A Multimodal Enhancement Techniques Using For Visual Improvement Of Dense Foggy & Hazy Weather Images,

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Abstract – Dense Foggy images in traffic is a special class of degraded images, and the enhancement or restoration of these image is very important for traffic safe. Image Enhancement is one of the most important and difficult techniques in image 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,[3,4] 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

A Contrast image enhancement technique is proposed for the images degraded by fog. This paper introduces a Multimodal enhancement techniques (more than three techniques) applied A Contrast image enhancement, color modification and Gama correction method to enhance foggy images. The proposed algorithm 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] The output image has high efficiency and reduces computational complications for many applications.

Keywords- Contrast image enhancement, HIS components, Intensity, MSE, PSNR, RGB components.

I Introduction:

In recent years, visual enhancement techniques have become vital for improving image quality in adverse weather conditions, particularly in dense foggy and hazy environments. These weather conditions significantly degrade the clarity of images, making it difficult for various applications such as autonomous driving, surveillance, and remote sensing to operate effectively. The scattering of light by particles in the atmosphere causes reduced visibility, contrast, and color distortion, which poses a major challenge for image processing systems.

To address these issues, multimodal enhancement techniques have emerged as a promising approach to enhance visibility in foggy and hazy images. These methods integrate multiple modalities such as depth information, color channels, and machine learning models to provide a more robust solution to weather-related image degradation. By leveraging complementary information from various sources, these techniques are able to restore visibility, enhance contrast, and improve the overall quality of images.

Multimodal enhancement techniques utilize advanced algorithms for dehazing and defogging, employing methods such as image fusion, contrast enhancement, and deep learning-based models. These approaches not only enhance the aesthetic quality of images but also restore essential details, ensuring better performance in real-world applications like transportation safety and environmental monitoring.

Image Enhancement is one of the most important and difficult techniques in image 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.

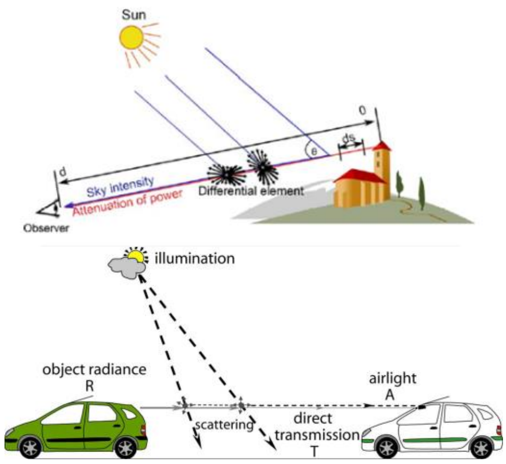


Fig. 1. Fog or haze luminance is due to the scattering of daylight.

Image Enhancement techniques which improve the quality (clarity) of images for human viewing, removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations.
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 wind 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.

Fig.-2 types of fog

Based on visibility and composition, various phenomena
which reduce the clarity of image are described as follows:-
(a) Fog. When relative humidity **is** more than 75% the fog appears, however the visibility reduces to less than 1000 mts., with the following types of cases:
(i) If the fog visibility is between 1000 & 500 mts, it is known as shallow fog
(ii) If the visibility is between 500 & 200 mts, it is called moderate fog.
(iii) For dense fog the visibility range should be between 200 and 50 mts.
(iv) In thick fog the visibility further reduces to less than 50 mts.
(b) Haze. When the relative humidity is equal or less than 75% the haze forms, however the visibility reduces to 2000 mts to 5000mts.
(c) Mist. When the relative humidity is equal to 75% the mist forms, however the visibility reduces to 1000 mts to 2000mts.
(d) Smog. When pollutants and smoke remain suspended in the air near ground with wind flow remaining light the smog forms, but no humidity criteria. The visibility reduces but no specific range criteria. Fog is the least dynamic of all cloud phenomena. Cloud dynamicists often classify fog as a micrometeorological phenomenon because it forms next to the earth in the atmospheric boundary layer, a domain traditionally covered by micrometeorologists. Lectures in micro meteorology, however, often consider for to be in the discipline of cloud dynamics or, perhaps, mesoscale meteorology.[15] 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 meteorology.

