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Hybrid Approach for Image Defogging Process based on Atmospheric Light Estimation Process

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ABSTRACT

Due to unfavorable weather circumstances, images captured from multiple sensors have limited the contrast and visibility. Many applications, such as web camera surveillance in public locations are used to identify object categorization and capture a vehicle's licence plate in order to detect reckless driving. The traditional methods can improve the image quality by incorporating luminance, minimizing distortion, and removing unwanted visual effects from the given images. Dehazing is a vital step in the image defogging process of many real-time applications. This research article focuses on the prediction of transmission maps in the process of image defogging through the combination of dark channel prior (DCP), transmission map with refinement, and atmospheric light estimation process. This framework has succeeded in the prior segmentation process for obtaining a better visualization. This prediction of transmission maps can be improved through the statistical process of obtaining higher accuracy for the proposed model. This improvement can be achieved by incorporating the proposed framework with an atmospheric light estimation algorithm. Finally, the experimental results show that the proposed deep learning model is achieving a superior performance when compared to other traditional algorithms.

Keywords: Image defogging, deep learning

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1. INTRODUCTION

Over the years, foggy weather is emerging as a continuing issue. Fog is one of the most common causes for automobile accidents. Research on single image defogging has gained significant advances in recent years; however, defogging techniques often require a range of previous assumptions or assumptions to find solutions, which are hardly used in reality [1-5].

Recently, the outdoor images are damaged due to foggy weather circumstances such as fog, rain, clouds, and mist. With the adverse weather circumstances, capturing a photo in cloudy environment reduces image contrast, colour saturation, image quality, and makes object features nearly difficult to discern by humans and standard computer vision systems. Image dehazing is critical for many computer vision applications, including surveillance, image categorization, detection, tracking, identification, and collecting satellite images [6-8]. An effective dehazing process should be able to significantly improve contrast, brightness, correct optical distortion, erase visual flaws, and improve image quality in order to improve contrast, balance luminance, correct distortion, remove unwanted visual effects, and improve overall image quality [9]. Figure 1 shows the sample image of foggy mode.

Figure 1 Sample Foggy Images

Generally, the image dehazing or defogging may be accomplished via image enhancement, image restoration, fusion-based techniques, and machine learning [10]. While image enhancement algorithms just improve the colour and contrast, image restoration

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algorithms defog the image according to the amount of fog present. The effect of air pollution produced by extremely tiny particles in the atmosphere, called fog, causes atmospheric conditions to be unclear. Computer vision researchers often study how fog affects picture quality and image analysis techniques [11, 12]. It's difficult to recover a clean image from a provided hazy image since fog removal is such a challenging subject. There are several defogging strategies in the literature that rely on the atmospheric degradation model. The reference foggy and defogged image datasets are shown in Figure 2.

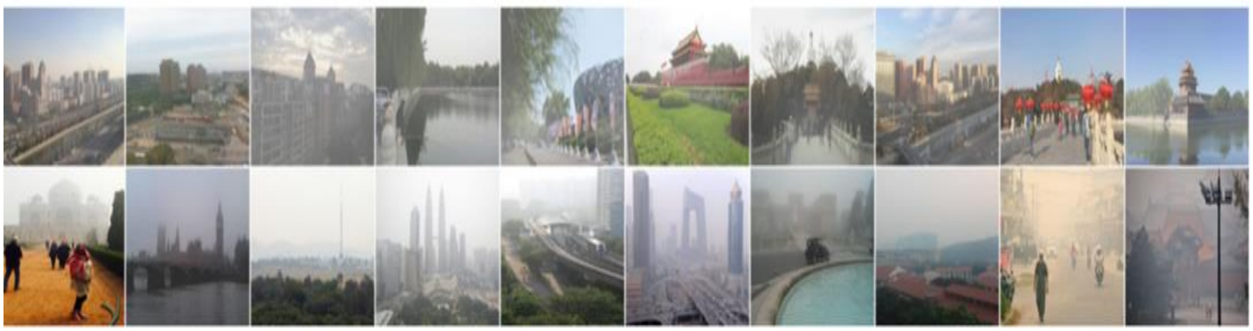

Figure 2 RESIDE Datasets for Image Defogging Process

Defogging techniques may be classified as prior-based or learning-based. Fog-related characteristics may be obtained via data collection and empirical testing. In addition, it is sometimes known as hand-crafted priors. For this reason, these techniques typically function within the tight constraints of a given system, which may lead to fog artifacts in the recovered images [13].

