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A COMPREHENSIVE STUDY ON IMAGE DEHAZING-A SURVEY

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ABSTRACT
In the recent years the processing of digital images participate a dominant role in the acquiring the information within the image. Even though images contain the information due to various hazards accusation of information standards are reduced. One of the main image hazards is haze that is captured along with the image. Haze diminishes the visual quality of the images which causes poor performance of image processing. To acquire the quality information from the image and upgrade the visual quality of image causes development of various dehazing mechanisms to remove the haze in the image. Due to various mechanisms available it becomes arduous to select a efficient strategy based on the application. In this work various recently developed strategies are studied. And detailed reviews of these mechanisms were accomplished along with challenges, utilization together with future scope of studied mechanism were also discussed in this work.

Keywords: *Haze, Image dehazing, Digital Image Processing, Image Preprocessing.*

I. INTRODUCTION

A. Haze
Haze is defined as smoke, fog, dust and mist that occurred by the micro particles that exist within the air which degrades the visual quality by slightly concealing air or environment. In image, haze is phenomena that occurred naturally or artificially when image is captured in the hazy environment or can also be added to the image by using the hazing insertion mechanisms. Haze reduces the visual quality of the images as it conceals the environment which makes the identification of objects arduous. Along with this contrast and sharpness of the image is also diminished. Haze will be removed from the images by utilizing the dehazing mechanisms.

B. Image Dehazing
Removal of haze that is fog, mist and smoke from the hazy image to enhance the visual quality is called image dehazing. Image dehazing comes under the category of image enhancement. When image dehazing is applied on the image haze exist in the image will be removed to certain extent. If the haze is too low to process additive haze will be added into the image by hazing mechanisms [1].

Importance of Image Dehazing
Dehazing is utilized to enhance the aesthetic and artistic quality of images and videos. It is exploited to increase the contrast of images and videos. Along with this dehazing is implemented to enhance the visual quality, information of the image and visual perception.

Dehazing of Image Can Be Obtained By Three Mechanisms
1. By implementing image enhancements techniques:

a) By applying histogram equalization.

b) By applying Retinex method.

c) By applying frequency transformation.

Mechanism
Step1: Identification of region of haze in the image.

Step2: If haze is too low to process, artificial haze will be added to image to process.

Step3: Haze will be removed by processing algorithm by pixel rearrangement and Contrast enhancement along with filters.

Step4: Dehazed image is obtained.

2. By Exploiting Image Fusion Techniques:

a) Applying Image fusion on single images.

b) Applying image fusion on multi spectral images.

Mechanism

Step1: Various hazed image of same source will be selected.

Step2: Regions in various images which have no or little haze will be chosen.

Step3: These are fused together to get non process image.

Step4: After processing final dehazed image is acquired.

3. With Image Restoration Techniques

a) By utilizing additional information methods.

b) By prior knowledge methods.

c) By using multiple image methods.

Mechanism

Step1: Hazed image will be dismantled.

Step2: Hazed region will be removed.

Step3: Image will be restored.

Step4: Dehazed image will be obtained.

Challenges Faced When Dehazing

To dehaze an image, first we need to identify the haze exists in the image. And dehazing should be applied with maximum perseverance of authentic information [2]. Along with these visual criteria like contrast, texture, object boundaries etc. should be preserved and enhanced. Complexity of image dehazing becomes arduous if other hazards are existed.

C. Applications of Image Dehazing

- Utilized in remote sensing algorithms.
- Exploited in object recognition algorithms.
- Exploited in underwater observation.
- Used in intelligent vehicle control algorithms.
- Implemented in data analysis in hazy, smog and fog environment.
- In satellite image process and analysis of images from mining regions.
- In image sharpening and weather analysis.
- Used in military applications.

In the following section 2 contains literature survey about latest method were discussed and section 3 contains research finding and future scope.

LITERATURE SURVEY

Deoyani Mujbaile and Dinesh Rojatkar [3] developed a mechanism for dehazing of images by utilizing Minimum white balance optimization. Mainly invoked to solve the common crisis of dehazing algorithm that is contrast changes and dense layer of haze in resultant dehazed image. Dynamic duplication dehaze system which developed on minimum white optimization is stated and utilized in this mechanism. This system combines some of the well known single image dehazing algorithms increase the quality of the resultant dehazed images from a single hazed image by exploiting adaptive histograms. From the resultant images one will be selected for the final output which has least white balance to get feasible result. It is stated that this mechanism have better performance, stability, increases the field of application, visual perception. Along with these contrast and radiance of the output enhanced to a certain limit.