Table 1.1: International Visibility Code with Meteorological Range

Code no	Weather Condition	Meteorological Range, Rm	Scattering coefficient $\beta sc(km-1)$
0	Dense fog	50m	>78.2
1	Thick fog	1 50m - 200m	78.2 - 19.6
2	Moderate fog	200m - 500m	2 19.6 - 7.82
3	Light fog	500m - 1000m	7.82 - 3.91
4	Thin fog	1km - 2km	3.91 - 1.96
5	Haze	2km - 4km	1.96 - 0.954
6	Light haze	km - 10km	0.954 - 0.391
7	Clear	km - 20km	0.391 - 0.196
8	Very clear	20km - 50km	0.196 - 0.078
9	Exceptionally clear	>50km	0.078
10	Pure air	277km	-0.0141

II. IMAGE ENHANCEMENT TECHNIQUES

Images and visual understandings are basis of every moment of of our life and are very important tool for decision making. Images degraded by fog (a) adversely affect the quality of vision-based physical security system & (b) resulting into distortions which obscure contrast in image frames. So, there is the need of some image enhancement techniques to improve the quality of these pictures [5]. Image enhancement techniques can be divided into two parts: spatial domain and frequency domain.

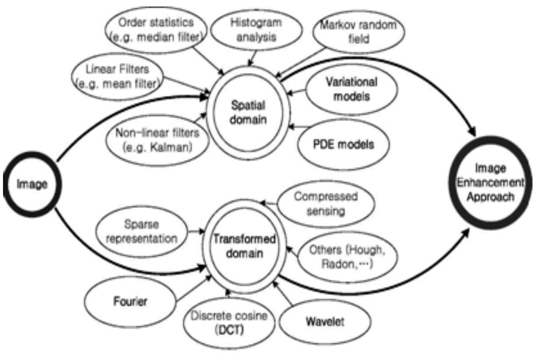


Fig-3 Classification of Enhancement Techniques

The techniques of spatial domain can be further divided into point processing, spatial filtering, image subtraction and image averaging. Further Spatial filtering techniques are low pass, median and high pass filtering. The frequency domain is further divided into low pass filter, high pass filter, homo-morphing filter and pseudo color image processing. A pictorial representation of these techniques is shown in figure 2 is as given below:

III. LITERATURE SURVEY

Bad weather caused by atmospheric particles, such as fog, haze, etc., May significantly reduces the visibility and distorts the colors of the scene. This is due to the following two scattering processes, (i) light reflected from the object surface is attenuated due to scattering by particles, and (ii) some direct light flux is scattered toward the camera. These effects result in the contrast reduction **which i**ncreases with the distance. [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.

During enhancement of foggy images, it should be kept in mind that over enhancement leads to saturation of pixel value. Thus, enhancement should be bounded by some constraints to avoid saturation of image and preserve appropriate color fidelity. Initial works in fog removal are based on the contrast enhancement without any knowledge of the fog model.[17] The most commonly used contrast enhancement method is histogram equalization and its variations. Some other image enhancement techniques are also presented by many researchers in order to restore contrast of fog-degraded images. All the techniques proposed, assumes a certain set of attributes of the fog degraded images. Histogram equalization may not improve contrast of the image which lies in right range of histogram. In computer vision, the atmospheric scattering model is usually used to describe the formation of a foggy or hazy image. Almost all established methods are based on this model. Some of them require multiple input images of a scene; e.g., images taken either under different atmospheric conditions or with different degrees of polarization. [25]

Another methods attempt to remove the effects of fog from a single image using some form of depth information either from terrain models or user inputs .In practical applications, it is difficult to achieve these conditions. So such approaches are restricted. The very latest defogging methods are able to defog single images by making various assumptions about the depth 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 COLORED FOGGY IMAGES** Images taken under foggy weather conditions suffer from degradation due to severe contrast loss and also due to loss in color characteristics. The degree of degradation increases exponentially with the distance of scene points from the sensor. Foggy conditions drop atmospheric visibility and brings whitening effect on the images causing poor contrast. Hence basic challenge is to nullify the whitening effect thereby improving the contrast of the degraded image. Manoj Alwani and Anil Kumar Tiwaria present a contrast enhancement algorithm for degraded color images. [23] To restore both contrast and color, here they propose four steps. The RGB component of the input image is first converted into HIS space to get brightness component. Because of scene depth varies differently over whole image. The global enhancement method does not reflect depth change. So to take care of local scene depth changes, they process the image on a block by block basis, assuming that the pixels in the block are now of same scene depth. Then enhance the block according to pixel intensities in it.

