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Visual Improvement For Dense Foggy & Hazy Weather Images, Using Contrast Enhancement And Colour Modification Techniques

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Abstract: Image enhancement processes consist of a collection of techniques that inquire about to improve the visual appearance of degraded image. This paper introduces a multimodal enhancement technique for dense foggy images using contrast enhancement and colour modification. The present available techniques don't work in low visibility like dense fog. The proposed methods changes the intensity component among the converted HIS components from the RGB components of the original foggy image. Again by converting back to RGB components, the foggy image tends to appear more clearly than the original image in terms of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE).[2] Finally the enhanced foggy image is obtained and the results are presented.[9]

Keywords: Contrast enhancement, Foggy Images, HIS components, HE, MSE, PSNR, RGB components.

I. INTRODUCTION

Digital Image Processing has become a very important tool for processing of variety of signals, images etc. The many applications like Gray scale modification, Earth sciences, Medical Imaging, Remote Sensing, Finger print identification are used in Image processing. An Image has the array or matrix of square of pixels arranged in rows and columns. Pixel is widely used term and it denote by improving the visibility of its elements of an image. Image enhancement is process of making the images more useful by improving the visibility of its details the quality of images, removing noise from the images etc.

The various techniques have been developed in the area of Digital Image Processing during the last four to five decades. Most of the techniques are developed for enhancing images obtained from medical image, unmanned spacecrafts, space probes and military flights. Image Processing are suitable and accepted due to now days easy availability of powerful personnel computers, large size memory devices, graphics software, display systems etc.[11]

Image Enhancement is one of the most important techniques in image processing research. The aim of image enhancement is to improve the visual appearance of an image. Bad weather such as fog and haze reduce the visibility and color fidelity,[6,7] and the particles in atmosphere cause absorption and scattering, fog and haze removal is critical for a wide range of image-related applications, such as surveillance systems, intelligent vehicles, satellite imaging, and outdoor object recognition systems. It is necessary to enhance the contrast and remove the noise to increase image quality. Image Enhancement techniques which improve the quality (clarity) of images for human viewing, increasing contrast, and revealing details are examples of enhancement operations. The enhancement technique differs from one field to another according to its objective.[12]

The aim is to develop the better visual appearance of the image, such as vehicle driver assistance system under the dense foggy and hazy weather condition. Towards this in mind, as a first step the image processing technique presented here has shown encouraging results. This system will help in seeing the background information of the screen of the vehicles with much more clarity. Carrying out image enhancement under low quality image is a challenging problem such as with low contrast etc., we cannot clearly extract objects from the dark background. In this paper we have proposed a multi modal enhancement processing techniques which shown better results by presently available techniques. Finally, we have pointed out promising directions of research in image enhancement field.

II. CLASSIFICATION OF VISIBILITY

Based on visibility and composition, various phenomena are described as follows:-

- ✓ Fog. When relative humidity is more than 75% the fog appears, however the visibility reduces to less than 1000 mts. The international definition as follows:
    - Shallow fog: If the fog visibility is between 1000 & 500 mts.
    - Moderate fog: If the visibility is between 500 & 200 mts.
    - Thick fog: Visibility range should be between 200 and 50 mts.
    - Dense fog: Visibility further reduces to less than 50 mts.
- ✓ Haze. When the relative humidity is equal or less than 75% the haze forms, however the visibility reduces to 2000 mts to 5000mts.
- ✓ Mist. When the relative humidity is equal to 75% the mist forms, however the visibility reduces to 1000 mts to 2000mts.
- ✓ Smog. When pollutants and smoke remain suspended in the air near ground with wind remaining light the smog forms, but no humidity criteria. The visibility reduces but no specific range criteria are standardized.

Fog is the least dynamic of all cloud phenomena. Cloud dynamicity often classifies fog as a micrometeorological phenomenon because it forms next to the earth in the atmospheric boundary layer, a domain traditionally covered by micrometeorologists. Fog does, in fact, span all these discipline (as do many cloud systems); it occurs in the atmospheric boundary layer; it is a well-defined cloud in most instances, and it exhibits horizontal and temporal variability on scales normally thought to be the domain of mesoscale.

