Performance Evaluation of Fast DCP Algorithm for Single Image Dehazing

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Abstract. Poor weather circumstances including fog, dust, and atmospheric dispersion of other particles can degrade the clarity of photos taken in outdoor settings. High-level computer vision tasks like picture segmentation and object detection may become more difficult as a result of this issue. However, earlier research on image dehazing, such as Dark Channel Prior (DCP), suffers from a significant computing burden and degradation of the original image, such as oversaturation and halos. In this work, an improved image dehazing approach (Fast DCP) based on down sampling has been proposed. The proposed algorithm executes the dehazing of a haze image with a smaller amount computational time without degrading the quality of the image. The performance measures of proposed algorithm have been analysed in terms of PSNR, MMSE and SSIM and compared with existing DCP algorithm. The simulation results proven that, the computational time for proposed algorithm has been reduced by 70% when compared to DCP without degrading image quality.

Keywords: Computer Vision · Computational Time · Dark Channel Prior · Dehazing · Object Detection · Segmentation · Scattering

1 Introduction

Haze is a typical environmental peculiarity brought about by tiny samples such as; dirt, fume, fog in the air, driving to debasement of picture lucidity. Customarily, specialists treated picture dehazing as a picture handling method to recuperate image subtleties and this confined the utilization of dehazing calculations to a restricted scope of uses. Be that as it may, the quick improvement of independent frameworks, artificial insight, and the prerequisites of significant level computer vision assignments has prompted re-established examination into further developed picture dehazing procedures [1]. The improvement of dehazing estimations has, therefore, become perhaps the best area of artificial intelligence and an undeniably basic supplication is the utilization of dehazing calculations in order to move along the showcase of the self-governed structures and stages for antagonistic barometrical circumstances.

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The optics of a computer vision framework are for the most part planned utilizing the presumption of splendid weather patterns, where the shading power of every pixel is exclusively related with the brilliance of the first scene. Consequently, learns at a beginning phase of computer vision errands specifically overlooked the state of awful climate [2]. Nonetheless, specialists soon understood the significance of picture reclamation procedures. Outside pictures are unavoidably antagonistically affected by the circumstances, and refraction, scattering and maintenance occur indeed, even on moderately sunny mornings, bringing about loss of itemized data and low differentiation. These debased info pictures lead to unfavorable effects on independent frameworks [3]. The model of haze formation has been depicted in Fig. 1.

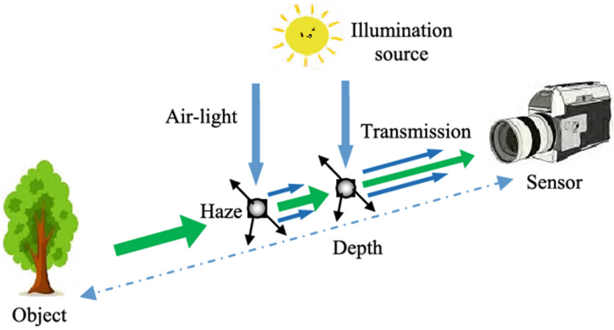

Fig. 1. Model of haze creation [3]

Haze expulsion is exceptionally alluring in various fields like computer vision calculations, picture handling and photography [4, 5]. To begin with, the amputation of haze rises the perceptibility of a dim sceneries formed by air particles. The relating picture is the scene Luminant in most computer picture handling approaches, from higher scale picture processing to advanced scale shape recognition. The assessment of these methods relies upon the scenes. In the event that the picture or scene is dull, vision calculations face many issues and try not to show proficient execution. In this way, eliminating fog is required for better outcomes and productivity. The awful pictures can be put to all the more likely use. Scattering relay on the scene length, and this sleaze is called three-dimensional variation. Expulsion of murkiness from the picture expands the perceivability of dim picture brought about by the air particles. Hence, this work focuses on developing an algorithm for dehazing of images with high accuracy and less computational time by maintains adequate picture quality [6, 7].

2 Literature Review

Most single picture dehazing calculations utilize either prior based picture handling determined to anticipate the broadcast, while deducing the barometrical light by exact techniques. A crucial headway has the disclosure in [8], which elaborates the image dehazing phenomenon. The proposed algorithm in [9] offers the potential gains of straight inconvenience and feasibility yet moreover has drawbacks in flexibility, speed, and edge assurance, impelling numerous endeavours to manage the essential method.