Basically this mean that if the given image has many objects with varying scene depth, **then** global enhancement techniques are expected to do average kind of enhancement of various object. On the other hand, processing on a block-by- block basis will enhance the object effectively.

b) CONTRAST RESTORATION OF WEATHER DEGRADED IMAGES Most outdoor vision applications such as surveillance, terrain classification, and autonomous navigation require robust detection of image features. Under bad weather conditions, however, the contrast and color of images are drastically altered or degraded. Hence, it is imperative to remove weather effects from images in order to make vision systems more reliable. Unfortunately, the effects of bad weather increase exponentially with the distances of scene points from the sensor. As a result, conventional space invariant filtering techniques fails to adequately remove weather effects from images. Here a method is described to restore scene contrast for a fixed given depth segmentation of the scene. This method is simple and effective for scenes where depth changes are abrupt. However, it is hard to define good depth segmentation when scene depths change gradually with the movement
of the vehicle. A method to restore contrast of an arbitrary scene using scaled depths of scene points was given by S. G. Narasimhan and S. K. Nayar**,** [5] who proposed a physics-based model that describes the appearances of scenes in bad weather conditions. The air light and the attenuated light are calculated. Here they describe a simple method to restore scene contrast from one bad weather image using depth segmentation of the scène. They consider depth segmentation as the extraction of depth regions in the scene. The brightness at any pixel recorded by a monochrome camera is given. This procedure is repeated independently for each point in the scène and then a total brightness variation is calculated.
We note that such simple image processing techniques such as contrast stretching can be effective for scenes that are at the same depth from the sensor. [27]

c) CORRECTION OF SIMPLE CONTRAST LOSS IN COLOR IMAGES
Contrast enhancement methods fall into two groups. They are non-model-based and model-based. In non-model-based methods **we** analyze and process the image based solely on the information from the image. The most commonly used non-model-based methods are histogram equalization and its variations. For color images, histogram equalization can be applied to R, G, and B color channels separately but this leads to undesirable change in hue. Better results are obtained by first converting the image to the Hue, Saturation, Intensity color space and then applying histogram equalization to the Intensity component only. J. P. Oakley and H. Bu [**29**] proposed a method for determination of airlight level in digital images. The method involves the minimization of a scalar global cost function and no region segmentation is required. Once the airlight level has been obtained, simple contrast loss is easily corrected. The accuracy of the method under ideal conditions has been confirmed using Monte Carlo simulation with a synthetic image model. Useful levels of performance are also achieved when the synthetic image model is generalized to include noise and other variations in statistical properties. The accuracy of the airlight estimate is insensitive to the scale and contrast of the image fluctuation and the level of variation in image brightness. The synthetic image fluctuation for these studies is generated using the Gaussian distribution. However, useful levels of performance are achieved even when the fluctuation is generated using the Cauchy distribution. Since the Cauchy and Gaussian distributions are very different, so the method is very robust. The method is applicable to both black and white images and color images. It is interesting to consider other types of image that could be processed. Near- IR images generated using active illumination should have a similar structure to visible light images and so the algorithm described here could be applied. Images generated in the mid and far IR bands by passive emission have a statistical structure that is quite different. [30]
Here we note that since the thermal emission depends on absolute temperature, the images are formed over a relatively small relative temperature variation. The contrast in dark parts of the image can be expected to be roughly the same as in bright parts of the image an important difference from visible images. Thus, the algorithm may not give good results in this case.

