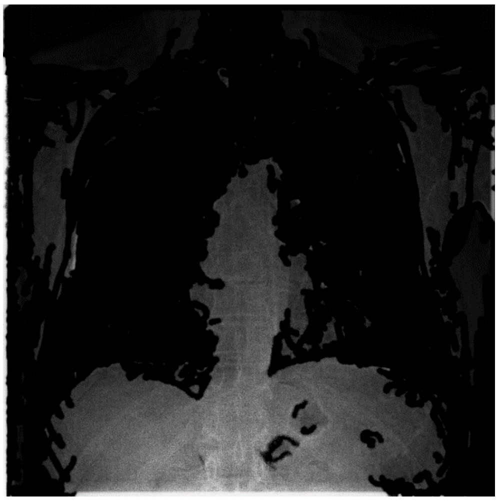
d) BBHE Method

e) DSIHE Method

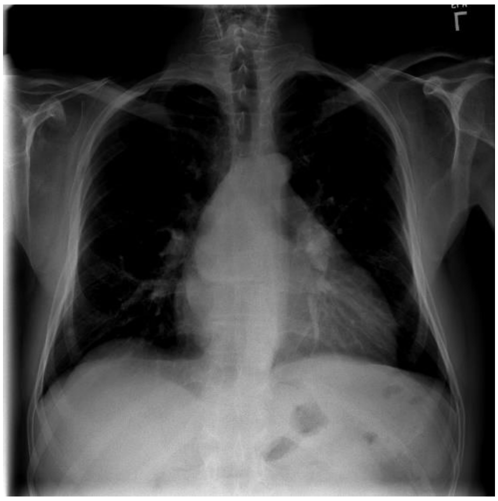
f) DCP Method

g) CAP Method

h) FVR Method

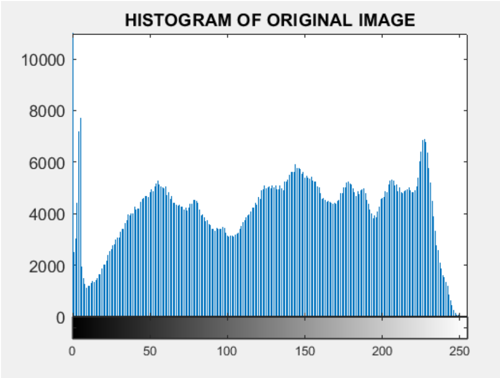


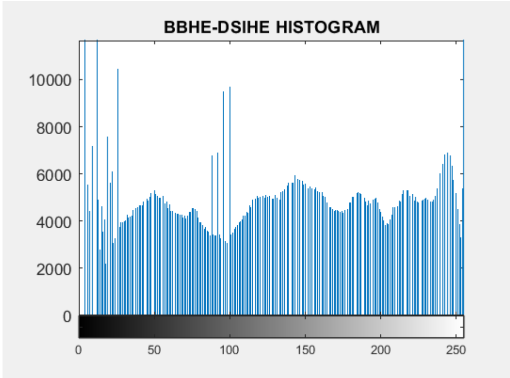
i) BCCR Method

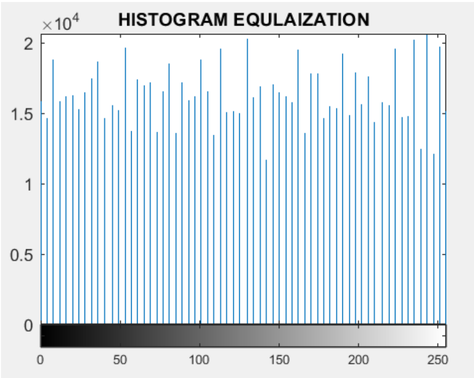


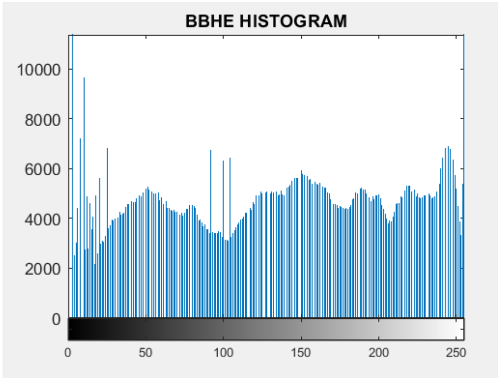
j) DehazeNet

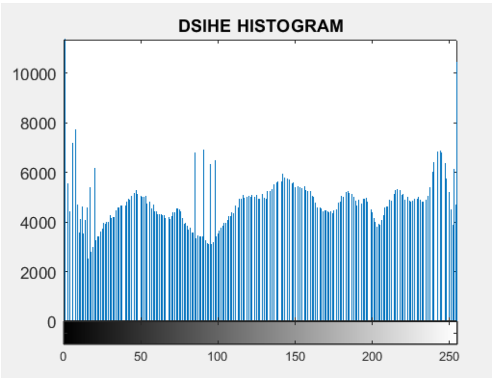
Fig 5.1 Original Image and Corresponding Dehazed Images

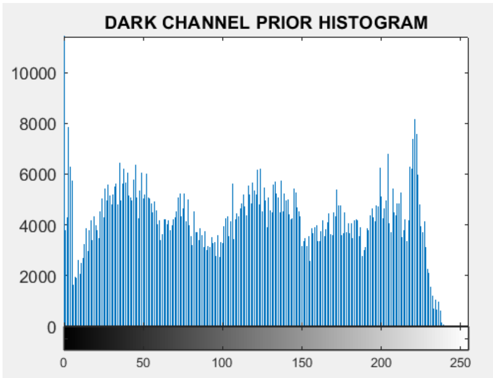

HISTOGRAM OF ORIGINAL IMAGE
10000
8000
6000
4000
2000
0
0 50 100 150 200 250

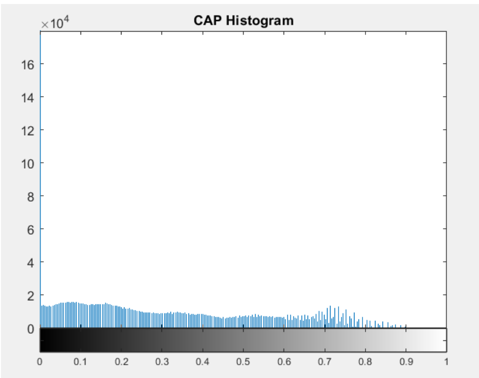