Figure 1: Types of fog

Based on visibility and composition, various phenomena which reduce the clarity of image are described as follows:-

Code no	Weather Condition	Meteorological Range, *Rm*
0	Dense fog	50m
1	Thick fog	1 50m - 200m
2	Moderate fog	200m - 500m
3	Light fog	500m - 1000m
4	Thin fog	1km - 2km
5	Haze	2km - 4km
6	Light haze	km - 10km
7	Clear	km - 20km
8	Very clear	20km - 50km
9	Exceptionally clear	>50km
10	Pure air	277km

Table 1.1: International Visibility Code with Meteorological Range

III. IMAGE ENHANCEMENT TECHNIQUES

Bad weather caused by atmospheric particles, such as fog, haze, etc. May essentially diminish the visibility and distorted the colors of the scene. This is because of the accompanying two diffusing procedures, (i) light reflected from the item surface is constricted because of disseminating by particles, and (ii) some immediate light flux is scattered toward the camera. These impacts result in the balance decrease which increments with the separation. [18] Under foggy weather conditions, contrast and color of the images are drastically degraded. Clear day images have more contrast than foggy images. The degradation level increases with distance from camera to the object. Enhancement of foggy image is a challenge due to the complexity in recovering luminance and chrominance while maintaining the color fidelity.

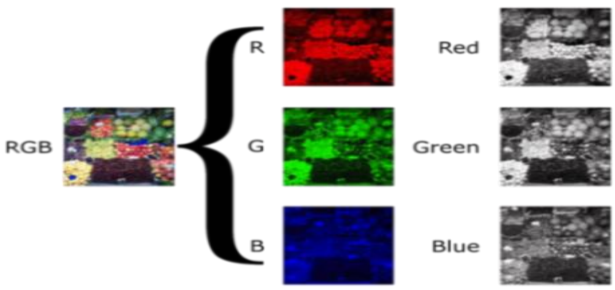


Figure 2: RGB color components

Amid enhancement of foggy images, it ought to be remembered that over enhancement prompts immersion of pixel quality. In this manner, enhancement ought to be limited by a few limitations to maintain a strategic distance from immersion of image and safeguard proper color loyalty. Starting works in fog expulsion depend on the complexity enhancement with no learning of the fog model.[17] The most usually utilized differentiation enhancement technique is histogram leveling and its varieties. Some other image enhancement strategies are likewise displayed by numerous analysts with a specific end goal to reestablish differentiation of fog-debased images. Every one of the strategies proposed; accept a specific arrangement of traits of the fog debased images. Histogram equalization may not enhance difference of the image which lies in right scope of histogram. In PC vision, the barometrical scrambling model is typically used to depict the development of a foggy or dim image. All settled techniques depend on this model. Some of them require numerous information images of a scene; e.g., images taken either under various air conditions or with various degrees of polarization. [25] Another techniques endeavor to expel the impacts of fog from a solitary image utilizing some type of profundity data either from territory models or client inputs .In useful applications, it is hard to accomplish these conditions. So such methodologies are limited. The exceptionally most recent defogging strategies can defog single images by making different suspicions about the profundity or colors in the scene.[19]

Classified details of work done by various researchers are given below:

A. CONTRAST ENHANCEMENT BASED ALGORITHM TO IMPROVE VISIBILIT OF OLORED FOGGY IMAGES

Images taken under foggy climate conditions experience the ill effects of debasement because of serious complexity misfortune furthermore because of misfortune in color qualities. The level of debasement increments exponentially with the separation of scene focuses from the sensor. Consequently essential test is to invalidate the brightening impact in this way enhancing the differentiation of the debased image. Manoj Alwani and Anil Kumar Tiwaria present a complexity enhancement calculation for debased color images. [23] To reestablish both differentiation and color, here they propose four stages. The RGB segment of the information image is initially changed over into HIS space to get splendor segment. Due to scene profundity fluctuates contrastingly over entire image. The worldwide enhancement strategy does not reflect profundity change. So to deal with neighborhood scene profundity transforms, they handle the image on a piece by square premise, accepting that the pixels in the piece are currently of same scene profundity. At that point upgrade the square as per pixel intensities in it. Essentially this imply if the given image has numerous items with shifting scene profundity, then worldwide enhancement methods are relied upon to do normal sort of enhancement of different article. Then again, preparing on a piece by-square premise will upgrade the item viably.