The authors in [10] have consolidated the dehazing methodologies to move along the computational time. Thusly, two or three papers [11–14] credited the long dealing with season of the essential dehazing procedure to the delicate matting development, supplanting it with different channels. More of late, morphological redirection has partaken in the dehazing collaboration, vanquishing the absence of detail accomplished by the base channel [15]. The authors in [16] presented a joint improvement between equipment and calculation, accomplishing ongoing handling with restricted corruption. A new report [17] utilized a book unaided learning strategy by means of minimization of the computational time, taking care of the organization with certifiable cloudy pictures as opposed to ordinarily utilized engineered information to keep away from the conceivable space shift. In [18], the authors have presented an algorithm, accepting the brilliance and immersion are significantly different by the fog focus. In [19], a non-neighborhood dehazing (NLD) calculation for single pictures has been proposed. As indicated by their perceptions, the quantity of tones is a lot more modest than the quantity of pixels in a picture.

All through the advancement of knowledge-based dehazing approaches, the longing for elite execution has driven the advancement of progressively complex procedures, for example, multi-scale designs. This pattern has decreased the commonsense utilization of single picture dehazing algorithms, specifically for asset obliged applications where ongoing activity with restricted computational assets is a key driver. Numerous new investigations based on Arduino integrated with IOT [20–24] perceive the requirement for ongoing handling and the advancement of methods to lessen the capacity, intricacy, handling time and other related angles without compromising the presentation. The proposed Fast DCP algorithm mainly focused on single image dehazing with less computational time when compared to DCP algorithm by maintain bearable picture quality.

3 Methodology

The primary disadvantage in DCP method is its computational time. Pragmatic applications require less opportunity to compute the dehazed picture from haze pictures. To beat this downside a superior adaptation of DCP calculation which is a Fast DCP has been proposed for dehazing of images. Image dehazing based on DCP method [25] in which the transmission medium $t'(x)$ is determined by utilizing confined area. In this way, the border area has been unbending for $t'(x)$. To smoothen these edges the algorithm utilized transmission map refinement, which is a tedious interaction and does not appropriate for pragmatic applications. Hence, to improve the computational time, a Fast DCP method has been proposed. The proposed algorithm consists of three basic steps in working such as;

- Down-sampling
- Estimation of pixel-wise approximation
- Assessment of robust ambient light

3.1 Down-Sampling Based Computation

The computational time is solidly comparing to picture size. By and large, the dim channel picture has low spatial repeat. There are no tremendous ramifications for the evaluated dim channel regard in any event, when down-inspected picture and a short time later add it to special size ensuing to determining the dim channel picture and including light. The picture is down-inspected to *N/4, M/4* utilizing the mean in this technique.

3.2 Assessment Dark Channel Image Through Element-Wise

The proposed calculation assesses the dark channel esteem utilizing one pixel rather than 15 × 15 pixel to lessen the computational time without trailing the spatial data like edge. The DCP utilizes pixel (1 × 1 fix) for estimation of dim channels, there is no requirement for delicate matting interaction to smoothen the created picture, which is a tedious cycle. Notwithstanding this the proposed technique utilizes down-tested picture and one pixel for estimation of dull channel which diminish the computational time essentially [25]. Allow us to think about the worth of direct light J in obscurity channel as nothing, therefore the right-hand side's starting term in Eq. (1) can be omitted.

In the proposed technique, the worth of dim divert in noticed light I determined by 1 × 1 fix is bigger than the ordinary dim channel esteem determined by 15 × 15 fix (see Eq. (2)). Because of the expulsion of spatial limiting, there an opportunity that the dim divert esteem in straight light J has little worth (see Eq. (3)).