TABLE2. Comparative Analysis of Various Techniques

	Methodes:	Description:	Advantages:	Limitations:
1. Histogram Equalization	Global Histogram Equalization (GHE)	GHE enhances the overall contrast of an image by redistributing the intensity values.	Simple and effective for uniform haze conditions.	Can lead to over-enhancement and noise amplification in non-uniform haze conditions.
	Adaptive Histogram Equalization (AHE)	AHE divides the image into small regions and applies histogram equalization to each region separately.	Improves local contrast.	May produce artifacts and noise amplification.
	Contrast Limited Adaptive Histogram Equalization (CLAHE)	CLAHE limits the amplification of noise by clipping the histogram at a predefined value.	Reduces noise amplification and artifacts compared to AHE.	Computationally more intensive
2. Dehazing Algorithms	Dark Channel Prior (DCP)	DCP is based on the observation that haze-free outdoor images have at least one color channel with low intensity in some pixels.	Effective in removing haze and improving visibility.	Computationally intensive and may not perform well with bright objects in the scene.
	Color Attenuation Prior	This method exploits the relationship between scene depth and image color to estimate the transmission map.	Good performance with minimal computational complexity.	Assumes a linear relationship between depth and color attenuation, which may not always hold.
	Atmospheric Scattering Model	This model uses the physical principles of light scattering in the atmosphere to recover the haze-free image.	Provides a physically accurate solution.	Requires accurate estimation of atmospheric light and transmission map.
3. Retinex Theory	Single-Scale Retinex (SSR)	Enhances the image by estimating the reflectance using a single scale.	Simple and effective.	Prone to halo artifacts.
	Multi-Scale Retinex (MSR)	Combines multiple scales to enhance the image, reducing halo artifacts.	Better visual quality compared to SSR.	More computationally intensive.
	Multi-Scale Retinex with Color Restoration (MSRCR)	Adds color restoration to the MSR to preserve natural color.	Provides natural-looking results.	Complex parameter tuning.
4. Wavelet Transform	Discrete Wavelet Transform (DWT)	Decomposes the image into different frequency components and enhances each component separately.	Effective at enhancing details at multiple scales.	: May produce artifacts at the boundaries
	Stationary Wavelet Transform (SWT)	A translation-invariant version of DWT that can produce better enhancement results.	Reduces boundary artifacts.	Higher computational cost.
5. Fusion- Based Techniques	Multi-Exposure Image Fusion	Combines multiple images taken with different exposure settings to produce a well-exposed image.	Enhances dynamic range and details.	Requires multiple input images
	Multi-Scale Fusion	Combines different scales of enhanced images to produce the final result.	Preserves details and natural appearance.	Complex implementation.

6. Deep Learning-Based Methods	DehazeNet	A convolutional neural network designed specifically for dehazing images.	Learns complex features and mappings for effective dehazing.	Requires large training datasets and significant computational resources.
	Generative Adversarial Networks (GANs)	Uses GANs to generate high-quality enhanced images by learning from large datasets.	Produces high-quality, realistic results.	Training GANs can be challenging and computationally expensive.
7. Anisotropic Diffusion	Perona-Malik Anisotropic Diffusion	Reduces image noise while preserving significant parts of the image content, typically edges.	Preserves edges and enhances image quality.	May require careful parameter tuning.
	Edge-Enhancing Diffusion	nhances edges while diffusing other regions to improve overall image quality.	Effective at enhancing edges and reducing noise.	Computationally intensive.
8. Contrast and Brightness Adjustment	Gamma Correction	Adjusts the luminance of the image to improve visibility.	Simple and effective for global contrast enhancement.	: May not handle non-uniform haze well.
	Linear Contrast Stretching	Stretches the range of intensity values to cover the full range.	Simple and improves overall contrast.	Can lead to loss of details in some regions

VI. Problem Identification:

Problem Identification In this phase, the problem of the removal of fog, haze and rain drizzle is investigated in order to improve the visibility of fog, haze and rain drizzle images by addressing the problem of low contrast and color infidelity.

Visibility improvement, contrast enhancement and features enhancement of images/video captured in bad weather environment is very much useful for many outdoor computer vision applications like video surveillance, long range object detection, recognition and tracking, self-navigating ground and air-based vision systems etc. Usually, in bad weather environments with haze and fog, the captured scenes suffer from poor visibility, contrast and distorted color.[33] However, conventional image and contrast enhancement techniques works well for some scenes, but are not suitable for distant images because the haze and fog thickness depends on the depth of the scene. The accurate thickness of haze or fog from a single image in these bad weather environments is still a challenging task, but the approximate relative thickness of haze or fog is obtained from the low frequency information of the scene. Proposed method uses nonlinear function to transform the luminance image to approximate the haze intensity image.