B. CONTRAST RESTORATION OF WEATHER DEGRADED IMAGES

Most outside vision applications, for example, observation, territory order, and self-ruling route require hearty location of image components. Under awful climate conditions, in any case, the difference and color of images are radically adjusted or debased. Consequently, it is basic to expel climate impacts from images keeping in mind the end goal to make vision frameworks more solid. Sadly, the impacts of terrible climate increment exponentially with the separations of scene focuses from the sensor. Therefore, ordinary space invariant separating procedures neglects to enough expel climate impacts from images. Here a technique is portrayed to reestablish scene contrast for an altered given profundity division of the scene. This strategy is basic and successful for scenes where profundity changes are sudden. Be that as it may, it is difficult to characterize great profundity division when scene profundities change step by step with the development of the vehicle. A strategy to reestablish complexity of a discretionary scene utilizing scaled profundities of scene focuses was given by S. G. Narasimhan and S. K. Nayar, [5] who proposed a material science based model that portrays the appearances of scenes in awful climate conditions. The air light and the constricted light are ascertained. Here they portray a straightforward strategy to reestablish scene contrast from one terrible climate image utilizing profundity division of the scène. They consider profundity division as the extraction of profundity districts in the scene. The shine at any pixel recorded by a monochrome camera is given. This strategy is rehashed autonomously for every point in the scène and afterward an aggregate shine variety is ascertained. We take note of that such basic image preparing strategies, for example, contrast extending can be powerful for scenes that are at the same profundity from the sensor. [27]

C. CORRECTION OF SIMPLE CONTRAST LOSS IN COLOR IMAGES

Contrast enhancement strategies fall into two gatherings. They are non-model-based and show based. In non-model-based techniques we investigate and handle the image construct exclusively with respect to the data from the image. The most usually utilized non-model-based techniques are histogram evening out and its varieties. For color images, histogram evening out can be connected to R, G, and B color channels independently yet this prompts undesirable change in tone. Better results are gotten by first changing over the image to the Shade, Immersion, Power color space and after that applying histogram evening out to the Force segment as it were. J. P. Oakley and H. Bu [29] proposed a strategy for determination of airlight level in computerized images. The technique includes the minimization of a scalar worldwide cost capacity and no area division is required. Once the airlight level has been acquired, straightforward differentiation misfortune is effectively adjusted. The exactness of the technique under perfect conditions has been affirmed utilizing Monte Carlo reenactment with an engineered image model. Helpful levels of execution are additionally accomplished when the engineered image model is summed up to incorporate clamor and different varieties in measurable properties. The precision of the airlight evaluation is unfeeling to the scale and complexity of the image change and the level of variety in image brilliance. The manufactured image change for these studies is created utilizing the Gaussian appropriation. Be that as it may, valuable levels of execution are accomplished notwithstanding when the vacillation is created utilizing the Cauchy dispersion. Since the Cauchy and Gaussian dispersions are altogether different, so the strategy is extremely vigorous. The technique is material to both highly contrasting images and color images. It is intriguing to consider different sorts of image that could be handled. Close IR images produced utilizing dynamic brightening ought to have a comparative structure to unmistakable light images thus the calculation portrayed here could be connected. Images produced in the mid and far IR groups by uninvolved discharge have a measurable structure that is entirely diverse. [30] Here we take note of that since the warm emanation relies on upon outright temperature, the images are framed over a generally little relative temperature variety. The differentiation in dim parts of the image can be relied upon to be generally the same as in splendid parts of the image a critical distinction from obvious images. In this manner, the calculation may not give great results for this situation.