BBHE-DSIHE HISTOGRAM
10000
8000
6000
4000
2000
0
0 50 100 150 200 250

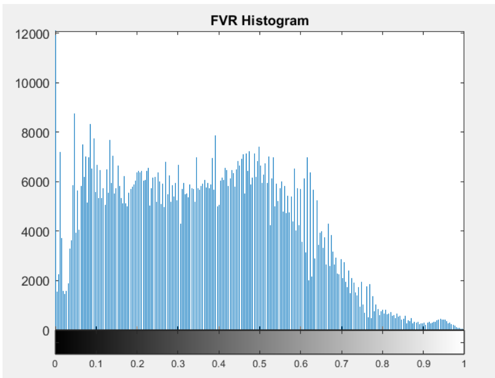

×10^4
HISTOGRAM EQULAIZATION
2
1.5
1
0.5
0
0 50 100 150 200 250


BBHE HISTOGRAM
10000
8000
6000
4000
2000
0
0 50 100 150 200 250


DSIHE HISTOGRAM
10000
8000
6000
4000
2000
0
0 50 100 150 200 250


DARK CHANNEL PRIOR HISTOGRAM
10000
8000
6000
4000
2000
0
0 50 100 150 200 250


×10^4
CAP Histogram
16
14
12
10
8
6
4
2
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1


FVR Histogram
12000
10000
8000
6000
4000
2000
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

