

Vision Enhancement using Image Processing

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Abstract— This study compares two popular image preprocessing methods: dark channel and bilateral filtering. They are evaluated on a set of low-light images and compared based on visual quality metrics. Dark channel performs better for removing haze and improving contrast, while bilateral filtering is more effective for preserving details and reducing noise. To evaluate the performance of the methods in a practical application, they are applied to dataset provided. Both methods can effectively enhance nighttime driving images, but bilateral filtering produces more visually pleasing results with fewer halo artifacts. The study can give some idea for selection of appropriate techniques for specific applications, such as enhancing visibility in foggy scenarios.

Index Terms— Dark channel, Image Processing, Vision Enhancement

I. INTRODUCTION

Drivers face specific challenges when driving in difficult weather conditions due to reduced visibility. The two main problems they encounter are reduced visibility and decreased depth perception. In foggy situations, visibility is significantly reduced, and drivers may struggle to see the road ahead, other vehicles, and obstacles. Fog can make it difficult to judge distances, as well as make it harder to identify objects or other drivers on the road. This can lead to accidents, especially if drivers are driving too fast in the conditions or following too closely. At night, visibility is also reduced, and drivers may struggle to see the road ahead, other vehicles, and obstacles. Additionally, drivers may also experience decreased depth perception, making it harder to judge distances accurately. This can be especially challenging when approaching intersections, changing lanes, or passing other vehicles. Thus it is essential to find methods to overcome the problems faced in these conditions and provide solution for the same. Here, we compare and contrast two major techniques and provide insights.

II. PROBLEM STATEMENT

The problem statement is to compare the effectiveness of these two techniques in enhancing the visibility of images captured in low-visibility conditions. The comparison can be made using objective metrics such as peak signal-to-noise ratio (PSNR) or structural similarity index (SSIM), which measure the similarity between the original and enhanced images.

III. LITERATURE REVIEW

The paper proposes a single image haze removal algorithm using a dark channel prior. The algorithm utilizes the

observation that the dark channel of a hazy image has low values in the haze-free regions[1]. Performance measure: The algorithm is evaluated on a dataset of hazy images and compared against several state-of-the-art methods. The performance is measured using the image quality assessment metric, Peak Signal-to-Noise Ratio (PSNR). The algorithm is not effective when the haze is too thick, and the scene contains significant texture details.

The primary focus of the paper is to propose a fast single image dehazing algorithm based on the dark channel prior. The algorithm uses a guided filter to refine the transmission map[2]. The algorithm is evaluated on a dataset of hazy images and compared against several state-of-the-art methods. The performance is measured using the image quality assessment metric, Structural Similarity Index (SSIM). The algorithm is not effective when the haze is too thick, and the scene contains significant color casts.

The paper tells about a non-local image dehazing algorithm that utilizes the dark channel prior and non-local means filter to estimate the transmission map[3]. Performance measure: The algorithm is evaluated on a dataset of hazy images and compared against several state-of-the-art methods. The performance is measured using the image quality assessment metric, PSNR. The algorithm is computationally expensive, and it may fail to remove haze when the scene contains significant color casts. The author proposes a robust single image dehazing algorithm that uses an adaptive dark channel prior to estimate the transmission map[4]. The algorithm is evaluated on a dataset of hazy images and compared against several state-of-the-art methods. The performance is measured using the image quality assessment metric, SSIM. The algorithm may produce artifacts when the haze is too thick, and the scene contains significant texture details.

The paper proposes a fast and robust dehazing method based on a new dark channel prior. The algorithm uses a guided filter to refine the transmission map[5]. The algorithm is evaluated on a dataset of hazy images and compared against several state-of-the-art methods. The performance is measured using the image quality assessment metric, PSNR. The algorithm provided may produce artifacts when the scene contains significant texture details. The paper proposes an algorithm for estimating the air light map for deblurring hazy images based on the dark channel prior. The algorithm uses an iterative optimization process to estimate the air light map[6-10]. The algorithm is evaluated on a dataset of hazy images and compared against several state-of-the-art methods. The performance is measured using the image quality assessment metric, PSNR. The algorithm may produce artifacts when the haze is too thick, and the scene contains significant texture details[11-12].