D. ENHANCEMENT OF IMAGE DEGRADED BY FOG

Under terrible climate conditions, the light achieving a camera is extremely scattered by the environment. So the image is getting profoundly corrupted because of added substance light. Added substance light is structure from disseminating of light by fog particles. Added substance light is made by blending the obvious light that is radiated from various light sources. This added substance light is called air light. Air light is not consistently disseminated in the image. It is realized that under fog climate conditions, the difference and color characters of the images are definitely debased. Crisp morning images have more difference than foggy images. Henceforth, a fog expulsion calculation ought to improve the scene contrast. Enhancement of foggy image is a test because of the intricacy in recouping luminance and chrominance while keeping up the color constancy. Amid enhancement of foggy images, it ought to be remembered that over enhancement prompts immersion of pixel quality. Accordingly, enhancement ought to be limited by a few requirements to stay away from immersion of image and safeguard fitting color constancy. It is noticed that impact of fog is the capacity of the separation between the camera and the scene. On the off chance that information is just a solitary foggy image, then estimation of the profundity data is under compelled. For the most part, estimation of profundity requires two images. [28] In this way, numerous strategies have been proposed which utilize different images. Yet, these techniques can't be connected on straightforward uncalibrated single camera framework. There are numerous calculations which evacuate fog utilizing single image.

IV. MATHEMATICAL ANALYSIS OF FOG REMOVAL

The proposed analysis by our multimodal technique is given below:

Fog effect may be given as

$$I(x,y) = I_0(x,y)\, e^{-kd(x,y)} + I_\infty (1 - e^{-kd(x,y)}) \qquad (4.1)$$

Where I_0 (x,y) = Image intensity in absence of fog

k = coefficient of extinction

$d(x,y)$ = Distance between scene point and camera or device.

I_∞ = Sky constant and

I (x,y) = Image intensity of observed image.

So we can say that, in equation (4.1)-

Image Intensity = Attenuation + Air light

= Attenuation (Exponential decrease Function) + Air light (Increasing Function of the scene point)

= Contrast reduce of the scene + Whiteness in the scene added.

We can represent airlight as

$$I_\infty (1 - e^{-kd(x,y)}) = A(x,y) \quad \text{then}$$

$$I(x,y) = I_0(x,y)\left[1 - \frac{A(x,y)}{I_\infty}\right] + A(x,y) \qquad (4.2)$$

We normalised I(x,y) for simulating foggy image. To set pure white , $I_\infty = 1$ (Sky constant)

For restoring the image I_0 (x,y) , A(x,y) required

$$I(x,y) = I_0(x,y)\,[1 - A(x,y)] + A(x,y) \qquad (4.3)$$

It is to investigate the fog which has no effect on hue of the image scene.

For restoring the foggy image there is a need to process two components viz saturation and intensity coordinates.

By equation -(4.3) -Colour Component are

$$\min_{c\in(r,g,b)}(I^c(x,y)) = \min_{c\in(r,g,b)}(I_0^c(x,y))(1 - A(x,y)) + A(x,y) \qquad (4.4)$$

and Intensity components are

$$I_{int}(x,y) = I_{0\,int}(x,y)\,[1 - A(x,y)] + A(x,y) \qquad (4.5)$$

that may be written as

$$\min_{c\in(r,g,b)}(I^c(x,y)) - A(x,y) = \min_{c\in(r,g,b)}(I_0^c(x,y))\,([1 - A(x,y)] \qquad (4.6)$$

$$I_{int}(x,y) - A(x,y) = I_{0\,int}(x,y)\,[1 - A(x,y)] \qquad (4.7)$$

By the equation (4.6) and (4.7)

$$\frac{\min_{c\in(r,g,b)}(I_0^c(x,y))}{I_{0\,int}(x,y)} = \frac{\min_{c\in(r,g,b)}(I^c(x,y)) - A(x,y)}{I_{int}(x,y) - A(x,y)} \qquad (4.8)$$

$$1 - S_{I_0}(x,y) = \frac{\min_{c\in(r,g,b)}(I^c(x,y))\left[1 - \frac{A(x,y)}{\min_{c\in(r,g,b)}(I^c(x,y))}\right]}{I_{int}(x,y)\left[1 - \frac{A(x,y)}{I_{int}(x,y)}\right]} \qquad (4.9)$$