$$\min_{y\in\Omega(x)}\left(\min_{c}\left(\frac{I^{c}(y)}{A^{c}}\right)\right)=\tilde{t}(x)\min_{c}\left(\min_{c}\frac{j^{c}(y)}{A^{c}}\right)+(1-\tilde{t}(x)) \tag{1}$$

$$T_{J}(x)=1-\gamma\frac{\left(\min\limits_{c\in\{R,G,B\}}\left(\frac{I^{c}(x)}{A^{c}}\right)-\min\limits_{x\in\Omega}\left(\min\limits_{c\in\{R,G,B\}}\left(\frac{I^{c}(x)}{A^{c}}\right)\right)\right)}{\left(\max\limits_{x\in\Omega}\left(\min\limits_{c\in\{R,G,B\}}\left(\frac{I^{c}(x)}{A^{c}}\right)\right)-\min\limits_{x\in\Omega}\left(\min\limits_{c\in\{R,G,B\}}\left(\frac{I^{c}(x)}{A^{c}}\right)\right)\right)} \tag{2}$$

$$t'(x)=\frac{\left(1-\omega\min_{y\in\Omega(x)}\left(\min_{c\in\{R,\mathrm{G},\mathrm{B}\}}\frac{I^{c}(y)}{A^{c}}\right)\right)}{T_{J}(x)} \tag{3}$$

3.3 Estimation of Robust Ambient Light

In DCP strategy [25], at first the creators have picked the top 0.1% most brilliant pixels in obscurity channel of cloudiness picture I, and from these pixels the most noteworthy power pixels has been recognized. Prior techniques for dehazing, overlooks the little white article because of dim channel picture which is assessed by 15 × 15 fix. In any case, in the Fast DCP the dull channel is determined by utilizing 1 × 1 fix. What is more, the DCP technique needs an opportunity to sort the top 0.1% most splendid pixels in obscurity channel of fog picture *I*.

4 Simulation Analysis

The simulation has been performed using MATLAB with 1.5 GHz operating frequency. Firstly, the input haze image has been subjected for proposed algorithm (see Fig. 2(a)). First, it is down sampled by four and applied for dark channel construction (see Fig. 2(b)).