2. ORGANIZATION OF THE RESEARCH

The remaining part of this research article has been reported as follows; section 3 provides the existing work for the image defogging process. Section 4 discusses the proposed framework for image defogging. Section 5 discusses about the performance results with a graph chart. The final section provides conclusion for the proposed research work.

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3. PRELIMINARIES

Tan et al have conducted the experiment based on the assumption that fog-free images have a greater local contrast ratio than foggy ones [14]. Fattal et al postulate that reflectance levels in the immediate surroundings are static and make use of independent component analysis to eliminate fog [15]. He et al used a huge number of fog-free pictures to do a statistical analysis of the dark channel priority theory, and then used the dark channel priority theory to defog. While useful algorithms are shown above, they have certain limitations [16].

A segmentation-based defogging method utilizing adaptive factors was suggested by Cai et al. The binary thresholding technique is used for the segmentation of the sky and non-sky areas in this method. Fusion is used to fuse areas of sky and non-sky. The colorization at the borders of the resulting picture is inaccurate [17]. The DCP-based algorithm's algorithm map, created by T. H. Kil and team. They have discovered areas with trustworthy previous information that can be used to calculate DCP. This transmission map is calculated using only pixels that are known to be accurate [18]. To determine the transmission map for inconsistent pixel values, a linear fitting curve is first calculated and then applied. K-means clustering for depth map computation has been suggested by Qing et al. [19]. When using K-means for image segmentation, we must divide the picture into regions with varying depth ranges. Afterward, a transmission map is calculated for each area. As the picture gets closer to completion, you may see rough, choppy edges along with a "fog" effect at the edge of the image.

At the moment, machine learning frameworks are being used by researchers. Using the random forest, the four characteristics of the foggy picture are combined to generate the transmission map, as stated by Tang et al. [20]. Zhu et al using a supervised learning method, constructed a linear model for the depth map and trained the model's parameters. Even though significant progress has been achieved in these algorithms, they still need different previous information or conditions, and they still have their limits [21, 22]. Wang et al tried in their experimental that foggy pictures were corrected using wavelet transform and single-scale retinex, and brightness was improved by these methods. To minimise halo artefacts in the pictures, Bayesian theory and Markov regularisation were used [23].

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Research Gap

The following contributions are lacking in image defogging research:

1. The modified dark channel prior is the primary function for transmission mapping in the single image defogging.
2. Combination of estimation of fog density in the modified dark channel prior and atmospheric light estimation.
3. The implementation of a statistical approach in an image defogging process is not efficient.

4. Proposed Framework

Object detection has a major coverage issue when it comes to covering numerous object sizes. The template must be matched to the spatial support of the item to be identified. It may generally be identified as quickly-moving objects on the foggy roadside pictures. Our proposed framework is consisting for image defogging process with prior segmentation process [24]. Here we are combining the atmospheric light estimation and transmission map estimation and refinement technique for image defogging. Figure 3 shows the block diagram of our proposed architecture. The framework of our proposed work is going to discuss in this sections;

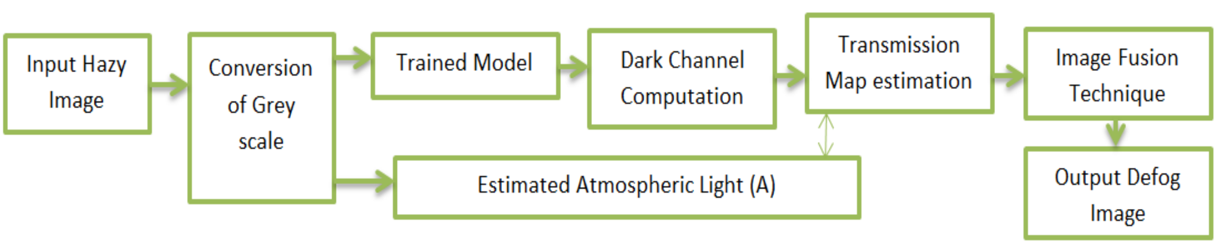

Figure 3 Proposed Hybrid framework

4.1 Segmentation process for image defogging

Here, we have devised a defogging algorithm by utilizing an image segmentation method. The graph-based segmentation method is often used for performing image segmentation. The portions are based on areas that are near the sky, and other parts that are farther from the sky. Each section has a set of equations for dark and ambient light, which are combined to get the final result. We use the average light level in the atmosphere to determine the transmission map

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[25]. As with the prior approach, refining involves applying a guided picture filter. It has better SSIM and PSNR values, as well as a reduced MSE cost, thanks to the segmentation-based method.