Therefore the final image output is:

$$S_{I_0}(x,y) = 1 - \frac{(1 - S_I(x,y))\left[1 - \frac{A(x,y)}{\min_{c\in(r,g,b)}(I^c(x,y))}\right]}{\left[1 - \frac{A(x,y)}{I_{int}(x,y)}\right]} \qquad (4.10)$$

where $S_{I_0}(x,y)$ = saturation in absence of fog and

$S_I(x,y)$ = saturation of foggy image

V. PROPOSED FOG REMOVAL ALGORITHM

The block diagram of proposed fog removal algorithm is shown in figure. No 3. For remove fog, first pre-processing (histogram equalization) is performed over foggy image. [16] This pre-processing increases the contrast of the image prior to the fog removal and results gives better estimation of airlight map. Then initial value of airlight map is estimated by black channel prior. Airlight map is obtained using anisotropic diffusion method. Once airlight map is obtained, image is restored using the methods suggested in ref No.[20],and[22]. Histogram stretching of output image is performed as post-processing. Proposed algorithm adopted the data-driven transfer function for the histogram stretching to avoid user intervention.

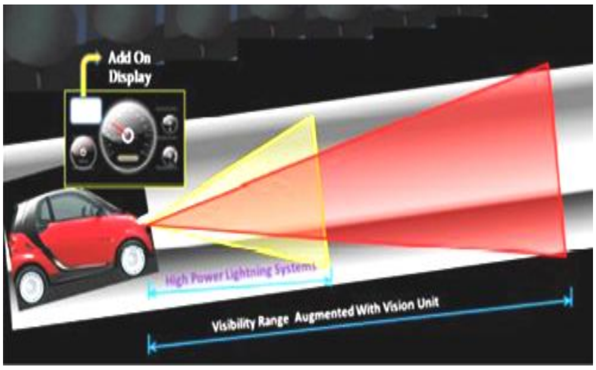


Figure 3: Proposed plan for enhance visibility

Driving under the foggy weather and hazy visibility conditions is normally the major cause of accident in the highway & expressway, where the traffic density is increasing every day. The proposed research work will be using a number of different techniques in order to improve the visual appearance of an image or for converting the image to a form better suited for analysis by a human or machine. [32][33]

A LCD display with improved visibility can be of great help to automobile drivers and it will definitely minimize the road accident in foggy and hazy, specially dance foggy weather condition**s.** For this, an automated on-line-display has been proposed to enhance the visibility.

VI. EXPERIMENTAL RESULTS

The existing techniques were applied on a single image for better visibility in heavy foggy and hazy Indian weather conditions. The results were shown on the basis of human perception and best results were found out. In the proposed techniques after lot of experiments(near 100) we had chosen 10 set of algorithm for processing hazy/ foggy images and had finally chosen 5 best out of them for testing.

Input Image	Original Foggy Images	Model 1	Model 2	Model 3
Image No.1 File06				
Image No.2 File101				
Image No.3 File109				
Image No.4 File102				
Image No5 File108				
Image No.6 File105				
Image No.7 File112				

Figure 6.1: Original dense foggy images (b) model 1 (c) model 2(d) model 3

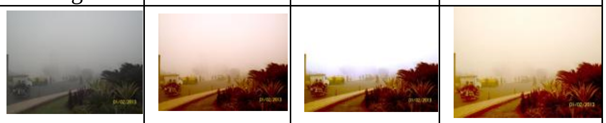
Input Image	Original Foggy Images	Model 4	Model 5	Model 6
Image No.1 File06				
Image No.2 File10 1				
Image No.3 File10 9				
Image No.4 File10 2				
Image No5 File10 8				
Image No.6 File10 5				
Image No.7 File11 2				

Figure 6.2: (a) original dense foggy images (b) model 4 (c) 5(d) model 6

MATLAB (Matrix Laboratory) is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, we can analyze data, develop algorithms, and create models and new functions. The language, tools, and built-in math functions enable us to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java. Although MATLAB is