IV. MATHEMATICAL ANALYSIS OF FOG REMOVAL BY MULTI- MODAL TECHNIQUE:

The proposed analysis by our multimodal technique is given below:

Fog effect may be given as

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

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

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

$$\mathbf{I(x,y)} = \boldsymbol{I_0}\ \mathbf{(x,y)}\ \mathbf{[1-}\frac{\boldsymbol{A(x,y)}}{\boldsymbol{I_\infty}}\mathbf{]} + \boldsymbol{A(x,y)} \quad \text{--------}\mathbf{(4.2)}$$

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

$$\mathbf{I(x,y) = I_0 (x,y) [1- A(x,y)] + A(x,y)} \quad \text{--------(4.3)}$$

It is **to** investigate the fog **which** has no effect on hue of the image scene.
For restoring the foggy image there **is a** ~~are~~ need to process two components **viz** saturation and intensity coordinates.
By equation -(4.3) -Colour Component are

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

and Intensity components are

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

that may be written as

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

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

By the equation (4.6) and (4.7)

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

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

Therefore the final image output is:

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

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 5. 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 [20]. 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.

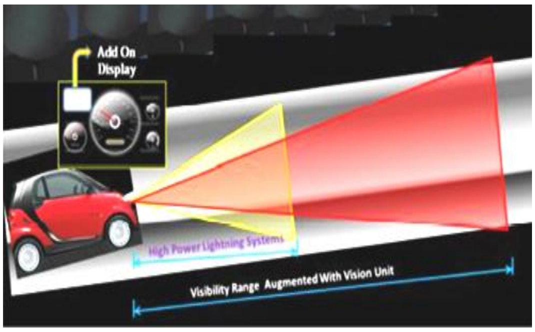


Fig.4 proposed plan for enhance visibility

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.

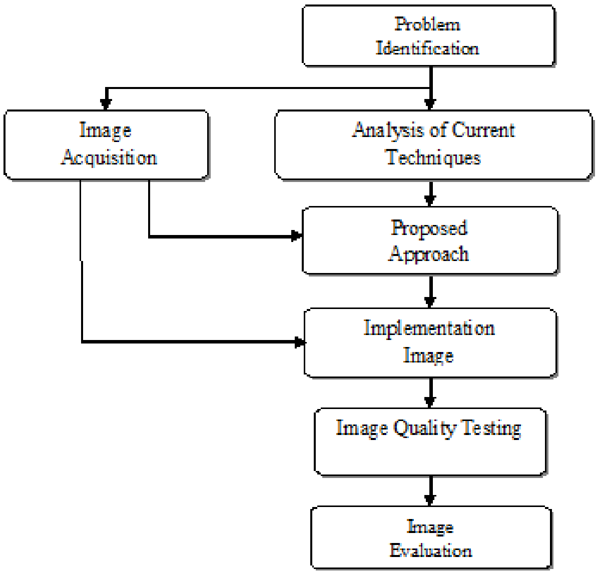
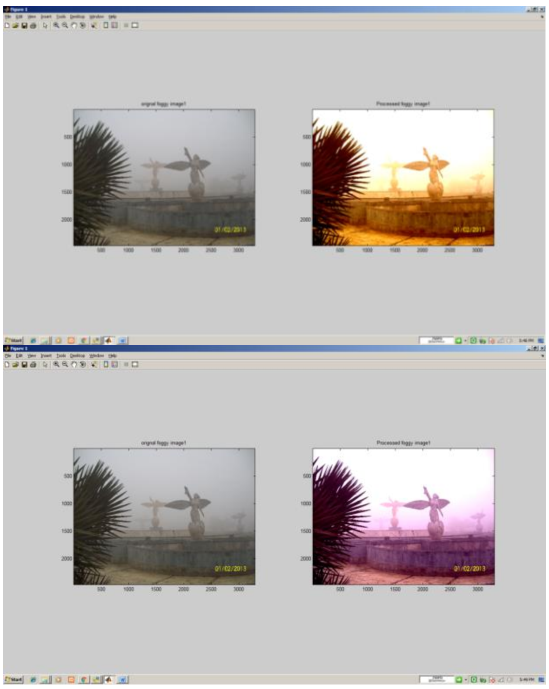


Fig-5 proposed plan of implementation

VI. EXPERIMENTAL RESULTS

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 applications. 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 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, 7, and 8.