4.2 Image defogging using modified dark channel prior

To aid in transmission map estimate, a modified dark channel is calculated. A guided image filter is afterward used to refine the transmission map (GIF). Concerning its transmission map refinement time optimization, the GIF is a more efficient refinement filter than the other two options [26]. Figure 3 is a depiction of our suggested process, which shows that the proposed model is applied to the foggy picture to compute the light from the atmosphere and the darkness from the earth. To calculate the transmission map, atmospheric light is utilized. The results are adjusted to retain the gradient information. Using the improved transmission map, a fog-free picture is subsequently generated.

4.3 Dark channel and atmospheric light estimation

The atmospheric light estimation is very important in image defogging process which can be obtained from the dark channel filter function. This filter function can be varied with window size and calculation is very easy.

Remarks 1:

$$Modified\ function = \min_{input\ \epsilon\ window\ size} \left(\min_{y \epsilon color\ co-ordinates} I(y) \right)$$

4.4 Transmission map estimation and refinement

The transmission map is obtained from the atmospheric light effect. This RGB color channel can be divided this input images based on the intensity of the color.

$$T_m(x) = 1 - \zeta \frac{I(x)}{A}$$

Where, “A” is atmospheric light. For the provided input hazy picture, the fog density is calculated. FADE is used for calculating the fog density given a picture. The functions of fog densities are stable, as long as the method of guarding against oversaturation is kept constant. The cross-validation on the datasets yields these function values. This may result in estimates of the model's performance.

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Remarks 2:

$T_{refined}(x) = a_k T_k + b_k$

This "a" and "b" are linear co-efficient to transmit the refined transmission maps. This refining the transmission map function can be defogged the images during reconstruction of the output image.

Remarks 3:

Reconstructed image = $\frac{I(x)-A}{T_{refined}+\epsilon} + A$

ϵ is a constant to avoid negative values. This approach is used to improve the brightness of fur defogging algorithm.

5. RESULTS DISCUSSION

At this time, there is no real-world natural fog-free picture collection publically accessible for defogging study. In our opinion, including pictures that are natural in their look is an excellent means for creating effective defogging solutions [27]. In this work, we have gathered pictures of 200 natural outdoor landscapes that are clear and images of foggy situations. A year was spent on each scene and each had a single fixed camera.

(a) By other traditional algorithm

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(b) Done by Hybrid Proposed Work

Figure 4 (a) & (b) Comparison of various methods with proposed framework

A collection of several real-world fog images were chosen, one clear image with four fuzzy images to create the Multiple Real Fog Images Dataset (MRFID). This dataset is believed to be valuable for the research community, and we want to make it freely accessible so that the development of defogging methods may be supported. Here we are comparing our hybrid proposed algorithm with dark channel prior model alone for image defogging and atmospheric light estimation process without transmission and refinement techniques [28]. In the future, the dataset will be made accessible online.

Table 1 Calculated metrics from obtained results

Image defogging methods	SSIM	PSNR	MSE	NIQE	FR-IQA
Dark Channel Prior model alone	0.71	14.58	0.0899	4.55	0.7923
Atmospheric Light Estimation alone	0.632	15.21	0.094	2.93	0.6843
Hybrid Proposed algorithm	0.861	21.2	0.019	2.239	0.849

This comparison tests if the experimental findings match those of the conventional method. With respect to assessing the defogging algorithm, it is essential to consider the visual impact, visibility improvement, edge and texture information, color, and image structure. Full reference image quality assessment (FR-IQA) and mean square error (MSE) are used to compare algorithm outputs to the current state of the art. Additional non-reference measures, such as NIQE are also computed and tabulated in table 1.