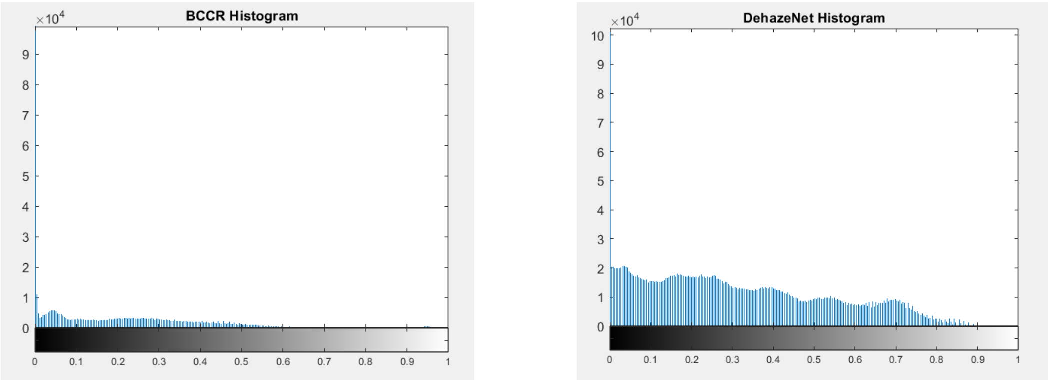


Fig 5.2 Histogram of Original Image and Corresponding Dehazed Images

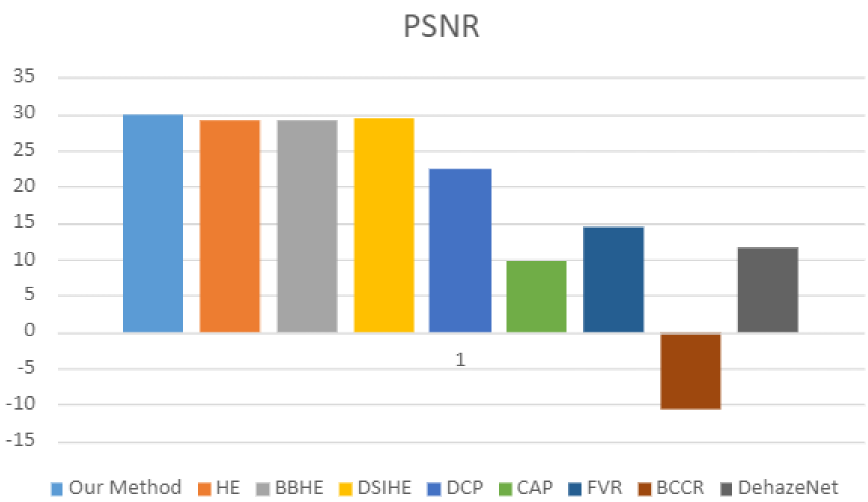


Fig 5.3 Comparison of PSNR parameter in Our Method, HE, BBHE, DSIHE, DCP, CAP, FVR, BCCR and DehazeNet for chest X-ray Image

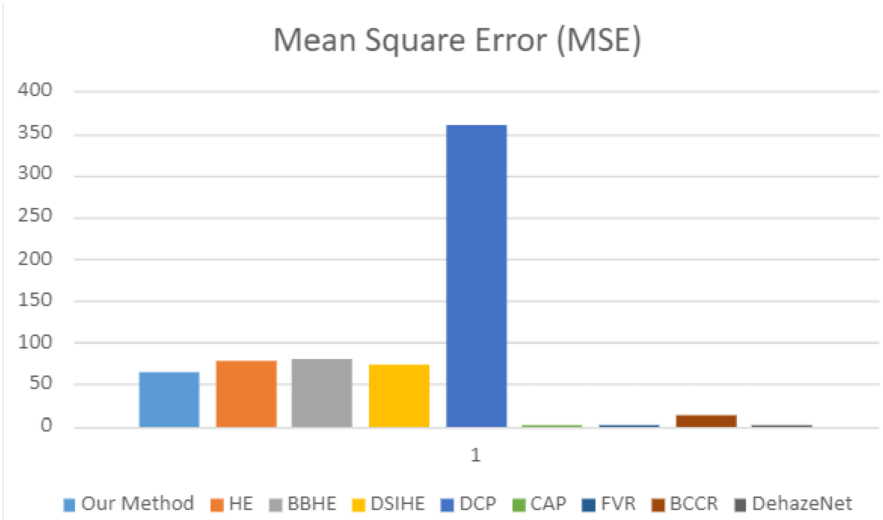


Fig 5.4 Comparison of Mean Square Error (MSE) parameter in Our Method, HE, BBHE, DSIHE, DCP, CAP, FVR, BCCR and DehazeNet for chest X-ray Image