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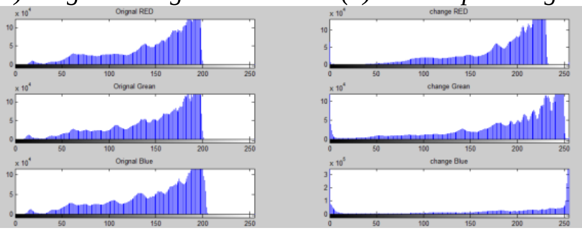
used in wide variety of applications, it plays a vital role in image processing. The foggy image is given as input to the MATLAB and the input and output images are shown below in fig 6, we are using 15 different set up experimental results shown encouraging 5- output, fig.-7 other dense foggy images outputs shown using highest encouraging output model applying and fig 8. Shown comparison RGB components input v/s our output images.

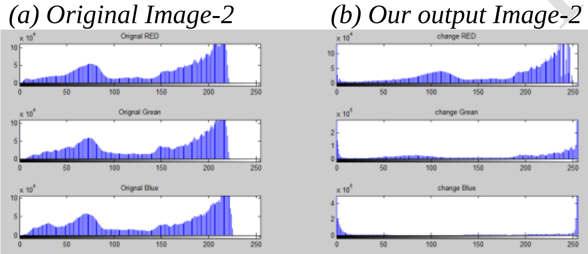
The given our highly encouraging output image multi model enhancement techniques have apply to others dense foggy images the outputs results are show here below:

(a) Original Image-1 *(b) Our output Image-1*



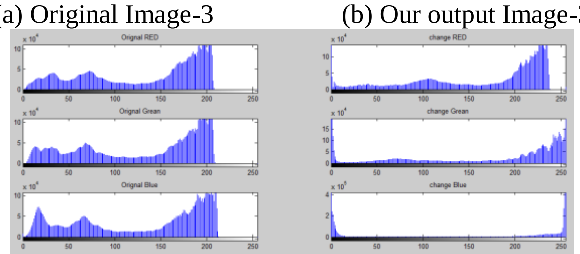
(c) RGB Histogram (a) and (b)

(a) Original Image-2 *(b) Our output Image-2*



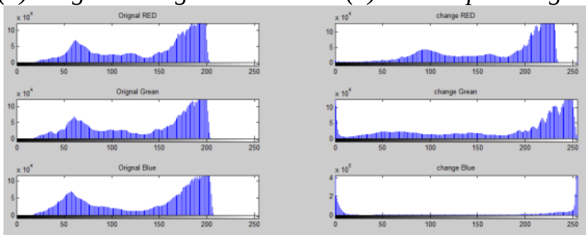
(c) RGB Histogram (a) and (b)

(a) Original Image-3 (b) Our output Image-3



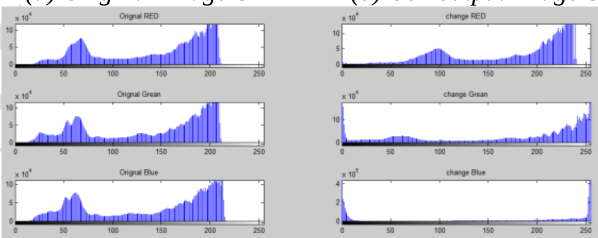
(c) RGB Histogram (a) and (b)

(a) Original Image-4 *(b) Our output Image-4*



(c) RGB Histogram (a) and (b)

(a) Original Image-5 *(b) Our output Image-5*



(c) RGB Histogram (a) and (b)

Figure 7: Compare (a) original dense foggy image (b) our output image (c) Compare original dense foggy image histogram and our output image histogram

VII. EVALUATION OF OUR TECHNIQUE

Now the results of the suggested methods are to be evaluated compared with existing methods in order to prove that the proposed tech give the best result in terms of quality of output image. To carry out the evaluation, two different methods will be used as follows:

A. QUALITATIVE -HUMAN PERCEPTION APPROACH

The human perception method will be used to compare the input-image with output- image, and the image captured in clear weather for the same scene. In this method we will use different images with different levels of visibility to examine the quality of images based on human perception. [13] To achieve this method, a number of users were invited to examine the quality of the output image and write their notes on the questionnaires that were distributed to them for this purpose.