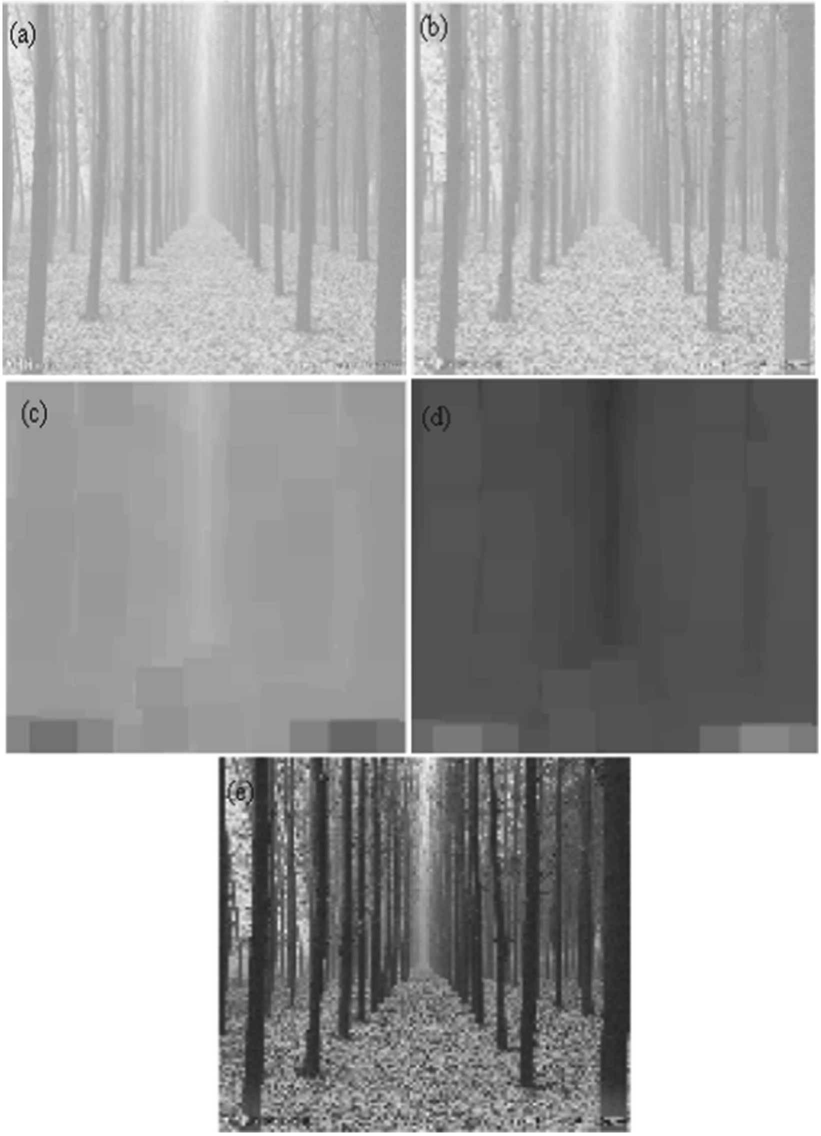

Fig. 2. (a) Input Hazy Image, (b) Down-Sampled Image, (c) Dark Channel Image, (d) Transmission Map, (e) Dehazed image.

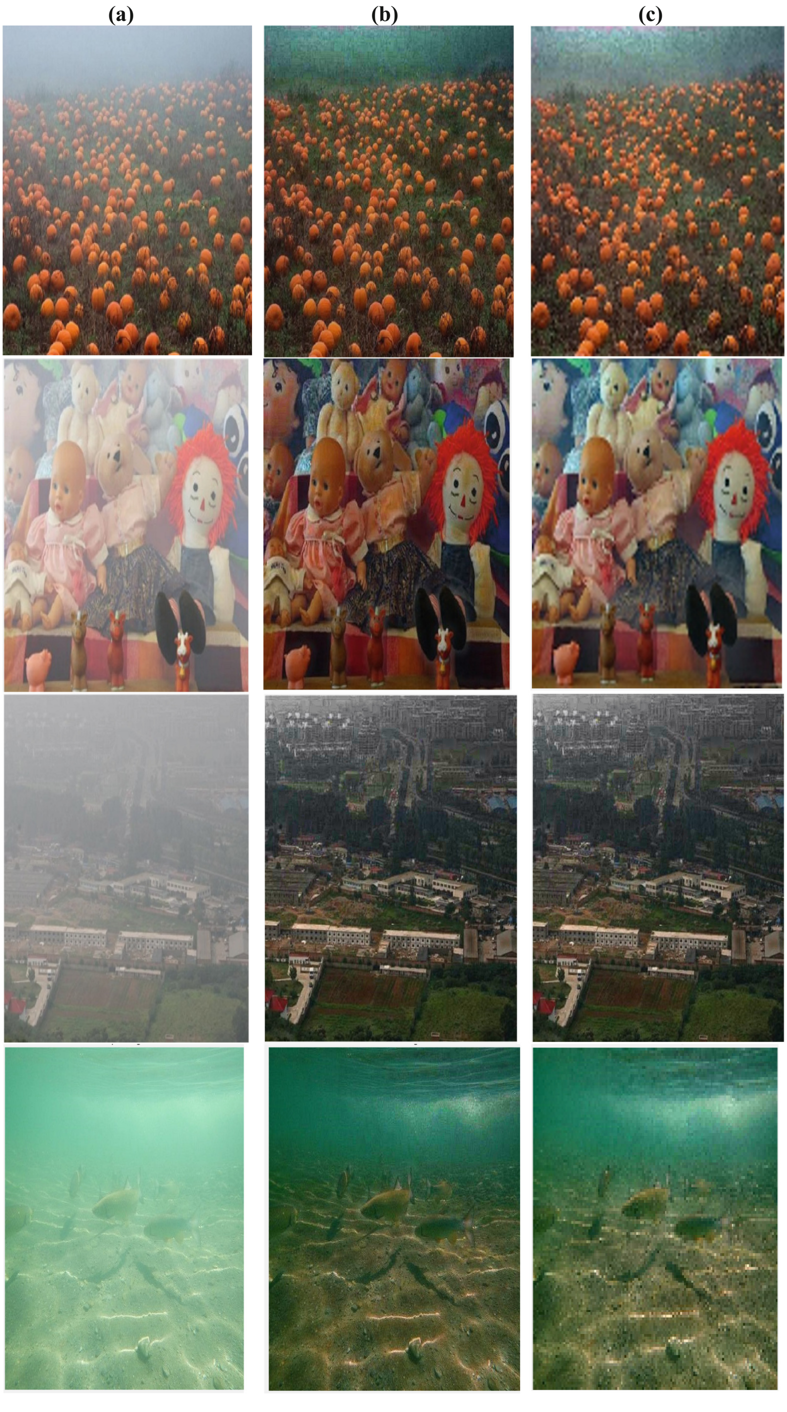

Fig. 3. (a) Input Hazy Image, (b) Dehazed Image using DCP algorithm, (c) Proposed