Keping Wang et al.[4] proposed a single image dehazing algorithm which work on the principle of pyramid multi-scale interchanged conventional network. Proposed to solve the problems of atmospheric distribution

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model like partial dehazing, color travesty, divergent image optimization and reconfiguration of output. Constructs peer to peer image dehazing network to know the mapping correspondence between hazy image and its clear image. This network implement descending attribute extraction block to acquire the attribute information of image that works on principle of Multi-channel chained architecture to construct the interpretation of attributes of subsequent corresponding layers in the block format. Multi-scale interchanged conventional network is used for reconstruction of dehazed image, attribute map is also constructed. It is stated that proposed algorithm have enhanced results in both dehazing and maintenance of visual color precision when compared to present state-of-the-art methods.

Vinay Kehar et al. [5] introduced a single image dehazing model by utilizing brightness channel prior which is dependent on Meta heuristics data for efficient dehazing. This model mainly invoked to eradicate the haze in image which has highest haze gradient and to ignore the performance of hyper parameters tuning. Along with gradient filter to enhance the transmission map. Initial parameters for BCP are achieved by general Sorting Genetic Algorithm and tuning of hyper parameter is done by NSGA. BCP have enhanced performance even with various range of haze degradation magnitude which does not lead to visible artifacts. And also proposed BCP have better performance than competitive dehazing models in various terms and attributes.

Gengqian Yang and Adrian N. Evans [6] developed single image dehazing strategy to process on resource constrained or restricted platform. This strategy is invoked to reduce the complexity of dehazing and increase the performances in individual system and platform. Further a newly developed dark Channel Prior-dependent algorithm is proposed for single image dehazing which have an enhanced atmospheric light detection method with a very low-complexity structural remodeling. Along with this undemanding peer-to-peer network is also proposed which eradicate loss of information and reduces the implementation burden by eradicate pooling and fully connecting layers. It is stated that resultant dehazed image from this algorithm can be compared with state-of-the-art techniques and also outperform them in both qualitative and quantitative analysis with significantly least complexity. And suitable to utilize in resource constrained and restricted platforms.

Cahyo Adhi Hartanto and Laksmita Rahadianti [7] develop a methodology for single image dehazing by utilizing deep learning techniques. In this methodology novelist architecture is proposed which is dependent on PDRNet by exploiting pyramid sensitive convolution, pre-processing, processing, post processing modules and awareness applications. Network is trained to eradicate L1 and intangible loss with the help of O-Haze dataset. Architecture’s result is evaluated with SSIM, PSNR, and color variance along with psychovisual techniques for objective and subjective analysis respectively. This methodology utilize Pyramid sensitive convolution that exist in architecture to maintain spatial information over a wide range of receptive fields.

Jing Qin et al. [8] proposed a technique for single image dehazing by utilizing Sparse Contextual Representation. This technique is mainly developed for enhancement of image dehazing. Sparse representation is stated and processed for contextual conciliate tool to reduce the occurrence of block artifacts and halos that are generated by utilizing dark channel prior without implementing soft matting as the transfer is not always regular in a local region. By using proposed dictionary to flat an image and produce the sharp and accurate dehazed result. It is assed that after comparing the resultant dehazed image has a higher quality than the available state of the art methods along with light color, refined image structure and local information.

Wenjiang Jiao et al. [9] introduced a single image mixed dehazing methodology which is dependent on the numerical repetition model and DehazeNet. This is a mixed methodology which in obtain by the integration of physical model dependent methods and learning dependent methods to obtain refined, enhanced dehazed image. The image is first categorized based on the intensity of haze in the image to compute précised a tmospheric light to reconstruct haze free image. Later dark channel prior and DehazeNet are integrated and utilized to calculate the transformation to promote the final refined haze-free image which is close to the original. Then a numerical repetitive method to is implemented to optimize atmospheric light and transformation. It is stated that this technique have enhanced results than existing state of art methods in both artificial datasets and original datasets. It is also stated that even in the remote sensing datasets the results are up to visual standards.