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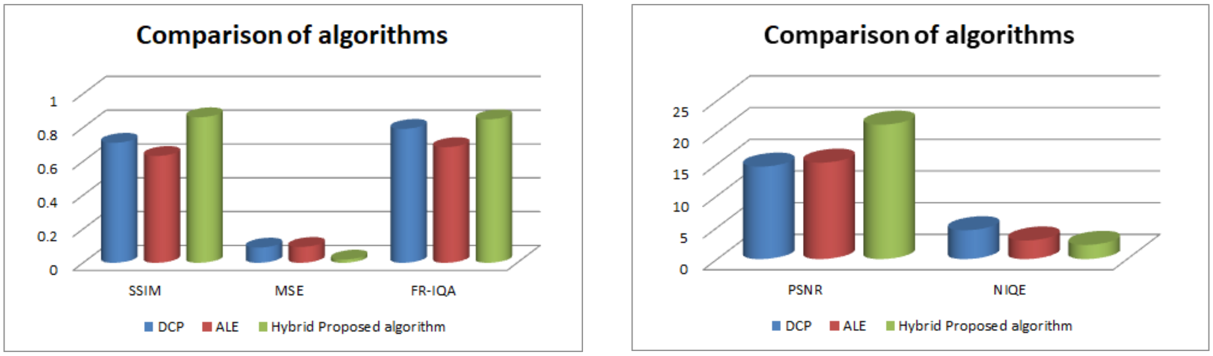

Figure 5 Performance comparisons between algorithms

Figure 5 shows some performance metrics and its evaluation between image defogging algorithms. The proposed hybrid algorithm is providing a good structural similarity index and higher FR-IQA value when compared to other methods. Besides, the MSE value is minimal compared to all other methods. It was computed through a formula and plotted in the graph.

6. CONCLUSION

As a result, the proposed hybrid approach has outperformed all existing picture defogging methods in terms of overall performance. The visibility is much higher than with other conventional algorithms, which is another plus. This has been accomplished by integrating DCP, transmission map estimation with refinement, and the ambient light estimate module to increase performance. We were able to complete and test it successfully. In the future, we aim to pay a special attention to the computation speed of the proposed approach. It is anticipated that the proposed system will be used to process many other types of datasets in the future.

REFERENCES

[1] Chincholkar, Shruti, and Manoov Rajapandy. "Fog image classification and visibility detection using CNN." In International Conference on Intelligent Computing, Information and Control Systems, pp. 249-257. Springer, Cham, 2019.

[2] B. Li, W. Ren, D. Fu, D. Tao, D. Feng, W. Zeng, Z. Wang, Benchmarking single-image dehazing and beyond. IEEE Trans Image Process. **28**(1), 492–505 (2019)

ISSN: 2582-2012 (online)
Submitted: 17.07.2021
Revised: 08.08.2021
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Published: 28.08.2021

[3] Hamdan, Yasir Babiker. "Construction of Statistical SVM based Recognition Model for Handwritten Character Recognition." Journal of Information Technology 3, no. 02 (2021): 92-107.

[4] Z. Chen, J. Shen, P. Roth, Single image defogging algorithm based on dark channel priority. J. Multimed. **8**(4), 432–438 (2013)

[5] Dhaya, R. "Hybrid Machine Learning Approach to Detect the Changes in SAR Images for Salvation of Spectral Constriction Problem." Journal of Innovative Image Processing (JIIP) 3, no. 02 (2021): 118-130.

[6] K. He, J. Sun, X. Tang, Single image haze removal using dark channel prior. IEEE Trans. Pattern Anal. Mach. Intell. **33**(12), 2341–2353 (2011)

[7] Chen, Joy Iong-Zong. "Design of Accurate Classification of COVID-19 Disease in X-Ray Images Using Deep Learning Approach." Journal of ISMAC 3, no. 02 (2021): 132-148.

[8] J. Tang, Z. Chen, B. Su, J. Zheng, in *Chinese Conference on Image and Graphics Technologies*. Single image defogging based on step estimation of transmissivity (Springer, Singapore, 2017), pp. 74–84

[9] Sungheetha, Akey, and Rajesh Sharma. "Design an Early Detection and Classification for Diabetic Retinopathy by Deep Feature Extraction based Convolution Neural Network." Journal of Trends in Computer Science and Smart technology (TCSST) 3, no. 02 (2021): 81-94.