B. QUANTITATIVE - STATISTICAL APPROACH

In this method, we use a histogram to evaluate the images before and after visibility enhancement. The suggested method is compared with the established methods (i.e. Gray World and Histogram Equalization) as well as with the latest research methods.

The image metrics were measure for the various features of the fused image of the quality measurement. Assumptions made for this in the following equation:

A – the original image,

B – the output image to be applying

i – pixel row index, j – pixel Colum index

✓ Mean Squared Error

$$MNS = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij} - B_{ij})^2$$

✓ Peak Signal to Noise Ratio

✓ $PSNR = 10 \log_{10}(\frac{peak^2}{MSE})$

Thus we have able to prove that the technique proposed here the gives best quality of image. [44]

Peak Signal to Noise Ratio (PSNR) Analysis

The Peak Signal to Noise Ratio is expressed in dB. The PSNR values are applicable when quantifying and comparing different image coding algorithms. For this reason, PSNR is used throughout the image coding community as a valid way to compare images coding algorithms

Model	a	b	c	d	e
	Model 1	Model 2	Model 3	Model 4	Model 5
file1	14.9771	11.5253	12.6505	14.0311	10.8785
file2	15.4267	12.0388	12.7683	14.2252	11.7152
file3	15.4169	11.3069	12.5851	14.0746	10.1411
file4	15.3062	10.9145	12.1001	13.9713	9.8036
file5	15.4898	11.138	12.2327	14.1293	10.0126
file6	15.1177	11.7936	13.0135	14.2643	11.1945
file7	15.1597	10.6924	12.0687	13.8417	9.3709
file8	15.6041	10.8945	12.0081	14.0462	9.7368
file9	15.636	11.5689	12.3848	14.5272	10.6835
file10	14.9142	10.7074	12.0468	13.7072	9.9024
file11	15.4454	11.8726	12.9129	14.3787	11.0475
file12	15.5463	10.7847	11.9233	14.1865	9.7476
file13	14.8803	10.7978	12.0559	13.9244	9.9397
file14	15.8995	11.2315	11.8906	14.5206	10.338
file15	15.5993	11.1025	11.9169	14.4205	10.0167
file16	15.163	11.4413	12.2861	13.9068	11.1026
file17	15.5989	11.0287	11.8848	14.4376	9.8789
file18	14.8122	10.5408	12.0289	13.8526	9.534
file19	15.3838	11.0188	12.1621	13.9619	9.8058
file20	15.1615	10.6924	12.0687	13.8417	9.3709
file21	14.5745	10.709	12.1496	13.6577	9.9496
file22	14.725	10.5473	12.1452	13.5373	9.1515
file23	14.811	10.5749	11.9194	13.9502	9.6824
file24	15.2849	10.9859	12.1387	14.0735	10.127
file25	15.0725	10.8171	12.0582	13.7818	9.9364