Hong Xu Yuan et al. [10] introduce a dehazing mechanism for the foggy images which works on the long range dependence. This mechanism is to justify LRD of foggy images. In this mechanism the Hurst parameters of 1,000 foggy images within SOTS are calculated and discussed. This mechanism proposed Residual Dense Block Group (RDBG), which has enhanced long gaps among two Residual Dense Blocks to customize for LRD of foggy images. It is stated that Residual Dense Block Group significantly enhance the information in dehazing image in dense and thick fog. It is also stated that this mechanism reduce the occurrence of the artifacts and obstruction of resultant dehazing image.

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Daosong Hu et al. [11] introduced a dehazing method for outdoor hazy image in rapid pace which depend on brightness and concentration of haze in the image. This mechanism works on the principle of HSV color space to reconstruct the visibility of regularized distribution model. It leads to control of miscomputing the transformation and atmospheric light. This mechanism utilizes brightness to compute global atmospheric light to reduce the effect of luminescent region in the image. Along with this a model is developed to compute concentration of scene by utilizing atmospheric distribution model, stretching function is utilized for rapid computation, to repetitive models are exploited for solving parameters. It is stated that this mechanism have enhanced dehazing along with low time to compute than the existing mechanism.

Won Young Chung et al. [12] developed a method for image dehazing by utilizing LiDAR constructed grayscale depth prior. This method is developed by utilizing a single channel grayscale depth image construction from a LiDAR point cloud 2D projection image. This method calculates the optimal distribution coefficients for numerous artificial hazy images and explains the relation between the optimal distribution coefficient and dark channels, linear regression is used find equation between them. Transformed image for dehazing is explained with distribution coefficient and a grayscale depth image which is generated from LiDAR 2D projection. Dehazing is implemented by utilizing the atmospheric distribution model by explained atmospheric light and transformation image. This method was quantitative and qualitative analysis is done by image quality parameters through simulators and SSIM showed 24% enhancement.

Usman Ali et al. [13] developed a algorithm for single image dehazing by utilizing robust homogenization. This algorithm is mainly invoked to solve the restricted robustness on outliers and to distinguish between initial and guidance transmission map by utilizing non convex energy function which is calculated by maximize-minimize algorithm. This algorithm generate enhanced transmission map were edge are preserved and generate enhanced haze free image with light colors on both artificial and real hazy images. It stated that the quantitative and qualitative analysis explains the effect of this algorithm and compared with the state-of-the-art strategy by utilizing SSIM, FADE and VLD.

Xiang Chen et al. [14] proposed a strategy for untangled deep image dehazing by utilizing effective disentanglement learning. This strategy divides the images into two categories depending on the haze relevant scattering. Contrastive learning is inserted to a CycleGAN framework to study disentangled relation by managing the constructed images to be associated with undiscovered factors. This strategy's CDD-GAN consist negative constructer to associative the encoder network to update and to generate collection of possible negative factors. Then these negative factors are trained one-to-one along with the backbone representation network to improve the biased data and increase the possibilities factor for disentanglement implemented by maximizing the main contrastive loss. It is asserted that extensive experiments on both artificial and real-world datasets explain that this method implemented favorably against existing untangled dehazing genesis.

II. RESEARCH FINDINGS

Images dehazing by exploiting Minimum [3] White Balance Optimization. This method can be implemented on hazy images of various dimensions.

Applications

1. Image dehazing on image that has object distortion, higher fog intensity.
2. Dehazing with optimized result.
3. Utilized in surveillance drone, cameras and aerial view capturing of landscapes.

Draw Backs

1. Completely dependent on white balance optimization.
2. As the dimensions of image increase, the time required to accomplish the dehazing will be increased.

Future Scope

Parallel implementation on large set of images, reducing time complexity, reducing the white balance optimization influence.

Single image dehazing method [4] works principle of pyramid multi-scale interchanged conventional network. This method maintains color fidelity.

Applications

1. Dehazing on both synthesized and natural haze image.
2. Can be utilized on low illuminated images.

3. Can be used in low illuminated area image capturing cameras.

Drawbacks
1. Dependent on atmospheric distribution model.
2. Require large set of data to train the network.

Future Scope
Multiple image dehazing, reducing space requirements, sintegration of CNN with other dehazing mechanisms.

Single image dehazing model [5] by utilizing brightness channel prior which is dependent on Meta heuristics data for efficient dehazing. This model can be performed even in large haze gradient.

Applications
1. Can be utilized on various contrast images.
2. Can be used in highly hazy images.
3. Can be used in underwater, space, climate observations.