IV. METHODOLOGY

The problem statement is to compare the effectiveness of these two techniques in enhancing the visibility of images captured in low-visibility conditions. The comparison can be made using objective metrics such as peak signal-to-noise ratio (PSNR) or structural similarity index (SSIM), which measure the similarity between the original and enhanced images.

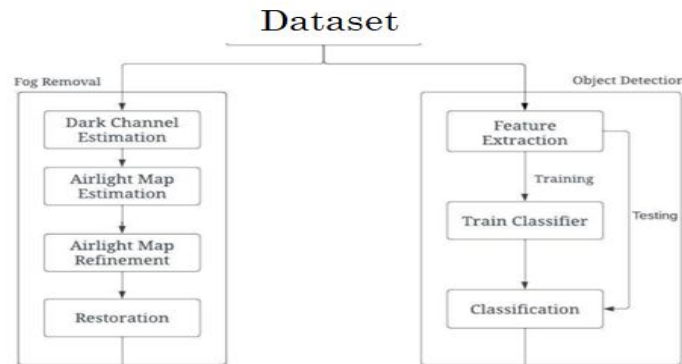


Figure 1: System Design

A. Fog Removal

a. Dark Channel and Airlight mapping

b. Dark channel estimation

$J_{\text{dark}}(x) = \min(\min(I_r(x+r, y+s))),$ for all pixels (r, s) in the local patch centered at x , where I_r is the intensity of the red channel of the input image at pixel $(x+r, y+s)$.

Dark channel estimation is a technique used in image enhancement by de-noising to estimate the amount of haze or fog in an image.

c. Air-light map estimation

$A = \max(I)$, for all pixels p , where $I(p)$ is the intensity of pixel p in the input image.

Air-light map estimation is a technique used in image enhancement by de-noising to improve the visual quality of hazy or foggy images. In such images, the presence of atmospheric particles causes light to scatter, leading to reduced visibility and contrast.

d. Air light map refinement

$J(x) = (I(x) - A) / t(x) + A$, where $J(x)$ is the dehazed image at pixel x , $t(x)$ is the transmission map at pixel x , $I(x)$ is the intensity of pixel x in the input image, and A is the estimated airlight.

Air light map refinement is a technique used in image enhancement, specifically in the context of de-noising. In this technique, the air light map of an image is refined to reduce noise and improve image quality. Figure 1 depicts about the architecture of system design for fog removal.

e. Restoration

Restoration with respect to image enhancement by de-noising refers to the process of removing noise or unwanted artifacts from a digital image to improve its visual quality and clarity.

f. Bilateral filtering

Bilateral filtering is an edge-preserving smoothing technique used in image processing that can be effective in removing fog from images. In fog removal, bilateral filtering works by smoothing the image while preserving important edges and details. The filter considers both the spatial and intensity differences between pixels when smoothing the image, which means that regions with similar color and intensity are smoothed together, while regions with different color and intensity are preserved as distinct edges.

B. Object Detection

Yolo dataset is used for input.

a. Feature extraction

Feature extraction refers to the process of identifying and extracting relevant information or features from an image. In the context of image enhancement by de-noising, feature extraction involves identifying important characteristics of the image that can be used to distinguish between noise and the underlying signal. Figure 1 depicts about the architecture of system design for fog removal and object detection.

b. Train Classifier

Training a classifier involves using a set of labeled data to teach a machine learning algorithm how to identify specific patterns or features in an image. In the context of image enhancement by de-noising, training a classifier would involve using a set of images with known noise levels to teach the algorithm how to distinguish between noisy and clean images.

c. Classification

Classification is the process of categorizing or labeling an image based on its features. In the context of image enhancement by de-noising, classification would involve using a trained algorithm to identify whether an image contains noise or not, and then applying appropriate enhancement techniques to remove the noise and improve the quality of the image.