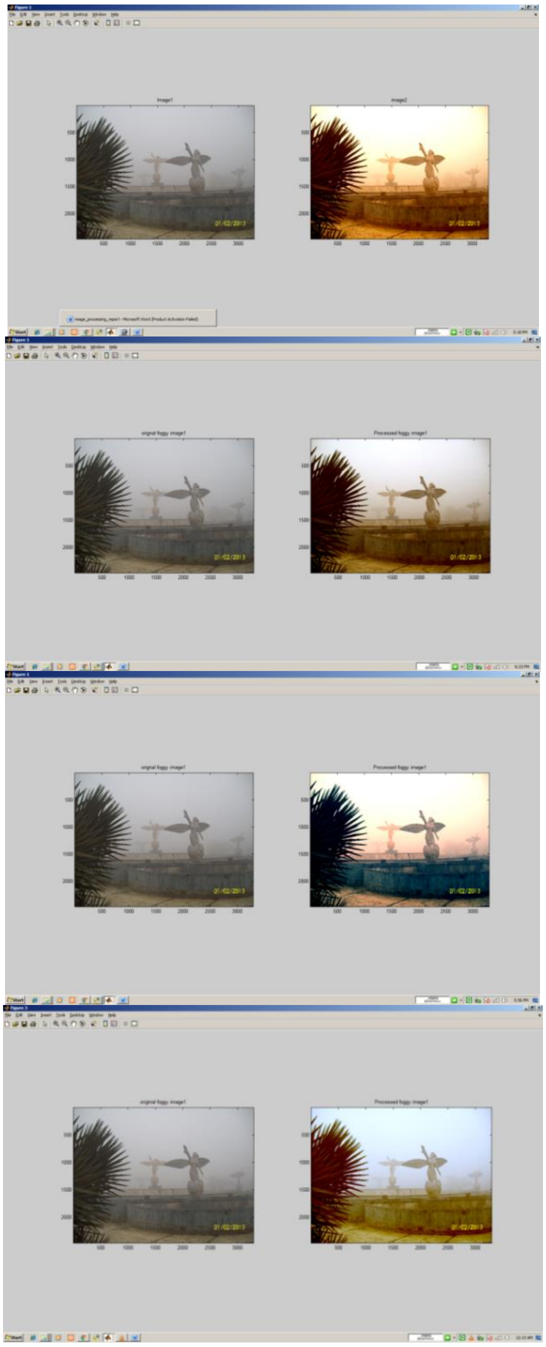
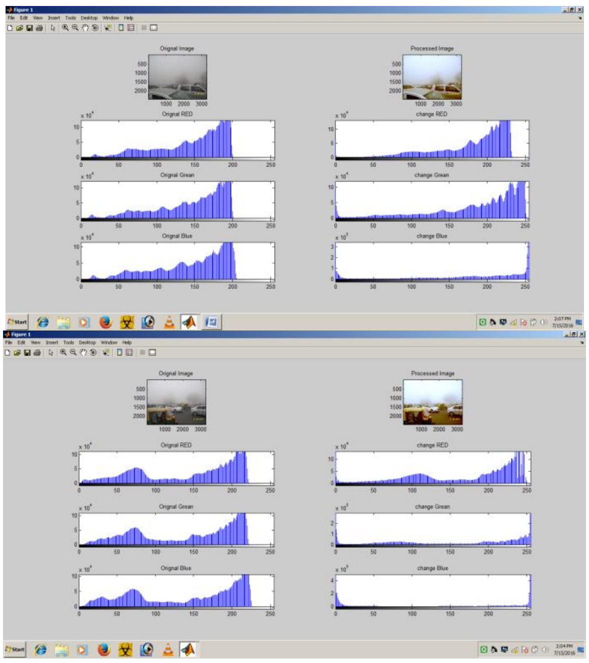


Fig- 6 Compare (a) original dense foggy image (b) our output image

The best visible output image human perception enhancement techniques apply to others dense foggy images the outputs results are show here below: fig-7. The contrast enhanced encouragingly. The color components change shown in fig-8 RGB components of the original foggy image RGB histogram & our contrast enhanced results histogram receptively.