Drawbacks
1. Require various resources and have high complexity.
2. Time required to implement is high.

Future Scope
Multiple image dehazing, reducing the implementation complexity and requirements, implementation with denoising.

Single image dehazing strategy to utilize [6] on resource constrained or restricted platform.

Applications:
1. Dehazing implementation on low resources platforms.
2. Dehazing implementation with low specifications.

Drawbacks
1. Low colour fidelity.
2. Cannot be implemented on multiple images.

Future Scope
Increasing the performance of dehazing, multiple image dehazing, increasing color fidelity.

Single image dehazing by utilizing deep [7] learning techniques. This technique can be implemented on various images with different haze metrics.

Applications
1. Dehazing on mining images.
2. Dehazing on low illuminated images.
3. Performing dehazing with preserving spatial information.

Drawbacks:

1. Require a large collections of training set to train the algorithm.
2. Require large collection of modules for processing of image.
3. Complexity to implement.

Future Scope
Implementation on multiple images, reducing implementation complexity and time, increasing the range of utilization.

Single image dehazing by utilizing [8] Sparse Contextual Representation.

Applications
1. Dehazing with smoothing and sharpening of image.
2. Dehazing implementation on rigid images.

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Drawbacks

1. Require other algorithms for smoothing.
2. Have high complexity and resource requirement.

Future Scope:

Implementation on multiple images, adding denoising mechanisms, increasing color fidelity with less complexity.

Single image mixed dehazing [9] methodology which is dependent on the numerical repetition model and DehazeNet.

Applications

1. Can be implement on large variety of images.
2. Dehazing with both fidelity and preserving information.

Drawbacks

1. Complex integration of both physical and deep learning.
2. Require large amount of data and complex algorithm to integrate and implement.

Future Scope

Integration with other mechanisms, reducing complexity, increasing the effective by integrating image pre and post processing mechanics.

Dehazing mechanism for [10] the foggy images which works on the long range dependence.

Applications

1. Dehazing on higly mist and foggy images
2. Can be utilized in forest surveillance.
3. Can be utilized in remote sensing.

Drawbacks

1. Classification of region based on haze increases complexity
2. Estimation of transmission and atmospheric light is somewhat arduous.

Future Scope

Increasing the scope of application, mixing with filters, texture analysis of dehazed image.

Dehazing mechanism [11] for outdoor hazy image in rapid pace which depend on brightness and concentration of haze in the image

Applications

1. Rapid implementation of dehazing
2. Vehicle surveillance in hazy environment.
3. Dehazing for wide range of haze concentration

Drawbacks

1. Cannot perform well in low illuminate images.
2. Highly dependent on haze concentration and brightness.

Future Scope

Implementing on low illuminate image, implementation along with denoising and glare reduction.

Image dehazing by utilizing [12] LiDAR constructed grayscale depth prior

Applications

1. Can be used in robust environment.
2. **Can be utilized in data in the image is sensitive.**

Drawbacks

1. Complexity of LiDAR algorithm.

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2. Require more resources to implement in real time.

Future Scope
Uitilization of filters, increasing the color fidelity, reducing the complexity and requirements.

Single image dehazing [13] by utilizing robust homogenization

Applications
1. Can be used in robust environment.
2. Can be implemented on rigid images.
3. Enhanced method for texture analysis.

Drawbacks
1. Robustness increases the complexity.
2. Have complex implementation for simple images.

Future Scope
Dehazing along with smoothness ehnacement, sharpness enhancement.

Untangled deep [14] image dehazing by utilizing effective disentanglement learning

Applications
1. Dehazing in both hazy and normal image.
2. Dehazing with large set of images.

Drawbacks
1. Impairing of hazy and normal images increase the complexity.
2. Implementation on less or no haze image is not up to standards.

Future Scope
Implementing with deep learning mechanisms, utilizing denoising mechanisms.

III. CONCLUSIONS

Increase in range of environment were a human can reach has leads to acquire the images from various sources. Even though image is obtained due to haze information exists in the image was reduced. Lead to utilization dehazing mechanisms. The research shows a passion to develop dehazing mechanisms by utilizing image restoration, image enhancement and image fusion dependent methodologies. Lead to increase in techniques. To give a details about the dehazing the statistical study of the assed dehazing methods was accomplished in this work. Every technique has its own advantages and applications. Some methods can be utilized in real time applications. The domain of dehazing has many scopes to advance in the future due its wide range of utility.

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