The dark channel formation involved in many phases with respect to DCP and the output mage padded with zeros (see Fig. 2(c)).

After the dark channel construction, transmission map has been constructed (see Fig. 2(d)). Finally, the dehazed image has been estimated (see Fig. 2(e)). The proposed algorithm has been justified by performing subjective and objective analysis respectively. The performance measures have been evaluated for various hazy images.

4.1 Subjective Analysis

Subjective analysis is the analysis which uses the observers to make the quality estimation based on their visual opinion of the image. The subjective analysis has been carried out for various hazy images (see Fig. 3) such as; Trees and Trunks, Colorful flowers, Dolls, Village and for an Underwater image. The subjective analysis has been carried out by performing the down sampling of an input hazy image there by constructing dark channel image and transmission map. Finally, the dehazed image has been obtained after transmission map. The subjective analysis has been carried out for both existing DCP and proposed Fast DCP algorithms. Figure 3 depicted that the dehazed images corresponding to both DCP and Proposed Fast DCP algorithms. The input hazy images have been taken from the existing data base of hazy images.

4.2 Objective Analysis

The objective analysis has been conducted for the proposed methodology in terms of PSNR, MSE and computational time. The detailed analysis has been depicted in Table 1. Along with the objective analysis; the computational complexity has been estimated for both the algorithms (see Table 2). The PSNR and mean square error has been evaluated for proposed Fast DCP algorithm and compared with existing DCP algorithm. The PSNR and MSE have been represented using (4) and (5) respectively. In addition to PSNR and MSE, the structural similarity index measurement (SSIM) has been evaluated for both proposed Fast DCP algorithm and existing DCP algorithm in order to know the quality of dehazed images.

$$PSNR = 20\,\log\left(\frac{Max}{\sqrt{MSE}}\right) \tag{4}$$

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \tag{5}$$

Table 1. Comparison of MSE, PSNR and SSIM values of DCP and fast DCP algorithms for various images

Image name	Parameter	DCP	Proposed
Trees and trunks	MSE	0.0087	0.0069
	PSNR	62.7544	69.7556
	SSIM	0.8341	0.9689
Colourful flowers	MSE	0.0065	0.0073
	PSNR	68.4634	67.1674
	SSIM	0.8535	0.8425
Dolls	MSE	0.0079	0.0067
	PSNR	66.7544	69.8670
	SSIM	0.7986	0.8466
Village	MSE	0.0092	0.0086
	PSNR	67.8243	69.5269
	SSIM	0.8742	0.9368
Under water	MSE	0.0079	0.0059
	PSNR	63.4570	69.8249
	SSIM	0.8721	0.9659

Table 2. Comparison of computational time.

Image name	DCP (s)	Proposed (s)
Trees and trunks	9.874	2.281
Colourful flowers	9.774	2.148
Dolls	9.869	2.119
Village	10.057	2.068
Under water	9.877	2.527

5 Conclusion

Image dehazing expulsion techniques have become more valuable for many picture handling and computer vision applications. All the dehazing techniques helpful for reconnaissance, for remote detecting and submerged imaging, photography and so forth A large portion of the techniques depend on the assessment of climatic light and transmission map. In, this work a Fast DCP method for dehazing the images have been proposed. The proposed method performs the dehazing without degrading the picture quality and with less computational time when compared to DCP for single image dehazing. It is clearly depicted from results, the computational time with proposed methodology has been reduced by 70% when compared to DCP algorithm. Image quality has achieved a value of 69.8670 (PSNR) with proposed algorithm whereas, for DCP the PSNR value is 66.7544.

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