Fig- 7 Compare (a) original dense foggy image (b) our output image



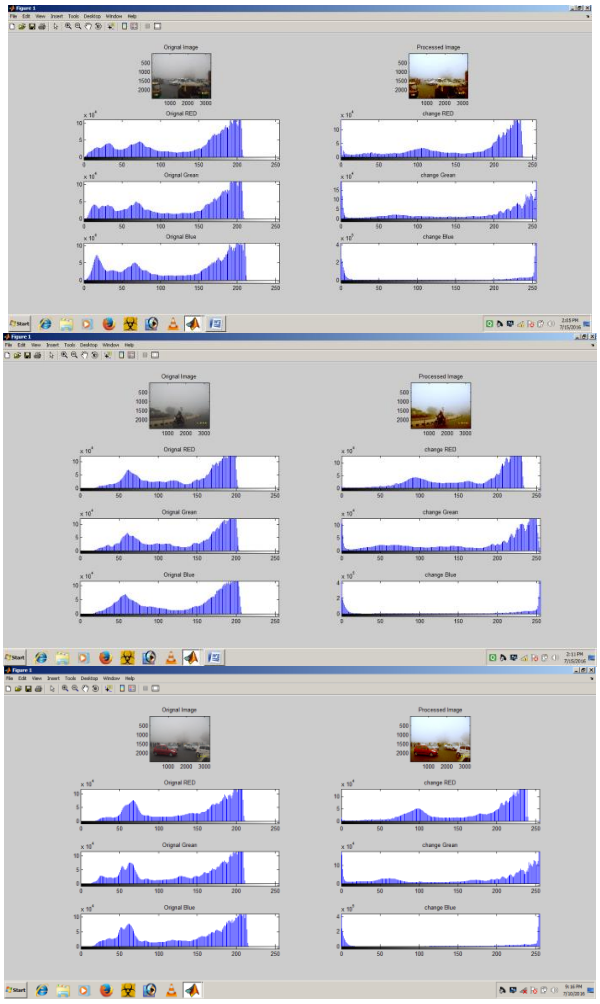


Fig- 8 Compare (a) original dense foggy image& histogram (b) our output image & histogram

Image	Original Foggy Images (a)	Model 1 (b)	Model 2 (c)	Model 3 (d)	Model 4 (e)	Model 5 (f)
File1						
File2						
File3						

Fig- 9 Compare (a) original dense foggy image our output images (b),(c),(d) (e)&(f)

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 fused image to be assessed

i – pixel row index, j – pixel Colum index

1) Mean Squared Error

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

2) Peak Signal to Noise Ratio

$$PSNR = 10 \log_{10}\left(\frac{\text{peak}^2}{\text{MSE}}\right)$$
$$thus$$

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

Image	Model 1 (b)	Model 2 (c)	Model 3 (d)	Model 4 (e)	Model 5 (f)
file1	11.5253	12.6505	14.0311	13.0268	10.8785
file2	12.0388	12.7683	14.2252	14.0449	11.7152
file3	11.3069	12.5851	14.0746	13.1564	10.1411
file4	10.9145	12.1001	13.9713	13.2118	9.8036
file5	11.138	12.2327	14.1293	13.6388	10.0126

Table- 3.1 Compare PSNR value of (a) original dense foggy image to our output images (b), (c), (d) (e)&(f)

VIII. CONCLUSION & FUTURE WORKS

In this study, we explored the effectiveness of multimodal enhancement techniques in addressing the challenges posed by dense foggy and hazy weather conditions on image quality. Traditional methods of image enhancement often fall short in severe weather scenarios, where significant light scattering and low contrast obscure critical details. Multimodal

techniques, by integrating information from multiple sensors and imaging modalities, such as thermal imaging, depth sensing, and polarization, offer a robust solution to these challenges.
The application of multimodal approaches leads to more comprehensive scene recovery by enhancing visibility, restoring lost details, and improving contrast in degraded visual conditions. These techniques not only provide sharper and clearer images but also support more reliable operation in real-time systems like autonomous vehicles, surveillance, and remote sensing, where accurate visual information is crucial.

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. By applying this technique to the foggy image, 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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