Table 7.1: PSNR Values of Model 1-5

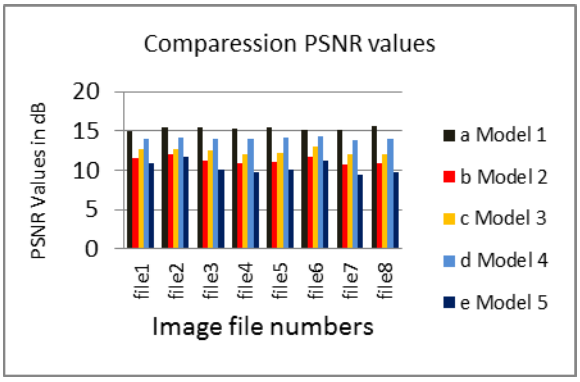


Figure 7.1: Compare PSNR values of our result model 1-5 images file 1-8

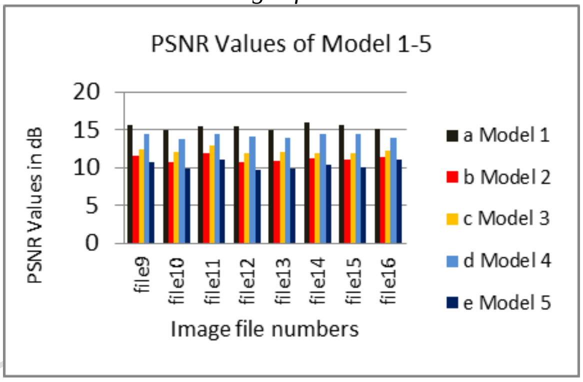


Figure 7.2: Compare PSNR values of our result model 1-5 images file9-16

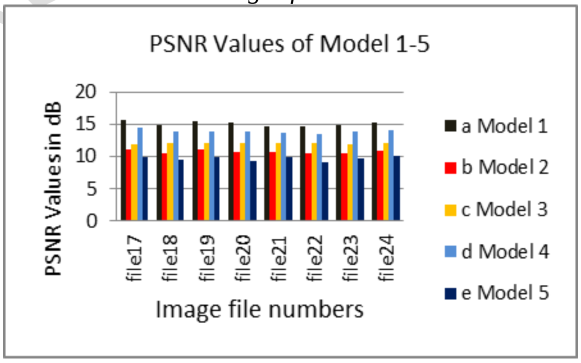


Figure 7.3: Compare PSNR values of our result model 1-5 images file 17-24

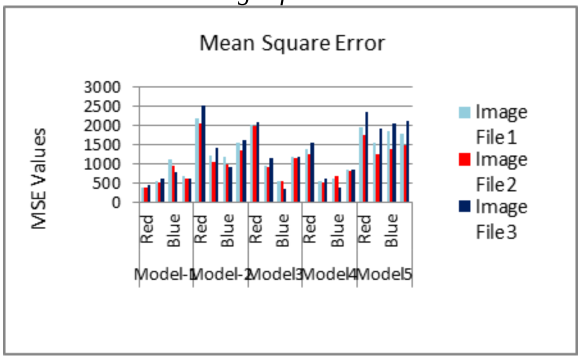


Figure 7.4: Compare MSE values of our result model 1-5 images file1-3

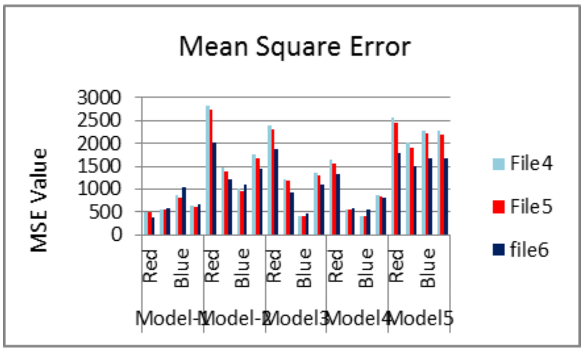


Figure 7.5: Compare MSE values of our result model 1-5 images file 4-6

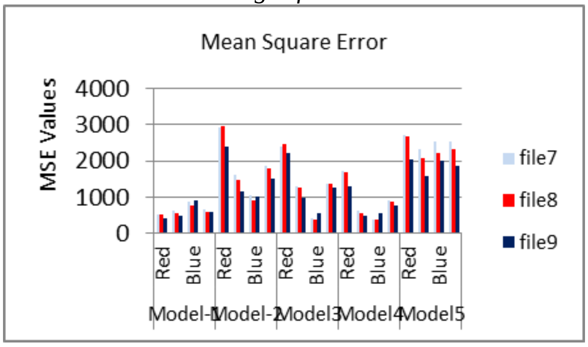


Figure 7.6: Compare MSE values of our result model 1-5 images file7-9

VIII. CONCLUSION & FUTURE WORKS

The image enhancement has become one of the recent research areas in image processing. This paper has proposed a contrast enhancement technique based on intensity adjustment, color restoration and Gama correction. By applying this technique to the dense foggy images, PSNR and MSE has increased to a significant value. The details of the image are clearer than the original foggy image. The visibility of the image has increased. The future scope of this paper includes enhancing this image further by using discrete wavelet transform and it is also one of the emerging trends in the field of image processing.

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