[10] D. Nair, P. Sankaran, Color image dehazing using surround filter and dark channel prior. J. Vis. Commun. Image Represent. **50**, 9–15 (2018)

[11] Adam, Edriss Eisa Babikir, and A. Sathesh. "Construction of Accurate Crack Identification on Concrete Structure using Hybrid Deep Learning Approach." Journal of Innovative Image Processing (JIIP) 3, no. 02 (2021): 85-99.

[12] W. Zhang, X. Hou, Light source point cluster selection-based atmospheric light estimation. Multimed. Tools. Appl. **77**(3), 2947–2958 (2018)

[13] Tripathi, Milan. "Analysis of Convolutional Neural Network based Image Classification Techniques." Journal of Innovative Image Processing (JIIP) 3, no. 02 (2021): 100-117.

[14] Tan, R. T. (2008, June). Visibility in bad weather from a single image. In Computer Vision and Pattern Recognition, 2008. CVPR 2008. IEEE Conference on (pp. 1-8). IEEE.

[15] Fattal, R. (2008). Single image dehazing. ACM transactions on graphics (TOG), 27(3), 72.

ISSN: 2582-2012 (online)
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DOI: https://doi.org/10.36548/jaicn.2021.3.003

[16] He, K., Sun, J., & Tang, X. (2011). Single image haze removal using dark channel prior. IEEE transactions on pattern analysis and machine intelligence, 33(12), 2341-2353.

[17] C. Cai, Z. Qiuyu, L. Yanhua, in *2015 IEEE International Conference on Mechatronics and Automation (ICMA)*. Improved dark channel prior dehazing approach using adaptive factor (IEEE, 2015. https://doi.org/10.1109/icma.2015.7237742

[18] T. H. Kil, S. H. Lee, N. I. Cho, in *2013 IEEE International Conference on Image Processing*. Single image dehazing based on reliability map of dark channel prior IEEE, 2013). https://doi.org/10.1109/icip.2013.6738182

[19] C. Qing, Y. Hu, X. Xu, W. Huang, in *2017 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData)*. Image haze removal using depth-based cluster and self-adaptive parameters (IEEE, 2017). https://doi.org/10.1109/ithings-greencom-cpscom-smartdata.2017.163

[20] Tang, K., Yang, J., & Wang, J. (2014, June). Investigating haze-relevant features in a learning framework for image dehazing. In 2014 IEEE Conference on Computer Vision and Pattern Recognition (pp. 2995-3002). IEEE.

[21] Zhu, Q., Mai, J., & Shao, L. (2015). A fast single image haze removal algorithm using color attenuation prior. IEEE Transactions on Image Processing, 24(11), 3522-3533.

[22] M. Zhu, B. He, Q. Wu, Single image dehazing based on dark channel prior and energy minimization. IEEE Sig. Process Lett. **25**(2), 174–178 (2018).

[23]Wang, Z., Bovik, A. C., Sheikh, H. R., & Simoncelli, E. P. (2004). Image quality assessment: from error visibility to structural similarity. IEEE transactions on image processing, 13(4), 600-612.

[24] Adam, Edriss Eisa Babikir. "Deep Learning based NLP Techniques In Text to Speech Synthesis for Communication Recognition." Journal of Soft Computing Paradigm (JSCP) 2, no. 04 (2020): 209-215.

[25] Z. Li, J. Zheng, Single image de-hazing using globally guided image filtering. IEEE Trans. Image Process. **27**(1), 442–450 (2018)

ISSN: 2582-2012 (online)
Submitted: 17.07.2021
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Accepted: 19.08.2021
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[26] Dhaya, R. "Hybrid Machine Learning Approach to Detect the Changes in SAR Images for Salvation of Spectral Constriction Problem." Journal of Innovative Image Processing (JIIP) 3, no. 02 (2021): 118-130.

[27] Kumar, T. Senthil. "Construction of Hybrid Deep Learning Model for Predicting Children Behavior based on their Emotional Reaction." Journal of Information Technology 3, no. 01 (2021): 29-43.

[28] Haoxiang, Wang, and S. Smys. "Overview of Configuring Adaptive Activation Functions for Deep Neural Networks-A Comparative Study." Journal of Ubiquitous Computing and Communication Technologies (UCCT) 3, no. 01 (2021): 10-22.

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