In image dehazing, the dark channel prior and air light estimation are two important techniques used for improving the quality of hazy images. The dark channel prior is a statistical property of natural images that can be used to estimate the amount of haze in an image. The air light is the color of the light that is scattered the least in the hazy environment, and it can be used to estimate the amount of atmospheric haze in the image.

d. Dark channel prior implementation

The dark channel prior is computed by taking the minimum value of each pixel in a local window. This is done separately for each color channel of the image, and the minimum value across all color channels is selected to create a grayscale image. The resulting image represents the dark channel of the scene, and the maximum value in this image represents the amount of haze in the scene. This value is then used to estimate the transmission map, which represents the amount of light that passes through the haze.

e. Air light map implementation:

The air light map is estimated by selecting the brightest pixels in the image, which are assumed to correspond to the least scattered light. This is done by selecting the top 0.1% of pixels in the image based on their intensity values.

The RGB values of these pixels are then averaged to estimate the air light, which represents the color of the light that is scattered the least in the hazy environment.

Overall, the dark channel prior and air light map are powerful techniques for image dehazing, and their implementation can significantly improve the quality of hazy images. By applying these techniques pointwise, we can dehaze each pixel in the image individually, resulting in a clear and visually appealing image.

V RESULTS

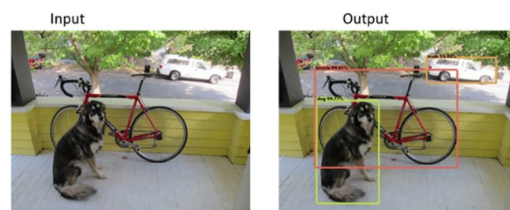


Figure 2a: Detection of a dog and a cycle

Figure 2a depicts about the dog and cycle in first image and detection of them in second one with an accuracy of detection 99.7%. Detection of a person and other objects are shown in Fig 2b.

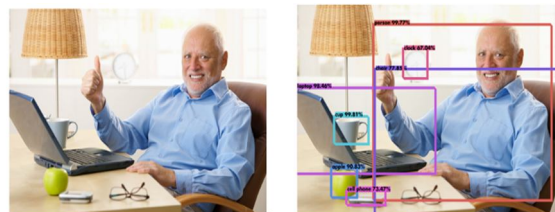


Figure 2b: Detection of a person and other objects

Figure 2b shows a person sitting on the chair with his laptop and other objects and detection of each object with the given accuracies.

A. Dark Channel with Airlight Map Estimation



Figure 3: First image consists of fog, second one is haze free of first one using dark channel and air light estimation

B. Bilateral filtering

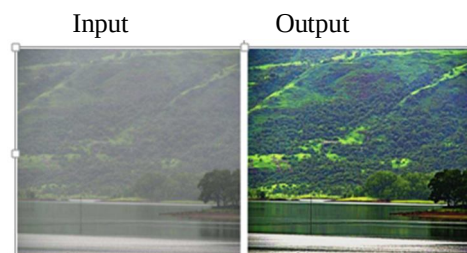


Figure 4: First image consists of fog, second one is haze free image of first one using bilateral filtering

Figure 3 depicts about the detection and removal of fog in a scenario and Figure 4 depicts about river and hill covered with fog which are removed in second image.

VI. CONCLUSION

Image dehazing using image processing involves applying various mathematical and statistical techniques to enhance the visibility of hazy images. There are several techniques available for image dehazing using image processing, including filtering, histogram equalization, contrast stretching, and image fusion. Overall, image dehazing using image processing is an important technique that can improve the visibility of hazy images, but it is important to carefully evaluate and choose the appropriate technique for a given situation. Here we gave two techniques dark channel with airlight map estimation and bilateral filtering and compared them based on different scenarios. Dark channel performs better for removing haze and improving contrast, while bilateral filtering is more effective for preserving details and reducing noise. Overall, object detection using machine learning is an important and rapidly evolving field in computer vision. With the continued development of deep learning-based techniques and the availability of large datasets, we can expect further improvements in object detection accuracy and the development of new applications in a range of domains, such as self-driving cars, robotics, and security.

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