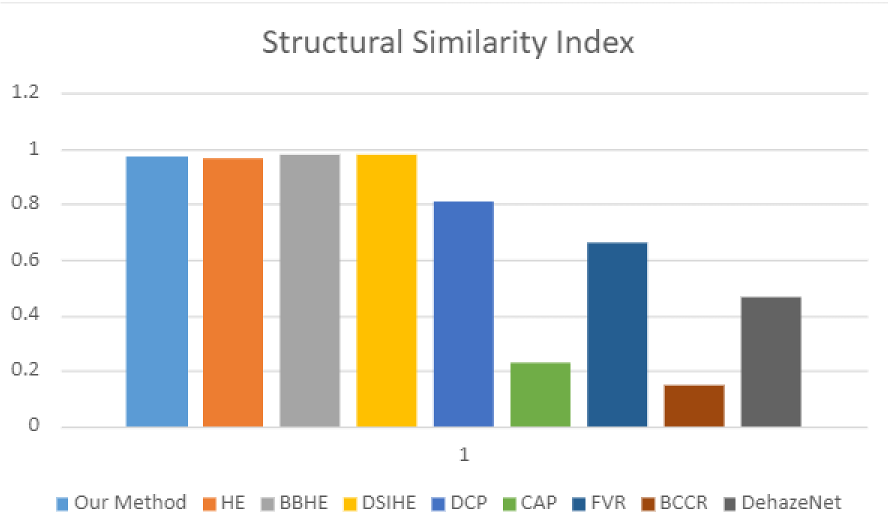


Fig 5.5 Comparison of Structural Similarity Index (SSIM) parameter in Our Method, HE, BBHE, DSIHE, DCP, CAP, FVR, BCCR and DehazeNet for chest X-ray Image

CHAPTER 6

Conclusion, Future Scope and Social Impact

We applied BBHE-DSIHE method on medical X-ray Image and compared the results with Histogram Equalization, BBHE, DSIHE, Dark Channel Prior, FVR, BCCR, CAP and DehazeNet, and verified that our method demonstrates superior performance for PSNR parameter falling within the range of 30-50dB. Although the Structural Similarity Index (SSIM) of our method is slightly lower compared to DSIHE, this is offset by a notable reduction in Mean Square Error (MSE), indicating overall improved image quality.

6.1 Future Scope

1. **Algorithm Optimization:** Further refinement of the BBHE-DSIHE method can be pursued to enhance SSIM without compromising other parameters. This could involve integrating advanced machine learning techniques or deep learning models to optimize the balance between contrast enhancement and structural preservation.
2. **Real-time Implementation:** Developing real-time dehazing algorithms based on BBHE-DSIHE for medical imaging equipment could significantly improve the efficiency of clinical diagnostics.
3. **Broader Applications:** The method can be extended to other types of medical imaging beyond X-rays, such as MRI and CT scans, to improve the quality and diagnostic value of these images.
4. **Comprehensive Evaluation:** Conducting extensive evaluations using diverse datasets and different imaging conditions will help validate and generalize the effectiveness of the proposed method.
5. **User-friendly Software Tools:** Developing user-friendly software tools that incorporate the BBHE-DSIHE method can facilitate its adoption in clinical settings, allowing medical practitioners to easily improve the quality of X-ray images.

6.2 Social Impact

1. **Improved Diagnostic Accuracy:** Enhanced X-ray images lead to better diagnostic accuracy, reducing the likelihood of misdiagnoses and ensuring timely and appropriate treatment for patients.
2. **Healthcare Accessibility:** Improved image quality can potentially lower the need for repeated scans, thereby reducing radiation exposure and making healthcare more efficient and accessible, particularly in resource-limited settings.

3. **Economic Benefits:** By reducing the need for additional imaging and enhancing diagnostic efficiency, the BBHE-DSIHE method can contribute to cost savings for healthcare providers and patients alike.
4. **Enhanced Training:** High-quality X-ray images can be valuable educational resources, aiding in the training of medical students and radiologists by providing clearer and more accurate visual information.
5. **Public Health Outcomes:** Ultimately, the implementation of advanced image enhancement techniques like BBHE-DSIHE can lead to improved public health outcomes through better disease detection, monitoring, and management.

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LIST OF PUBLICATION

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